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The effect of an experimental teaching program on postoperative ventilatory capacity

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THE EFFECT OF AN EXPERIMENTAL TEACHING PROGRAM
ON POSTOPERATIVE VENTILATORY CAPACITY

by

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THE EFFECT OF AN EXPERIMENTAL TEACHING PROGRAM ON POSTOPERATIVE VENTILATORY CAPACITY

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ABSTRACT

This investigation was conducted to determine if there were differences in postoperative ventilatory capacity between upper abdominal surgical patients who experienced a teaching program emphasizing deep breathing and coughing and those who received the nursing approach currently used.

An experimental pretest-posttest control group design was used with a sample of 22 patients admitted to the participating facility for elective upper abdominal surgery during a 5 month period. All patients were between the ages of 15 and 60 years and were less than 20% overweight. No subjects had a history of pulmonary or cardiac disease or respiratory infection. The groups were similar in age, sex, preoperative days in hospital, surgical ward and staff, preoperative medications, anesthetic, operative time, ambulation time, smoking history and IPPB therapy.

Patients were randomly assigned to an experimental or control group. All patients met with the investigator the evening before surgery and on Postoperative Day 1 and 2, each meeting was 30 minutes in length. Experimental subjects received the teaching program which was developed from nursing, teaching-learning, and atelectasis theories. The program included exploration of patient concerns; discussion of the patient as a participator in his care; and nurse modeling with patient practice of diaphragmatic breathing, deep breathing, coughing, and positioning.

Conversation with the controls was unrelated to pulmonary function.

Ventilatory capacity was measured by the following variables: 1) forced vital capacity expressed as a percentage of the predicted value; 2) one second forced expiratory volume expressed as a percentage of the predicted value; 3) one second forced expiratory volume expressed as a percentage of the vital capacity; 4) forced maximum mid-expiratory flow corrected for the vital capacity; 5) arterial oxygen partial pressure; 6) alveolar-arterial difference on room air; 7) arterial carbon dioxide partial pressure; 8) arterial blood pH; 9) percentage of venous-to-arterial shunt.

A general null hypothesis predicted no difference between the groups postoperatively when all variables were analyzed simultaneously. Null hypotheses predicted that there would be no significant differences between the groups in the postoperative measurements of each variable.

Preoperative measurements of the dependent variables were within normal limits and illustrated no significant differences between the groups. Mechanical variables were measured 24, 48, and 72 hours after surgery. $\dot{Q}s/\dot{Q}_T\%$ was measured 24 hours after surgery with the Pa_{O2}, $A\text{-}aDO_2$, Pa_{CO2}, and pH being determined 48 and 72 hours after the operative procedure.

Results of the study for the total sample indicated a 50% mean decrease in FVC% predicted on Postoperative Day 1. This measure continued to be 33% less than the preoperative value on Day 3. The decrease in volume was accompanied by only a slight decrease in $FEV_1/FVC\%$ and $MMF_{25-75\%}/FVC$. On Day 1 all patients had an increased $\dot{Q}s/\dot{Q}_T\%$. Hypoxemia continued on Day 2 and 3 with an increased $A\text{-}aDO_2$ and a decreased Pa_{O2}. Hypoxemia was not accompanied by hypoventilation.

When the data were analyzed for each day no differences between the groups met the specified .05 level of significance for a two-tailed test, therefore, all null hypotheses were accepted. Differences between the groups were found in the change scores with the controls having a greater decrease in $FEV_1/FVC\%$ from Preoperative to Day 3 and in $MMF_{25-75\%}/FVC$ from Preoperative to Day 1; both findings approached significance ($p < .10$). From Preoperative to Day 3 a greater decrease in $MMF_{25-75\%}/FVC$ for the controls reached significance ($p < .01$). Analysis of all variables simultaneously demonstrated a significantly higher ranking of the mechanical variables for the experimentals on Day 2. Smoking history and inhalation therapy had no significant effect on postoperative ventilatory capacity. The findings suggested that the teaching program decreased the postoperative development of small airways obstruction (2 millimeters or less).

Suggestions for nursing practice and future research were described.

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CHAPTER I

INTRODUCTION AND STATEMENT OF THE PROBLEM

Recent advances in man's knowledge of pulmonary function have established that most patients undergoing a surgical procedure develop some degree of postoperative atelectasis. This complication ranges from miliary atelectasis detected only by determining the percentage of pulmonary shunting to massive collapse of lobes of the lung characterized by obvious physical signs and changes on radiological examination. This study was designed to evaluate the effect of one nursing action on the problem of reduced postoperative pulmonary capacity. The primary purpose was to investigate the effects of an experimental teaching program emphasizing deep breathing and coughing on the postoperative ventilatory capacity of upper abdominal surgical patients.

Problem Area

In spite of advances in the care of surgical patients pulmonary complications continue to occur with significant frequency after operative procedures. The great diversity in the definition of a pulmonary complication, in the use of diagnostic criterion measures, and in the years and institutions in which the investigations were conducted has resulted in a wide variation in the reported incidence of respiratory complications. A review of the available studies of postoperative lung complications demonstrates a spread of incidence from 2 to 90 per cent (Elwynn, 1922; Sise, 1927; King, 1933; Dripps and Deming, 1946; Stringer, 1947; Mann, 1949; Wightman, 1968; Latimer et al., 1971). Additional studies have demonstrated that differences in the complication rate are related to operative sites and can be as high as 20 to 90 per cent after upper abdominal surgery, 10 to 40 per cent after lower abdominal surgery, and 10 to 30 per cent after surgery on the extremities (Ferguson and Latowsky, 1941; Harris, 1943; Kurzweg, 1953; Clendon and Pygott, 1944; Anscombe, 1957; Anderson et al., 1963; Bendixen et al., 1965; Forthman and Shepard, 1969). The majority of the above authors utilized definite changes in physical or X-ray examination as diagnostic measures and included only advanced degrees of pulmonary impairment, such as bronchitis or pneumonia. It is now believed that signs on physical or radiological examination are indicative of the advanced stages of atelectasis and that there are earlier degrees of this impairment which can only be detected by determining the degree of venous-to-arterial pulmonary shunting. If this latter criterion measure were used to identify postoperative changes in the pulmonary system and the true incidence of atelectasis were more closely approximated it is thought that the incidence of atelectasis after surgery may be almost 100 per cent (Hamilton, 1961; Ward et al., 1966b). Bendixen and Laver believe that, "Following operation atelectasis and shunting must be assumed to be present in all except minor surgery in young and healthy patients"(1965, p. 530).

In an attempt to decrease persistent incidence of postoperative atelectasis a variety of therapeutic modalities, such as the "stir-up routine", blow bottles, the rebreathing tube, endotracheal suctioning, and intermittent positive pressure have become established interventions used in the care of surgical patients. Atelectasis is still a health care problem and the effectiveness of these pulmonary therapeutic measures, used singularly or collectively, remains uncertain (Noehren, Lasry, and Legters, 1958; Sands et al., 1961; Traver, 1968; Collart and Brenneman, 1971).

A preoperative teaching program for patients emphasizing deep breathing and coughing followed by postoperative repeated practice of these breathing exercises has been suggested as one nursing action which has a high probability of reducing the frequency of atelectasis by decreasing muscle splinting, constant tidal ventilation, and accumulation of secretions (Noehren, Lasry and Legters, 1958; Thoren, 1954; Artz and Hardy, 1961; Bendixen et al., 1965; Hanamey, 1965; Ward et al., 1966b). It is generally agreed that breathing and coughing instruction has the greatest effectiveness if it is begun in the preoperative period (Thoren, 1954; Becker et al., 1960). According to Noehren, Lasry and Legters, "This early introduction is of considerable psychological advantage in addition to its therapeutic value. During this period the patient is able to give rather undivided attention to an understanding of the mechanics and principles involved" (1958, p. 660). Most authors also believe that the instruction and practice of breathing exercises should continue after the surgical insult to the pulmonary system when there is most likely to be constant tidal ventilation, splinting of chest muscles, and decreased patient activity.

Surgical patients, themselves, have reported the need for preoperative instruction in deep breathing and coughing and the importance of adequate explanation. In the evaluations of instruction patients had received before surgery, patients in Weiler's study (1968) repeatedly stressed the importance of understanding and learning the techniques of deep breathing and coughing and placed this information first on their list of knowledge needed. One patient stated, "I would try to stress the importance of coughing more and more..." (p. 1466). Because patients also believe that they deserve an adequate explanation of what will happen to them during hospitalization, preoperative instruction should include information about those areas which patients may see as danger threats to themselves. Patients in acute care settings have suggested that they desire knowledge about treatments planned for them, the status of their illness, and those behaviors that are expected of them (Ernstene, 1957; Dumas, Anderson and Leonard, 1965; Skipper, 1965; Duff and Hollingshead, 1968; Weiler, 1968; Mezzanotte, 1970). Since the patient is the most important "actor" in the hospital setting he should be given information and motivation to carry out his own role (Dumas, Anderson and Leonard, 1965). Skipper (1965) found that 65 per cent of a sample of 86 hospitalized patients felt that they deserved a good explanation of their illness. A poor explanation was the most criticized aspect of health care in Skipper's study. "Patients desired to secure information about what was supposed to be happening to them, so that they would have more control over the situation, and would be able to protect themselves better against errors and mistakes" (p. 64). In the investigation of the interrelationships between the care patients receive and the social environment of the hospital, Duff and Hollingshead found that the patient hoped for an explanation of what was being done. "Although he may have been given optimal treatment if he did not get an explanation of what was being done he often felt that he was being used as a 'guinea pig' " (1963, p. 367). As expressed by one patient in Weiler's investigation, "...a person fears that which is 'unknown' much more than that which he knows to be very unpleasant" (1968, p. 1467). Explanation is not only desired by patients, but it also has been shown to affect certain variables. Other research indicates that a positive relationship exists between preoperative explanation and a decrease in postoperative vomiting, patient anxiety, incisional pain, and a shortened hospitalization (Janis, 1958; Dumas and Leonard, 1963; Egbert et al., 1964; Healy, 1968).

Teaching patients in the hospital setting is recognized as one of the primary functions of the nurse (Pohl, 1968; Redman, 1968; Little and Carnevali, 1969; Beland, 1970). Explanation for patients about the plan of care has been suggested as an important function of the nurse-clinician or clinical specialist (Simms, 1965; Reiter, 1966; Georgopoulos and Christman, 1970). Although preoperative teaching has been recognized as the nurse's responsibility, the scientific base has not been established and it, therefore, remains one of many intuitive nursing interventions. Preoperative teaching has become another ritualistic behavior usually performed without previous support of theory, adequate planning, or follow-up evaluation. Content, methodology, and frequency of nursing action vary with each practitioner and institution. At the present time there is little evidence as to whether preoperative instruction is being attempted at all, what method of instruction is preferable, or more important, the subsequent effects on patient recovery if a method of preoperative instruction is subjected to systematic study. Despite advances in this problem area since the inception of this study (Lindeman and Van Aernam, 1971) a need exists for further exploration of the effects of other preoperative instruction programs concerned with pulmonary function. Such studies, developed from learning theory, physiological principles, and previous scientific findings, could incorporate the priority request of patients that they be an active participant in their care. Preoperative instruction programs should be structured so that any staff nurse in an acute care setting would be able to use the teaching-learning strategy during the patient's preoperative phase of hospitalization, even though the preoperative period may be of short duration.

The change in the definition of atelectasis from total obstruction or lobular collapse to the less obvious decrease in lung compliance followed by an increase in venous-to-arterial shunting demands the use of more precise criterion measures than those that have been used in past investigations of preoperative teaching programs. Variables which only demonstrate the mechanical ability of the lung or advanced atelectasis, such as, temperature elevation, X-ray changes, lung volumes, and lung flow rates, should be combined with the percentage of pulmonary shunting, a more accurate reflection of early atelectasis. The discovery of accurate and sensitive dependent variables that can be used to measure the process of nursing practice has been cited as an important step in the accumulation of research findings related to the clinical practice of nursing. "Criterion measures of patient care and precise instrumentation to measure the effects of nursing practice upon patient care are clearly the major gaps in nursing research" (Abdellah, 1970, p. 15). Abdellah gives high priority to the study of variables that measure the maintenance of an oxygen supply to all body cells.

This study is an attempt to partially satisfy the requirements suggested above for future research projects involving preoperative teaching programs for patients in acute care settings who are undergoing surgical procedures. A preoperative teaching program emphasizing pulmonary function was developed using principles derived from nursing, learning, and physiological theories. By involving the patient as an active participant and including an explanation of treatments and behaviors expected of the patient the program was designed to meet the patient requests suggested from earlier studies. Since the incidence of pulmonary complications has been found to be greater in upper abdominal surgical patients, the sample was confined to this group of patients. The sensitive criterion measures of arterial blood gas tensions and the percentage of venous-to-arterial shunting, as well as lung volume and flow rates, were employed to measure the postoperative ventilatory capacity, the degree of atelectasis, and the effect of the preoperative instruction on these variables.

Summary

Despite advances in the therapeutic modalities available to prevent postoperative pulmonary complications it is estimated that close to 100 per cent of surgical patients develop some degree of pulmonary atelectasis after surgery. A preoperative teaching program for patients emphasizing breathing exercises and coughing followed by postoperative repetition of these exercises has been suggested as one alternative for decreasing the incidence of postoperative pulmonary complications. This type of preoperative instruction program was developed from theoretical principles and tested with upper abdominal surgical patients in the acute surgical area. The criterion measures of lung volume, flow rates, arterial blood gas partial pressures, and venous-to-arterial shunting were utilized to determine the status of ventilatory capacity and the degree of postoperative atelectasis.

Problem Statement

Are there differences in postoperative ventilatory capacity, measured by lung volume, flow rates, gas exchange, and pulmonary shunting, between upper abdominal surgical patients who experience a teaching program emphasizing deep breathing and coughing and those who receive the nursing approach currently used?

Null Hypotheses

General Null Hypothesis

Measurements of all dependent variables considered simultaneously on three consecutive postoperative days demonstrate no significant differences between upper abdominal surgical patients who experience a teaching program emphasizing deep breathing and coughing and those who receive the nursing approach currently used.

Null Hypothesis I

Measurements on three consecutive postoperative days of forced vital capacity expressed as a percentage of the predicted value (FVC% predicted) demonstrate no significant differences between upper abdominal surgical patients who experience a teaching program emphasizing deep breathing and coughing and those who receive the nursing approach currently used.

Null Hypothesis II

Measurements on three consecutive postoperative days of one second forced expiratory volume expressed as a percentage of the predicted value (FEV_1% predicted) demonstrate no significant differences between upper abdominal surgical patients who experience a teaching program emphasizing deep breathing and coughing and those who receive the nursing approach currently used.

Null Hypothesis III

Measurements on three consecutive postoperative days of one second forced expiratory volume expressed as a percentage of the forced vital capacity (FEV_1/FVC%) demonstrate no significant differences between upper abdominal surgical patients who experience a teaching program emphasizing deep breathing and coughing and those who receive the nursing approach currently used.

Null Hypothesis IV

Measurements on three consecutive postoperative days of forced maximum mid-expiratory flow corrected for the forced vital capacity and expressed as a ratio ($MMF_{25-75\%}$/FVC) demonstrate no significant differences between upper abdominal surgical patients who experience a teaching program emphasizing deep breathing and coughing and those who receive the nursing approach currently used.

Null Hypothesis V

Measurements on the second and third postoperative days of the partial pressure of oxygen in arterial blood (Pa_{02}) demonstrate no significant differences between upper abdominal surgical patients who experience a teaching program emphasizing deep breathing and coughing and those who receive the nursing approach currently used.

Null Hypothesis VI

Measurements on the second and third postoperative days of the alveolar-arterial difference on room air ($A\text{-}aDO_2$) demonstrate no significant differences between upper abdominal surgical patients who experience a teaching program emphasizing deep breathing and coughing and those who receive the nursing approach currently used.

Null Hypothesis VII

Measurements on the second and third postoperative days of the partial pressure of carbon dioxide in arterial blood (Pa_{C02}) demonstrate no significant differences between upper abdominal surgical patients who experience a teaching program emphasizing deep breathing and coughing and those who receive the nursing approach currently used.

Null Hypothesis VIII

Measurements on the first postoperative day of the percentage of venous-to-arterial shunt ($\dot{Q}s/\dot{Q}_T\%$) demonstrate no significant differences between upper abdominal surgical patients who experience a teaching program emphasizing deep breathing and coughing and those who receive the nursing approach currently used.

<u>Null Hypothesis IX</u>

Measurements on the second and third postoperative days of the pH of arterial blood demonstrate no significant differences between upper abdominal surgical patients who experience a teaching program emphasizing deep breathing and coughing and those who receive the nursing approach currently used.

CHAPTER II

THEORETICAL FRAMEWORK

Two major purposes gave direction to the present investigation. The first purpose was to develop a preoperative instruction program for patients that emphasized deep breathing and coughing and that was based on relevant theory and findings of previous scientific investigations. The second purpose was to test the program's effectiveness in preventing harmful postoperative changes in the functioning of the pulmonary system. The theoretical framework for the patient teaching strategy utilized principles from physiological, nursing, and teaching-learning theories. Recent research findings and general principles relating to postoperative atelectasis were utilized to determine those dependent variables which would be reliable and valid measures of pulmonary function and feasible to use for the study. Selected theoretical bases found in the literature were used to ascertain those confounding variables affecting pulmonary function and needing to be controlled by selection or randomization. For the purpose of clarity the theoretical principles have been divided into the following sections:

I. Nursing Theory

II. Teaching-Learning Theory

- A. Principles of Modeling
- B. Principles of Reinforcement
- C. Selected Principles
  1. Individual Differences
  2. Motivation and Goal-Setting

3. Readiness

4. Active Participation

III. Physiological Theory

IV. Theoretical Bases For Intervening Variables

V. Application of Theoretical Framework to Study

Nursing Theory

The theoretical model proposed by McDonald and Harms (1966) illustrates the major principles of nursing theory that were used for the present investigation. The McDonald and Harms model defines nursing as a decision-making process. Nursing interventions are described as hypotheses concerned with ways of resolving a patient problem. "A problem occurs when a person experiences a disturbance of some kind, for example, illness" (p. 48). The hypotheses imply the expectation that the action will mitigate or resolve a problem (p. 48). McDonald and Harms have outlined four phases of the problem-solving nursing process. In the first phase the nurse observes behavior and identifies the nursing problem. In the second phase she chooses the intervention to which she has assigned the highest probability of success in coping with the problem. The third stage consists of deciding on the specific action and intervening with this action. Finally, the nurse observes the effects of this action and evaluates the results (p. 51). It is suggested that in some instances both the problem and the solution are known before the process is begun.

The concepts in the above model are not unlike those suggested in other writings concerned with the process of nursing (Orlando, 1961: Wiedenbach, 1964: Lewis et al., 1967). Although there is variation in terminology the following concepts seem to be included by most nursing theorists: observation, identification, validation, assessment, action, and evaluation. The nurse observes the patient's verbal and non-verbal behavior in order to identify the need or problem, validates this problem with the patient, decides on the appropriate alternative action, acts to meet the need or solve the problem, and evaluates the effects of this action. Communication is essential and used throughout the process (Orlando, 1961: Lewis et al., 1967).

In a further description of their paradigm, Harms and McDonald (1966) describe patient problems in a framework which includes phases in the health-disease continuum, patient systems, and types of interventions. Three phases in a health maintenance-restoration cycle are identified: initial, when the problem is pending or observable; restorative, when the patient is being restored to health; adaptive, when the patient learns to cope with the effects of the problem (p. 51). The major patient systems presented are the central, proximal, and distal. The core of the individual, without which the patient ceases to function, is described as the central system. The proximal system encompasses the directly observable features and actions of the patient. The distal system is defined as the patient's relations to objects, events or systems outside the proximal system (p. 51).

Nursing interventions are classified as follows: restorative, returning a patient function to its normal level; inhibitive, controlling a process initiated in a patient or his environment that would be detrimental; constructive, adding a process or structure to patient functioning; and preventive, forestalling the initiation of a process that would be detrimental to the patient's health (p. 52).

Teaching-Learning Theory

Principles of Modeling

The principles of modeling behavior have been developed within the context of social learning theory. Bandura (1968, 1969) has proposed that behavior change or learning is accelerated if people can successfully match the behavior of appropriate societal models. Bandura suggests that "... virtually all learning phenomena resulting from direct experiences can occur on a vicarious basis through observation of other persons' behavior and its consequences" (1969, p. 118). In both observation and laboratory experimentation he found that models in actual or symbolic form are highly effective in transmitting or controlling behavior. Learning from models is presented in contrast to Skinner's operant learning theory (1953) which uses the concepts of differential reinforcement and successive approximation to shape new behavior. Bandura (1962) believes that it is unlikely that many of our social responses would have ever been acquired if all learning proceeded solely by the lengthy process of differential reinforcement and successive approximation because these processes demand emission of the initial behavior before reinforcement can begin. He proposes that these processes can be avoided through simple demonstration or verbal description. Mager (1968) also believes that modeling can be used to learn appropriate behavior in unfamiliar situations: "... if we had to learn everything through trial and error, or by making responses and then having them corrected, a lot fewer of us would survive" (p. 62).

The principles of modeling theory are based on the assumption that behavior is governed not only by response-reinforcement contingencies but also by cultural behavioral examples, and that the unit of response acquisition is imitated in large segments, not in small units, through the gradual process of response differentiation facilitated by differential reinforcement. Modeling or imitative behavior refers to the tendency of a person to match the behavior or attitudes exhibited by actual or symbolic models. Bandura (1968) believes that the same learning processes are involved in identification, imitation, modeling, introjection, incorporation, and role-taking and, therefore, these terms are used interchangeably in the present investigation. Bandura (1969) differentiates between the acquisition, the learning of matching responses, and the performance of modeling behavior. Acquisition of modeling behavior is assumed to be acquired through representational mediators on the basis of stimulus contiguity and associated symbolic processes, while performance depends more on model or subject reinforcement. Learning is thought to involve "imaginal" and "verbal" representational systems. Modeling stimuli are coded into images or words for memory representation which then function as mediators for subsequent response retrieval and reproduction (Bandura, 1969, p. 133).

Contiguity is assumed to be necessary for learning by observation, but not sufficient. Other processes are also thought to influence the acquisition and degree of identificatory learning. The attention of the learner is the first component believed to be necessary for the acquisition and degree of identificatory learning. The observer must be attentive, perceive cues accurately, and be able to differentiate among distinctive features of the model's responses if he is to acquire matching behavior. "Attention-controlling processes" related to incentive conditions, observer characteristics, and the properties of the modeling cues will determine which stimuli will be observed or ignored (Bandura, 1969). Certain model and subject attributes have been found to influence the degree of attentiveness. Persons who are dependent, lack self-esteem, are incompetent, or have a history of frequent rewards for imitative behavior seem to be more attentive to a model. Models who are highly competent, expert in particular specialities, attractive, powerful, or imbued with rewarding qualities are more influential than models who do not possess these characteristics. Age, sex, social power, and ethnic status have been shown to influence the degree to which models are imitated. In contrast to psychoanalytic theories, social learning theory proposes that the behavior of powerful models receives attention and is reproduced because subjects have observed the high utilitarian value of the behavior of these models. Also, ". . . the effect of models' prestige tends to generalize from one area of behavior to another and to unfamiliar persons to the extent that they share similar characteristics with past reward-producing models" (Bandura, 1971, p. 22). "Attentive processes" include variables such as rate, number, and complexity of the modeling stimuli. The characteristics of the model and mode of presentation may affect learning. Modeled characteristics that are readily discernible are more likely to be acquired than those less discernible due to the complexity or subtlety. In addition, if the desired behavior is clearly specified, there is a greater learning expectation than if the behavior must be inferred from examples (Bandura, 1969, p. 146). An actual performance will provide clearer and more pertinent behavior cues than a verbal description (Bandura, 1962, p. 242). Attention can be increased by informing subjects in advance that they will be rewarded for correct performance. As in any type of learning, if the learner is to be attentive, the modeling behavior must be geared to his perceptual and motor capacity. If he cannot observe the significant cues the model presents, there will be no learning.

The second component thought to be important in the learning of modeled behavior is that of retention. Retention of modeled cues without external stimulation increases and is strengthened both in overt practice or rehearsal (Margolius and Sheffield, 1961) and in covert rehearsal (Micheal and Maccoby, 1961). Subjects are more likely to practice modeled responses which they know are effective in producing rewards. Retention appears to be increased through symbolic coding operations. Retention is facilitated by recoding, classifying, and reorganizing elements into familiar and more easily remembered schemes (Bandura, 1968).

The availability of necessary responses for motor reproduction is the third factor believed to be necessary for acquisition of modeling behavior. Complex motor responses are a combination of previously learned components. If the learner is lacking some of these he will be able to display only partial reproduction of the model's behavior, and if the behavior requires subtle adjustment of internal responses that are neither observable or communicable, overt practice with appropriate feedback will be necessary (Bandura, 1969, p. 142).

The final process suggested by Bandura to affect the acquisition of modeling behavior is motivation or "incentive sets." As in other learning, anticipating positive reinforcement for reproducing imitative behavior increases the selective attention of modeling cues and the probability that these will be performed (Bandura, 1969).

Numerous research studies have shown that the performance of modeling behavior is probably controlled respectively by reinforcement, incentive conditions, and characteristics of the model. These components are proposed in contrast to those of previous theories of imitation that have regarded psychoanalytic phenomena such,as cathetic attachment, nurturance, or defensive identification as important in promoting modeling behavior (Bandura, 1969).

The commonly accepted principles of reinforcement (Hilgard and Bower, 1966) are applicable to the learning and performance of modeling behavior. The reinforcing consequences and the social sanction associated with imitative behavior greatly influence the performance of modeling behavior (Bandura, 1968). Once imitative behavior has acquired secondary reinforcement properties, direct positive reinforcement increases matching behavior and establishes a generalized imitative response tendency which then remains in the absence of direct reinforcement (Bandura and Huston, 1961; Bandura, Ross and Ross, 1961).

Vicarious reinforcement, observation of a model being reinforced, also increases the performance of imitative behavior (Bandura, 1965). The reward or punishment of the model affects the observer in a way similar to direct reinforcement. Information that is gained from observing the outcomes experienced by models is particularly influential in situations where there is ambiguity as to the appropriate behavior and "... where the observer believes that the model's contingencies apply to himself as well" (Bandura, 1968, p. 40). As in the acquisition of modeling behavior, the performance of imitative behavior is influenced by the rewarding qualities and status variables of the model previously listed.

Bandura has shown that people can learn through observation of the performance of others. With the learning of increasingly greater units of response and the provision of societal models the process of learning new behavior can be shortened. Observation of modeled behavior and its consequences may create new response patterns, strengthen or weaken inhibitory responses, or facilitate the occurrence of previously learned behaviors. New responses are acquired and existing repertoires of behavior are modified continuously by both direct and vicarious experiences with a wide variety of actual and symbolic models. The attitudes, values and social responses of these models are exemplified behaviorally, or in verbally coded forms (Bandura, 1968, p. 65). This theory proposes that modeling behavior is acquired through contiguity of modeling stimulus with imaginal and verbal coding of observational inputs. The symbolic events with the other processes of attention, retention, motor capacity, and incentive, facilitate acquisition and overt response of the appropriate behavior; whereas, performance of learned responses is influenced by incentives, differential consequences from imitating the behavior of models possessing distinctive characteristics, and direct or vicarious reinforcement patterns. Reinforcement is seen as facilitative rather than necessary since imitative learning can occur without reinforcement to the learner or the model. Learning can also take place without overt practice, this too is facilitative rather than essential. Although most of Bandura's research has been conducted with children, Kramer (1972) described the use of modeling as a teaching strategy for baccalaureate students in the clinical setting.

Principles of Reinforcement

Behavior is controlled to a great extent by the consequences or reinforcements that follow it. Reinforcement is simply defined as an operation which indicates to the learner the degree of correctness of his response. Reinforcement can be positive (rewarding) or negative (punishing). When a given response is followed by a positively reinforcing consequence the response pattern is strengthened and is very likely to occur more frequently (Wallen and Travers, 1963; Hilgard and Bower, 1966). Whether positive feedback provides satisfaction of a need, information regarding correctness of a response, or motivation, it is a reward and will generally increase the frequency of a response. Since behavior that is not reinforced is usually dropped, another commonly accepted principle is that the learner needs feedback on the correctness of his response (Taba, 1962; Hilgard and Bower, 1966: Redman, 1968). Knowledge of a correct performance or performance errors improves the learning of a performance pattern (McDonald, 1965) and positive reinforcement is generally preferred over negative reinforcement (Hilgard and Bower, 1966).

Three essential features in the successful application of reinforcement processes have been identified: adequate motivation to maintain responsiveness and an incentive system of powerful reinforcers; a reinforcement plan or schedule contingent upon the performance of the desired response; and a reliable procedure for inducing the desired response (Bandura, 1969).

Adequate motivation can arise out of an unsatisfied need or goal. Although there are individual differences in the need for health as suggested by evidence that certain needs are satisfied by taking on the "sick role" (Parsons, 1951), it is generally agreed that most people want to be healthy and will be adequately motivated to maintain a healthy state. Published lists of human needs emphasize the need for survival (Murray, 1938; Maslow, 1961; Cronbach, 1963; Towle, 1965).

An incentive system of powerful reinforcement may be as important as intrinsic motivation for successful reinforcement processes. Theories of motivation based on internal needs may be misleading and prevent treatment of those patients who are thought to be lacking in motivation. If behavior is considered to be largely activated by the expected consequences instead of a previous state of motivation, then motivation can also be regulated by environmental stimuli or anticipation of reinforcing consequences (Bandura, 1969, p. 225).

The belief that motivation and reinforcement are closely allied and difficult to separate is accepted by other authors (McDonald, 1965; Deese and Hulse, 1967). If behavior is positively reinforced the rewards become the individual's goals, and the person is motivated to attain these goals; goals and reinforcers then become synonymous. Anticipation of a reward motivates a person to adopt or change a behavior.

Reinforcers for an individual are acquired partly through social learning within one's culture. In American society goals such as the desire to learn, the achievement of social prestige, and the maintenance of health are generalized reinforcers acquired through social learning. These goals are acquired by the individual because the environment consistently rewards this type of behavior.

Although there are many types of reinforcers, generalized conditioned reinforcers are important in this context. Generalized reinforcers acquire their rewarding properties through being paired with many types of primary and secondary reinforcers. Since people frequently show approval just before they provide many types of reinforcers, the word "good" or other signs of approval have also become conditioned generalized reinforcers (Holland and Skinner, 1961).

Reinforcement in the form of phrases of approval such as "that's good," "you did that right" will increase the incidence of the desired behavior. Using as the definition of reinforcement any stimulus that increases the probability of preceding responses, Bandura (1962) suggests that for human subjects a polite request can be a powerful generalized reinforcer which can provoke a response of great strength.

If motivation and an incentive system of powerful reinforcers are available, a plan or schedule of reinforcement can be developed. A well accepted principle concerning schedules of reinforcement is that the effectiveness of reinforcement is partly dependent on the promptness with which it is given (Holland and Skinner, 1961; McDonald, 1965; Hilgard and Bower, 1966). Generally the degree of control exercised by reinforcement decreases as the delay between behavior and reward increases. When reinforcement is made immediately contingent upon the desired behavior, learning proceeds most effectively. It is known that varying schedules of reinforcement have different effects on performance (Ferster and Skinner, 1957). Continuous reinforcement, rewarding each response, initially increases a given behavior, but when continuous reinforcement is withdrawn there is a rapid decrease in performance. Intermittent reinforcement has been found to produce more persistent behavior and to be less resistant to extinction than continuous reinforcement. Responses reinforced by affection or approval are reinforced intermittently due to the subtlety of the stimuli which makes them go unnoticed and, therefore, are extinguished slowly (Holland and Skinner, 1961). Intermittent reinforcement can be provided on a variety of schedules, i.e., fixed interval or ratio, and variable interval or ratio. Variable schedules of reinforcement have been found to generate higher rates of response and more stable, consistent performances than those schedules which reward on a fixed interval of time or a fixed ratio of performances (Bandura, 1969, p. 28). Under variable schedules of reinforcement, a variable-ratio schedule, i.e., when the number of responses per reinforcement is varied around a selected average ratio, generates a higher sustained rate of response than the variable-interval schedule. The variable-ratio schedule is the most powerful in sustaining behavior. This high rate of response found in laboratory experiments is illustrated in the persistent behavior of gamblers or salesmen who are rewarded sporadically. It has been found that expected rewards may exert more control over behavior than the reinforcement schedule actually in effect.

The final essential component for successful reinforcement is accessibility of the appropriate response pattern. If this response pattern is not present behavior can not be reinforced. If the behavior is absent, however, elicitation may be accomplished through successive approximation and shaping, graduated modeling with positive reinforcement, or verbal instruction as to how and when to perform the behavior to be rewarded (Bandura, 1969).

Learning may be influenced by observation of reinforcement experienced by others and self-evaluation processes. It is thought that self-reinforcement is important in regulating human behavior and that people control much of their behavior by anticipated external consequences or self-evaluative responses to their own actions (Bandura, 1971). Anticipated consequences provide a stimulus for foreseeable behavior. People buying fire insurance before the discomfort of a burning house or housewives shopping for food before the family is hungry are examples of behavior regulated by anticipatory consequences (Bandura, 1971, p. 2). Behavior in the absence of external reinforcement can be affected through self-evaluation. People have certain standards of behavior and reward or punish themselves depending on whether their performances fall short of, equal, or surpass their expectations for themselves (Bandura, 1969, p. 32).

Bandura (1969) has illustrated the importance of modeling processes in the development of self-reinforcement. It has been found that people use behavior patterned on that of others as norms for self-evaluation when their own responses do not provide them with objective feedback. While acting as their own reinforcement agents, people adopt the standards of models and use these as measures against which to evaluate their own behavior. Motivational effects of goal-setting are augmented by self-reinforcement. A person commits himself to a certain level of performance and his self-approval becomes dependent on the attainment of that goal. He then intensifies his efforts in order to avoid self-disappointing performances. People are usually not content with a given performance but make self-reward dependent on progressively more difficult achievements. Thus, motivation is not derived so much from the goals themselves as from the fact that people evaluate their own achievements and, therefore, are able to regulate their level of effort accordingly (Bandura, 1971, p. 40).

Learning and subsequent behavior patterns may be affected by vicarious reinforcement. Vicarious reinforcement is defined as a change in an individual's behavior as a result of observing the consequences accompanying the performance of others (Bandura, 1971). Several studies (Berger, 1961; Bandura, Ross and Ross, 1963; Bandura, 1965) have shown that responses in observers can be increased by observed reward and decreased by observed punishment. Viewing the consequences of a model's behavior can also affect the observer's evaluation of that model and subsequent imitative behavior.

Vicarious reinforcement seems to be governed by the same principles as direct reinforcement with regard to incentive variables such as schedules, magnitude, and percentage. Like direct reinforcement it provides information about possible reinforceable responses, knowledge of the appropriate situation to perform these responses, and motivation through the observation of desired rewards and expectation of similar rewards.

The combination of direct and vicarious reinforcement is thought to have a greater effect than either phenomenon would independently (Bandura, 1971). The history of direct and vicarious reinforcement in the individual will affect his self-evaluation and the subsequent responses he will make in a given situation. The effect of a certain reinforcement is dependent not only on its intrinsic properties but also on its relation to previous reinforcements. If an individual has previously been punished, a nonreward, as opposed to actual punishment, will act as a positive reinforcer. However, if he has previously been rewarded, a non-reward will be a negative reinforcer for him (Buchwald, 1960).

Selected Principles

Individual Differences. A major teaching-learning principle is that, although human beings are similar in many ways, each human is different and that these individual differences will affect learning. Learning is influenced by the learner's physical, intellectual, hereditary, and psychological status. These will be different for each individual and will have developed through experiences in a wide variety of social and cultural environments. The additional previous experiences with and attitudes toward hospitalization, illness, stressful events, and hospital personnel are only a few of the many factors which will differ and affect each individual's learning. These individual differences combined with those of the teacher's and the resulting interaction will influence the learning process.

Motivation and Goal-Setting. Learning proceeds more effectively and tends to be most permanent when the learner is motivated (Gagne, 1965; Hilgard and Bower, 1966). Intrinsic motivation is preferable to extrinsic motivation in effecting learning (Bigge, 1964; McDonald, 1965; Hilgard and Bower, 1966). Intrinsic motivation emerges from a need or anticipation of a certain reward or goal (McDonald, 1965; Bandura, 1971). Through social learning and past experience of reinforcement people learn the behavior that is most likely to be rewarded.

Published lists of human needs (Murray, 1938; Knowles, 1950; Maslow, 1961; Towle, 1965) have suggested a basic set of physiological needs related to survival and health maintenance. When a person becomes ill there is an immediate reorientation of all drives and interests. Usually an individual's major concern is re-establishing a healthy state.

Because our environment consistently rewards an individual for his knowledge, the desire to learn has also become one of the basic needs or goals for adults in our American society (Taba, 1962; Towle, 1965; Little and Carnevali, 1969). Although much behavior is goal-oriented humans also like to know where they are going, where to find things, and what is going to happen to them for the sake of knowing (Knowles, 1950, p. 13).

Motivation is increased when the individual takes part in setting realistic goals for himself. These goals can be thought of as kinds of behavior which have been reinforced in the past. Learning must be goal-directed for the learner and must provide reinforcement necessary for goal attainment (McDonald, 1965). Bandura (1971) believes that motivation is derived not only from a person's goals but from his responses to his own achievements, his self-evaluation, and his subsequent self-reinforcement as well. If, in fact, an individual has as his goals survival, health, and knowledge, it is to be expected that he would be motivated to set the goals and learn the behaviors that render the attainment of these rewards most likely.

Motivation and learning are also enhanced when the material is meaningful to the learner (Redman, 1968). New learning should be based on the subject's previous experiences and knowledge. Interest in a subject exists when it seems useful and worth knowing for situations other than that in which it was learned. An understanding of fundamental principles, ideas, and general phenomena, rather than specific detail increase the probability of transfer to other situations (Bruner, 1960).

Readiness. A sufficient level of mental and physical development is necessary for the learner (McDonald, 1965). Readiness is defined as the likelihood that an individual can make the response in which the teacher is interested. This is determined by previously learned behaviors and a person's mental and physiological system influenced as it is by heredity, maturation levels, and physical limitations (Wallen and Travers, 1963). If a strategy is concerned with learning a skill, the necessary neuromuscular components must be available to the learner. Adequate experience in the perceptions, verbalizations, and concept formation must be present in certain types of learning (Pohl, 1968).

Active Participation. The principle that learning is more efficient if there is active participation by the learner is generally accepted by most theorists (Wallen and Travers, 1963; Hilgard and Bower, 1966). There is less understanding of the reasons underlying the observation that learning is facilitated by the learner's active participation. Learning may be increased because overt responses present an opportunity for reinforcement (McDonald, 1965) or because active participation may increase the learner's motivation and heighten his attention processes (Bandura, 1962).

Closely allied to the principle of active participation is that of the effect of practice in learning. Repetition is considered an important factor in the process of "over-learning" a skill in order that retention will be assured (Hilgard and Bower, 1966). Realistic practice conducted under conditions similar to those where the behavior will be needed is considered the most efficient and beneficial technique in promoting learning (McDonald, 1965). Although it has been found that short and spaced practice is more beneficial to learning than massed practice, McDonald (1965) has suggested that when the task is simple and requires a short learning time massed practice may be preferable.

The principle of active participation by the patient in his care has been given little consideration in the literature. McDonald (1965) suggests that when people have the opportunity to participate in the decision-making process there are more frequent desirable behavior changes. Some authors (Abdellah et al., 1960; Orlando, 1961; Little and Carnevali, 1969) have suggested that active participation on the part of the patient is beneficial to learning. Other authors (Thoren, 1954; Skipper, 1965; Dumas, Anderson and Leonard, 1965) have proposed that the patient's active participation in his own care can aid in a more rapid return to physiological and psychological balance. Tryon and Leonard (1964), Tryon (1966), and Hallburg (1969) have investigated the principle of active participation by the patient, and emphasized the need for increased involvement of the patient in planning and decision-making based on mutual understanding and consent. If a patient is involved in his care he assumes responsibility for the effect of that care.

Physiological Theory

The theory of atelectasis has been modified significantly since it was first described by Pasteur in 1908 and 1910 as the complete collapse of one or more definite units of the lung. The traditional description of atelectasis as massive, localized collapsed lesions, which are caused primarily by airway reabsorption of gas, is now thought to be the extreme case in the health-disease continuum. The severe instance of atelectasis, complete collapse of anatomical units of the lung, was diagnosed through the symptoms of elevated temperature, pulse or respirations. Physical and radiological examinations were characterized by regional density to percussion, absence of breath sounds, shift of mediastinal or diaphragmatic boundaries, and differences in radiolucency of the chest X-ray (Safar, 1965). A large number of factors were thought by early theorists to be involved in the production of postoperative atelectasis because of their effect in reducing bronchial calibre, creating a deficient expulsive mechanism, and changing the viscosity of bronchial secretions (Palmer and Sellick, 1953, p. 165). During the last sixty years this concept of atelectasis has been utilized in numerous studies which were primarily concerned with the frequency of the incidence of pulmonary complications. The large number of diagnostic criteria and the variety of pulmonary complications used in past studies make it difficult to identify the true incidence of atelectasis in the population.

It is now known that the concept of atelectasis as a complete collapse of the lung or lobes of the lung resulting from airway obstruction with resorption of gas as the major factor in development was based on findings in severe or advanced degrees of the phenomenon. At the present time it is believed that collapse of even the smallest parts of the lung, the alveoli, is atelectasis and results from a decrease in lung volume and compliance leading to venous admixture. The current etiological literature places more importance on the failure to inspire deeply which results in venous-to-arterial shunting and hypoxemia before the extreme case of airway obstruction and total collapse.

Hypoxemia, a decrease of oxygen partial pressure in arterial blood (Pa_{02}), is caused by four major physiological mechanisms: hypoventilation, impaired diffusion, maldistribution, or venous-to-arterial shunting. Hypoventilation is associated with the retention of carbon dioxide when alveolar ventilation in relation to the metabolic rate is decreased (Comroe, 1965, p. 32). Impaired diffusion, the destruction or loss of an area available for transfer of oxygen at the alveolar-capillary membrane, although an infrequent cause, can also produce hypoxemia (Carman et al., 1969). The optimum relationship between alveolar ventilation and pulmonary circulation (the ventilation-perfusion ratio) requires an even distribution of adequate ventilation and proportionately adequate perfusion of pulmonary capillaries. When there is non-uniform ventilation, non-uniform blood flow, or a combination of the two maldistribution occurs. This is the abnormal distribution of alveolar ventilation in relation to pulmonary capillary blood flow. When some areas of the lung are poorly ventilated compared with their perfusion, the blood will pass through the capillaries of these areas without becoming fully saturated with oxygen. In the more extreme case when some alveoli have no ventilation and capillary blood flow is maintained through these collapsed or unventilated areas of the lung there will be venous admixture to arterial blood and a physiological venous-to-arterial shunt. A venous-to-arterial shunt is that fraction of the cardiac output that is not exposed to blood-gas exchange in the pulmonary capillary bed (Bendixen, Hedley-Whyte, and Laver, 1963). Normally, there is some mixed venous blood bypassing the lungs into the arterial blood through (1) anatomic or constant shunts of bronchial, pleural, and thesbian veins and pulmonary arteriovenous anastomoses, and (2) normal variable shunts or slight deviations of the ventilation-perfusion ratio from the ideal value. The total amount of this normal shunting of the venous system to the arterial system is 7 per cent or less of the cardiac output from the right ventricle (Comroe et al., 1962). In abnormal conditions this percentage can be greatly increased by a significant variation in the variable shunt or the ventilation-perfusion ratio caused by collapse or reopening of atelectatic area of the lung (Bendixen, Hedley-Whyte and Laver, 1963, p. 992). The characteristic feature of the venous-to-arterial shunt is that it is not reversed when the patient breathes pure oxygen.

It has been established that during anesthesia there is an increased venous-to-arterial shunt (Bendixen et al., 1963; Conway and Payne, 1964; Sykes, Young and Robinson, 1965; Nunn, Bergman and Coleman, 1965).

Postoperatively, low saturations of oxygen in arterial blood were first noticed by Maier and Cournand (1943). In a sample of 38 postoperative pulmonary resection patients, hypoxemia was found to be a common occurrence for as long as a week after surgery, with the time period being longer for lobectomy patients than pneumonectomies. This discrepancy in the duration of hypoxemia suggested that the earlier stages of atelectasis resulted in a disturbance of the ventilation-perfusion ratio. Bjork and Hilty (1954) later studied arterial oxygen and carbon dioxide tensions after pulmonary resection. They also found postoperative hypoxemia in a sample of 22 patients, the lowered oxygen tension again lasting longer in the lobectomy group. These authors did not find an increase in carbon dioxide tension except in those patients who had preoperative retention of this gas. This finding ruled out the presence of hypoventilation as the cause of hypoxemia. In both of these studies hypoxemia was present without the presence of hypoventilation. A slight degree of hypoxemia 24 hours after abdominal surgery was discovered by Gordh, Linderholm, and Norlander (1958) in most of their patients. Nunn and Payne (1962) found all sample patients undergoing minor operations under general anesthesia to be hypoxic several hours after operation. The mean arterial saturation was 90 per cent with a mean arterial oxygen tension of 65 mm. Hg (p. 632). Since all carbon dioxide tensions rapidly returned to normal, both of these studies excluded hypoventilation as a possible cause of the impaired oxygenation of the blood. Although Nunn and Payne acknowledged the probable importance of a disturbance in the ventilation-perfusion ratio, Gordh, Linderholm, and Norlander attempted to differentiate between the two possible etiological alternatives of venous-to-arterial shunting and maldistribution. Low oxygen tensions were obtained postoperatively while the patients breathed 100 per cent oxygen, indicating the presence of venous-to-arterial shunting which was assumed by the authors to be due to pulmonary atelectasis. It was concluded that maldistribution and impaired diffusion contributed little to postoperative hypoxemia. Campbell, Nunn and Peckett (1958), Clowes et al. (1960), Stark and Smith (1960), Palmer and Gardiner (1964), Diament and Palmer (1966), Pecora (1969), and Marshall et al. (1969), also found lowered arterial oxygen tensions postoperatively with controlled and spontaneous respirations. Since no significant increase in carbon dioxide tension was found in any of these studies, the hypoxemia was assumed to be due to venous-to-arterial shunting resulting from atelectasis. Palmer and Gardiner (1964) reported lower oxygen tensions in those patients who developed postoperative complications. Diament and Palmer (1966) found that the fall in oxygen tension was greater after upper abdominal operations and, therefore, related to the type of incision. A comparison of postoperative arterial gas tensions, radiographic examinations and physical examinations was made by Hamilton et al., (1964) using 27 patients undergoing abdominal or inguinal surgery. A high incidence of decreased arterial oxygen tension was found without hypoventilation. As predicted, this abnormality was not accompanied by X-ray evidence of atelectasis or abnormal physical signs.

The studies described above suggested that increased shunting takes place not only during anesthesia, but also several days postoperatively. It occurs during both spontaneous and mechanical respiration and is not always accompanied by evidence of atelectasis on X-ray or physical examination. Thus, increase in venous-to-arterial shunting has become part of the definition of atelectasis.

The variable of decreased lung volumes included in the present definition of atelectasis has been substantiated. Churchill and McNeill (1927) demonstrated a reduction in vital capacity to 50 per cent following abdominal surgery and to 20 per cent following upper abdominal procedures. With a sample of 26 patients undergoing abdominal surgery, Anscombe and Buxton (1958) found significant postoperative reductions in the total lung capacity, inspiratory capacity, expiratory reserve volume, vital capacity, and function residual capacity. These returned to normal within 10 days to 2 weeks after surgery. Powers (1928), Head (1927), Pecora (1969), Sheiner et al. (1970), and Latimer et al. (1971) have all measured marked reductions in vital capacity after upper abdominal procedures. Latimer et al. found a mean reduction to 35 per cent of the preoperative measurement on the day of operation rising to a mean of 70 per cent by the seventh postoperative day. The reduction in vital capacity has also been reported as greater in males than in females and is apparently independent of anesthesia (Davidson, 1964). At the present time it is generally agreed that a laparotomy increases respiratory frequency, decreases tidal volume, and reduces both inspiratory and expiratory capacities including reserve volumes (Bendixen et al., 1965).

Atelectasis may not necessarily exist as a well-localized condition; it can also appear as small and diffuse miliary lesions not observable on X-ray examination (Laver and Bendixen, 1966). Beecher (1933) was the first to suggest a postoperative decrease in functional residual capacity as large as the total volume of "supplemental air" (now known as the expiratory reserve volume) in the absence of physical signs. He believed this loss of lung volume signified actual pulmonary collapse, but was unable to find evidence of this on physical or X-ray examination. Although total collapse of lobes of the lung may have occurred Beecher observed the collapse to be "diffuse and partial, not local and complete" (p. 657). This diffuse collapse with no apparent symptoms was found in 82.9 per cent of his patients undergoing laporatomy. Using a sample of dogs, Mead and

Collier (1959) have demonstrated that atelectasis may exist in diffuse, widespread form throughout the lungs without areas of collapse being observed on X-ray or physical exam.

The theory that a decrease in lung compliance is an important factor in the concept of atelectasis is based on recent findings. Lung compliance is defined as the volume change produced by a unit of pressure change (Comroe, 1965). Mead and Collier (1959) using animals followed by Ferris and Pollard (1960) using human subjects were the first researchers to demonstrate that lung compliance decreases progressively during ventilation if this ventilation is normal in terms of tidal volumes and respiratory rate, but is lacking in periodic deep breaths. Ferris and Pollard found that lung compliance decreased 26 to 40 per cent both in poliomyelitic patients and normal subjects as measured in the tidal volume range during quiet breathing. After the period of quiet breathing, two or more deep breaths to the limit of inspiration produced an increase in lung compliance (p. 148). Bendixen, Hedley-Whyte and Laver (1963) questioned if constant ventilation at a normal tidal volume without periodic hyperinflation would increase shunting. They hypothesized that the impaired oxygenation caused by atelectasis would be reversed by passive hyperinflation of the lungs (p. 991). In the absence of deep breaths during surgery a sample of 18 patients under general anesthesia and controlled ventilation were found to have an average 15 per cent decrease in lung compliance. After an average of 76 minutes of constant ventilation, three successive hyperinflations of the lungs restored both arterial oxygen tension and lung compliance to control values (p. 996). Although the amount of shunting was not calculated, these authors suggested that the changes in the arterial oxygen tension primarily reflected changes in the variable venous-to-arterial shunt. This assumption was made because the alveolar-arterial oxygen gradient was too great to be caused by maldistribution, and a diffusion block would demand an increased cardiac output and alveolar oxygen tension below normal, both of which were constant (p. 994). Animal studies conducted in the same laboratory confirmed the relationship between the degree of shunting and constant tidal volumes (Laver et al. 1964).

These findings were expanded in two investigations which studied the hypothesis that progressive atelectasis with shunting of venous blood may occur with ventilation which is normal as measured by the usual criteria, but lacking in periodic deep breaths that are capable of reinflating collapsed airspaces. Egbert, Laver, and Bendixen (1963) demonstrated with a sample of 36 surgical patients breathing mechanically during anesthesia that there was a fall in lung compliance after 5 to 10 minutes. Passive hyperinflations significantly improved the compliance. Bendixen et al. (1964) studied 25 patients who were anesthetized with ether and oxygen and were breathing spontaneously for an average of 130 minutes. At the end of this period the average arterial oxygen tension was 402 mm. of mercury. After a 3 to 5 minute period of controlled hyperinflation the arterial tension rose to 553 mm. of mercury (p. 297). This significant relation between size of the tidal volume during constant volume ventilation and the amount of venous-to-arterial shunting has been confirmed in two additional studies (Hedley-Whyte, Laver, and Bendixen, 1964; Hedley-Whyte et al., 1965). These studies once again suggested that both shunting and decreased pulmonary compliance are internal variables of atelectasis and can be reversed by hyperinflation.

The normal ventilatory pattern of awake subjects has been found to be characterized by deep breaths of more than three times the average tidal volume approximately ten times per hour (Bendixen, Smith, and Mead, 1964). Ward et al. (1966b) studied the effects of different ventilatory patterns of hyperinflation on the amount of pulmonary shunting. In 10 male volunteers breathing 100 per cent oxygen, the oxygen tension was higher following a deep breath held for 3 seconds than after multiple deep breaths. The authors concluded that the body can decrease the amount of atelectasis more efficiently by taking a breath and holding it for 3 seconds than it can by merely taking a deep breath or even by taking multiple deep breaths. This action has the same effect as yawning or sighing deeply (p. 53).

In an attempt to study the hypotheses that a sustained maximal inspiration with an open glottis, simulation of a yawn, would prevent atelectasis by equilibrating ventilation and perfusion Bartlett et al. (1970) constructed and tested the effects of an incentive spirometer. The incentive spirometer sustained a specific inspiratory flow rate and assured increase of volume until total lung capacity was reached. In five normal volunteers there was an average slight increase in arterial oxygen tension both on air and 100 per cent oxygen which apparently indicated that ventilation-perfusion relationships were normal before the maneuver and could not be significantly improved. Improvement in the ventilation-perfusion ratio was found in ten postoperative laparotomy patients who had decreased vital capacities and increased alveolar-arterial gradients for oxygen. After five maneuvers the group's Pa_{O2} on air was increased from an average of 70 to 94 mm. Hg and the Pa_{O2} on 100 per cent oxygen increased on an average from 250 to

440 mm. Hg. Although this study was apparently exploratory and the report lacks explanation of specific controls, methods, or sample selection, it does offer tentative support for the theory that shallow ventilation produces atelectasis and that this collapse of alveoli can be reversed by sustained maximal inspirations.

A reduction in flow rates following surgery as a result of a loss in lung volume, not obstruction of the pulmonary system, substantiates the theory that atelectasis is not primarily caused by blockage of the airways. Pecora (1969), Paskin, Rodman and Smith (1969), and Latimer et al. (1971) demonstrated a reduction in flow rates following surgery, however, when the flow rates were presented as a percentage of the reduced vital capacity, i.e., FEV_1/ FVC%, there was little decrease in these values postoperatively. These findings suggested that the postoperative pulmonary impairment is restrictive rather than obstructive.

If the theory that atelectasis is characterized by collapse of alveoli and a decrease in lung volume and compliance leading to shunting of venous blood is physiologically correct, it is necessary to consider possible reasons for a collapse of alveolar units when the normal, intermittent sighing type of respiration is not present. With every return of the lungs to the resting end-expiratory position with atmospheric pressure throughout the airways, some alveoli collapse and stay collapsed (Bendixen, Hedley-Whyte, and Laver, 1963, p. 991). Any physical or pharmacological factor affecting the efferent stimulus to the respiratory muscles or interfering with their actual performance, such as pain, medication, restrictive bandages, or abdominal distention, would lead to a persistence of this collapsed state which has been shown to occur on a cyclical basis (Laver and Bendixen, 1966).

It has been substantiated that alveoli are lined with a substance , surfactant, which has a low surface tension and high degree of area-tension hysteresis (Finley, et al. 1960; Clements and Tierney, 1965). This film lining the alveolar units has the ability to reduce surface tension when its area is decreased thus providing stability to the lung and permitting alveolar units to remain inflated at low trans-pulmonary pressures and to exist simultaneously in different sizes at the same transmural pressure. This stability may not always exist. When this surfactant is not moved or stretched, such as in prolonged atelectasis, a phenomenon labeled "aging" takes place, (Clements and Tierney, 1965). "Aging" is defined as the increase of surface tension when the surface film is inactive. Increased surface tension encourages collapse or a decrease in size. Since the lung follows the Law of LaPlace, the pressure-volume relationship of $P=\frac{2T}{R}$, a unit of decreased size is more difficult to inflate than one of larger size (Laver and Bendixen, 1966). This encourages reinflation of the same alveolar units of larger size. Higher pressures are needed to open a completely collapsed air space than to inflate further those that are already open; therefore, tidal breathing is associated with progressive atelectasis. The periodic deep breaths could be sufficient pressure and volume to reopen collapsed alveolar units (Hamilton, 1961).

In conclusion, atelectasis is a commonly occurring phenomenon assumed to be present to some degree in all postoperative patients (Laver and Bendixen, 1966). Atelectasis is defined as a collapse of alveoli with a decrease in lung volume, a decrease in pulmonary compliance, and an increase in venous-to-arterial shunting. Atelectasis is viewed as a continuum with the formerly recognized characteristics of obstruction, altered physical signs and radiological diagnosis being later manifestations of a progressive disease process.

Theoretical Bases for Intervening Variables

Intervening variables may affect the dependent variable of postoperative ventilatory capacity. These variables were considered in decisions concerning control, randomization, and sample selection and are discussed below as possible sources of error.

The incidence of pulmonary complications in men has been reported to be more than three times that of women (Thoren, 1954; Gordh, 1964; Bendixen et al., 1965). Reasons for this difference may be that men are abdominal breathers and have greater musulature for splinting their breathing with pain (Kurzweg, 1953; Hamilton, 1961). A more recent study found no differences in the post-operative complication rate (Latimer et al., 1971). It is believed that the increased incidence in postoperative pulmonary complications in men is primarily due to their greater smoking habits. If both men and women are heavy smokers the frequency of respiratory complications is apparently the same (Morton, 1944).

Changes in the arterial oxygen tension, alveolar-arterial difference, percentage of pulmonary shunting, diffusing capacity, lung volumes, and lung compliance occur with advancing age in otherwise normal individuals (Mellemgard, 1966; Kanber et al., 1968; Holland et al., 1968). The literature differs on whether or not age influences the development of pulmonary complications. Patients over 60 years of age have been found to have a higher incidence of postoperative pulmonary complications (Dripps and Deming, 1946; Fomon, 1957; Klug and McPherson, 1959). Dripps and Deming reported a period of maximal resistance in the 31 - 40 age group with susceptibility increasing in patients over 70 years (p. 102). In a sample of 823 surgical cases Fomon found that the incidence of all surgical complications seemed to parallel the age of patients with the greater incidence of complications occuring after 60 years of age (p. 613). Patients over 60 years of age have been estimated by one author to develop postoperative atelectasis approximately three times more frequently than those under 60 years of age (Bendixen et al., 1965, p. 35). Other authors did not find a difference in postoperative complications related to age (Marshall and Fahey, 1964; Wightman, 1968; Latimer et al., 1971). Lindeman (1972) found that age did not effect postoperative pulmonary function when preoperative teaching was provided, however, patients who were over 60 years of age did receive fewer analgesics and required longer hospitalization.

Because an obese patient who is 20 per cent overweight has a higher oxygen intake and carbon dioxide output, he has a need for a higher level of alveolar ventilation. He also usually has less expiratory reserve volume, increased rate of respiratory work for a given ventilation, a lowered arterial oxygen tension, and a disturbance in ventilation-perfusion relationships (Bates and Christie, 1964, p. 104). Said and Banerjee (1963) found an increased venous-to-arterial shunt in a sample of 12 obese patients. Obese patients have been found to have a lowered compliance of the thoracic wall and a reduction in total respiratory compliance during recumbency (Gould, 1962). Using the Metropolitan Life Insurance Height/Weight Tables as a guide for average weights several authors have found that obese patients have a higher incidence of postoperative pulmonary complications than normal patients. Klug and McPherson (1959) found that patients whose weight was 30 per cent above their ideal weight showed a marked increase in the rate of pulmonary complications. Thoren's (1954) results showed that postoperative complications in those patients weighing over 70 kilograms occurred twice as frequently as those below this weight. In another study patients who developed complications after cholecystectomy were compared with a group who had no complications. As a group those who developed pulmonary complications were more obese than the controls (Gould, 1962). In Latimer's (1971) study more of the obese patients (42 per cent) had abnormal preoperative pulmonary function tests and postoperatively 53 per cent of these patients developed atelectasis compared to 9 per cent of normal patients.

The incidence of impaired postoperative pulmonary function has been found to be as high as three times greater in those patients who smoke more than one pack of cigarettes a day (Morton, 1944). This high incidence of respiratory complications may be attributed to the fourfold increase in chronic bronchitis and cough in heavy smokers (Bendixen et al., 1965), or the fact that asymptomatic smokers have been found to have an increased functional residual capacity, alveolar-arterial difference, and venous-to-arterial shunt (Streider, Murphy, and Kazemi, 1969; Craig et al., 1971). The negative effect of smoking history on postoperative ventilatory function was not found by Pecora (1969) or Lindeman (1972). Both of these authors found no differences in postoperative changes in lung volumes or flow rates between smokers and non-smokers. In Lindeman's study this variable did not affect length of hospital stay or number of analgesics required, and in Pecora's investigation smoking was not related to postoperative return to normal arterial oxygen levels.

It is estimated that patients with pre-existing cardio-pulmonary disease or respiratory infection develop postoperative pulmonary complications 23 times more often than those with normal lung function (Bendixen et al., 1965). Stein et al., (1962) found that of the 30 patients with preoperative abnormal pulmonary function tests, 21 developed respiratory complications while only one of the 33 normal patients developed complications. A postoperative pulmonary complication developed in 100 per cent of the 13 patients who had preoperative pulmonary impairment in Latimer's study (1971). In addition to a low arterial oxygen partial pressure, patients with cardiopulmonary disease have decreased compensatory mechanisms for atelectasis and hypoxia. Patients with pulmonary disease may have excessive secretions, retention of carbon dioxide, high work of breathing, or reduced potential ventilatory compensation (Horner, 1967). Cardiac disease, whether it involves the valves, myocardium, or coronary circulation, leads to a reduction in available compensation (Bendixen and Laver, 1965). Also a reduced hemogloblin can affect the oxygen carrying capacity of the blood and, therefore, requires a compensatory increase in cardiac output (Bendixen and Laver, 1965, p. 524).

The per cent of postoperative complications has also been found to be related to the site of the operative procedure. Proximity of the surgical incision to the thorax is an important determinant in the frequency of postoperative pulmonary complications. The lowest incidence of postoperative atelectasis is found in surgery on the extremities, followed by lower abdominal surgery, and the most in upper abdominal and chest operations (King, 1933; Mann, 1949; Sands et al., 1961; Stein et al., 1962). Lindeman and Aernam (1971) and Pecora (1969) found this relationship to be true for lung volumes and pulmonary flow rates. Egbert, Laver and Bendixen (1962) measuring intra-abdominal pressure during postoperative coughing found that the ability to cough in the postoperative period is significantly greater in those patients who have had extremity operations than in those having laporatomies or hernioplasties.

Although the type of anesthesia has been found to influence the incidence of respiratory complications (King, 1933; Dripps and Deming, 1946), the duration of anesthesia seems to be more important then the specific agent or route utilized (Hamilton, 1961; Meneely and Ferguson, 1961). King found pulmonary complications in 12.4 percent of those having ether, in 16.7 per cent of those having spinal anesthesia, and in 18.4 per cent of patients having local anesthesia. Dripps and Deming found pulmonary complications in 5.5 per cent of their sample having ether and in 4.8 per cent having spinal anesthesia, however, when the same postoperative care was applied to both groups the difference in incidence disappeared. At the present time it is thought that if equal recovery room care is given and there is early awakening after carefully administered anesthesia the influence of the anesthetic agent is eliminated (Hamilton, 1961; Bendixen et al., 1965). Muscle relaxants have been shown to increase the incidence of pulmonary complications when compared with ether anesthesia (Bunker et al., 1959). However, Bendixen et al. (1965) cite present literature and believe that, "...there is little or no difference in the incidence of respiratory complications following well-matched anesthesia with and that without muscle relaxants" (p. 40). As noted previously, patients undergoing spinal anesthesia were able to cough significantly better than general anesthesia patients (Egbert, Laver and Bendixen, 1962).

The length of anesthesia does affect the frequency of complications. It has been found that if an operation lasted less than 30 minutes 5.2 per cent of the sample developed postoperative complications. This incidence increased to

26 per cent when surgery lasted 60 to 90 minutes and to 40 per cent for operations over 90 minutes (Meneely and Ferguson, 1961, p. 1075). Latimer et al. (1971) reported that 29 per cent of his patients who developed "macro-atelectasis" had operations exceeding 3.5 hours and all 8 patients whose anesthesia lasted longer than 3.5 hours developed some type of pulmonary atelectasis (p. 631).

Certain medications, if given for a period of time before surgery, reduce the circulatory and ventilatory compensations necessary for combating hypoxia. Rauwolfia alkaloids deplete to some extent the catecholamine stores of the body. Therefore, a lack of sympathetic response to hypoxia and other stimuli and a decrease in the speed and magnitude of circulatory compensatory mechanisms may occur (Bendixen and Laver, 1965, p. 534). Phenothiazines produce an antiadrenergic effect, which is greatest with chlorpromazine. "Most likely, the phenothiazines will decrease the sympathetic compensation of myocardial depression by anesthetic agents, decrease the response to exogenous catecholamines, and decrease the sympathetic compensation of myocardial depression by anesthetic agents, decrease the response to exogenous catecholamines, and decrease the sympathetic response in hypoxia..." (Bendixen and Laver, 1965, p. 524). Corticosteroids may cause circulatory collapse during and after operations. If the dosage is not increased during surgery there will be a decreased response to catecholamines and circulatory compensation will be decreased in hypoxia (Bendixen and Laver, 1965).

Premedications and analgesics, such as barbituates and opiates, are respiratory depressants which can cause a decrease in circulatory and respiratory mechanisms and promote quiet, regular breathing which has been shown to cause atelectasis. "Pain-relieving drugs, except acetysalicylic acid, cause ventilatory depression of central and peripheral origin. This causes a reduction of both minute ventilation and alveolar minute ventilation, and suppression of cough and other respiratory reflexes" (Bendixen et al., 1965, p. 39). Moderate dosages (2.5 to 5 mg.) of morphine have been found to reduce postoperative periodic hyperinflation of the lung without depression of minute ventilation or change in respiratory frequency (Egbert and Bendixen, 1964). Bunker et al., (1959) found a marked increase in postoperative atelectasis in those patients who received morphine or meperidine before surgery or during surgery if muscle relaxants were used. Atropine, a common preoperative medication, decreases respiratory secretions, however, it can also thicken them (Comroe et al., 1962). Although atropine has been found to be associated with low preoperative arterial oxygen tensions (Tomlin, Conway and Payne, 1964), this effect has not been found in other studies (Nunn and Bergman, 1964).

The effect of certain inhalation therapy procedures on the incidence of pulmonary complications remains uncertain. The clinical impression has been that patients receiving intermittent positive pressure therapy (IPPB) had a smoother postoperative course and had less pulmonary difficulty (Rudy and Crepeau, 1958; Noehren, Lasry and Legters, 1958). Two controlled studies found no apparent advantage in using IPPB prophylactically for the prevention of complications (Becker et al., 1960; Sands et al., 1961). Traver (1968) found no significant differences in vital capacity after the use of the IPPB or the rebreathing tube. Significant decreases in pulmonary complications were found by Anderson et al., (1963) when the patient was taught the use of the respirator the evening before surgery and the authors used a pressure of 20 cm. of water for 15 minutes with 2 cc. of isoproterenol in a dilution of 1:200.

The intervening variable of pain from the operative site may prevent effective deep breathing and coughing by interfering with the free movement of the chest and abdominal muscles (Bendixen et al., 1965). The pattern of ventilation in severe pain has been found to be irregular with deep breathing occuring spontaneously but being limited in depth which promotes atelectasis (Egbert and Bendixen, 1964).

Respiratory motion also may be impaired by restrictive dressings or abdominal distention which increase intra-abdominal pressure and have been reported to cause reductions in vital capacity, functional residual capacity, ventilatory compensation, arterial oxygen tension, and respiratory complications (Caro, Butler and Dubois, 1960; Bendixen and Laver, 1965: horner, 1967).

Application of Theoretical Framework to the Present Study

Nursing Theory

The concepts of observation, identification, validation, assessment, action, and evaluation included in the proposed nursing process theories were utilized in part to define the experimental teaching strategy and evaluative measures. Previously, the patient problem of decreased postoperative pulmonary function had been observed and identified. The approach or action chosen to counteract this problem was a preoperative teaching program emphasizing deep breathing and coughing after surgery. It was assumed that teaching patients to understand and apply knowledge about health and illness is one function of the professional nurse. The preoperative teaching program also included an exploratory time for assessment and validation of other patient problems and concerns. The action was evaluated by measuring certain physiological indices of the pulmonary system. Using Harms and McDonald's (1966) paradigm the present study investigated whether manipulation of the distal and proximal systems would effect the central respiratory system. The nursing intervention assigned the highest probability of success was viewed as primarily constructive and preventive and was utilized in the initial phase of the health maintenance-restoration cycle.

Teaching-Learning Theory

It is assumed that patients want to help themselves and know those things that concern them. They should have the opportunity to participate in decisions regarding their care and to understand their health problems and the treatments affecting their status on the health-disease continuum. Although levels of anxiety may be higher than usual, it is expected that patients scheduled for surgical procedures are capable of learning new behaviors. The patient as a learner is an information-processing organism who is goal-directed and uses the information in his environment to obtain these goals. It is assumed that one of his goals or needs is the need for a healthy state or survival.

Bandura's principles of modeling behavior derived from social learning were the primary resources in the construction of the teaching program of this study. The following are the major principles which served as quidelines: the nurse, seen by the patient as a person who is competent and expert in her speciality, may be influential as a model of certain behaviors; modeled characteristics that are more discernible, particularly an actual performance, will provide clearer behavior cues than a verbal description; modeling behavior must be geared to the perceptual and motor capacity of the learner; retention of modeled cues increases with overt practice; necessary responses for motor reproduction must be available; anticipation of positive reinforcement for imitating the behavior increases attention and probability of performance; vicarious reinforcement increases the performance of imitative behavior; reinforcement of the model is not necessary for performance of modeled behavior; imitative behavior acquires secondary reinforcement properties and remains in the absence of direct reinforcement.

The following principles from reinforcement theory were utilized in the development of the teaching strategy: positive reinforcement immediately following a response will strengthen the probability and frequency of desired behavior; positive reinforcers, such as, "That's Good," "You did that well," or a polite request can be powerful reinforcers for human subjects; it is generally agreed that most people have a need for survival and will be adequately motivated to maintain a healthy state; motivation may be regulated not only by intrinsic motivation, but also by environmental stimuli or anticipation of reinforcing consequences; intermittent reinforcement produces more persistent behavior than continuous reinforcement; approval is a subtle stimuli which may go unnoticed and is considered to be intermittent reinforcement; if a response pattern is absent it may be accomplished through graduated modeling with positive reinforcement or verbal instruction as to how and when to perform the behavior to be rewarded; self-reinforcement processes may operate to provide the stimulus for self-evaluation and commitment to a certain level of performance.

The concepts of individual differences, motivation, and active participation provided the following additional guidelines for the teaching program: differences between patients and the patient and the nurse must be considered; learning tends to be most permanent when the learner is motivated toward a goal or by a positive reinforcement; motivation is increased when goals are set by the learner and the material is meaningful to him; learning is more efficient if there is active participation and/or practice by the learner.

Physiological Theory

Principles derived from recent research findings related to the development of atelectasis were used to develop the independent variable and determine valid dependent variables. Atelectasis is defined as venous-to-arterial shunting with a decrease in lung volume and compliance. The most important etiological factor in the development of atelectasis has been found to be a constant tidal volume ventilation which can be reversed by a deep inspiration, therefore, deep breathing is essential to decrease the frequency of postoperative atelectasis. A physical examination, X-ray, or measurement of pulmonary flow rates are not sufficiently sensitive to detect early atelectasis, therefore, the more sensitive measurements of lung volume, hypoxemia, and percentage of venous-to-arterial shunting were chosen as additional dependent variables.

Theoretical Bases for Intervening Variables

Research findings regarding those physical or environmental characteristics which may affect postoperative ventilatory function were used by the investigator in making decisions related to the control of confounding variables. Although the true magnitude of the effect of most of the variables on pulmonary function remains controversial, all variables discussed were controlled either by the criteria for sample selection or random assignment of the sample.

CHAPTER III

REVIEW OF LITERATURE

The review of literature was confined to those studies relevant to the problem of whether a preoperative instruction program, which emphasizes deep breathing and coughing, will make a difference in surgical patients' postoperative lung function. Although several of the reviewed studies are applicable to more than one classification, the available literature is presented in the following categories:

I. Patient Compliance with Medical Regimens

II. Teaching Strategies used by Nurses

III. Patients' Active Participation and Decision-Making in their Care

IV. Programs for Prevention of Postoperative Complications

- A. Investigations concerned with external breathing aids
- B. Investigations concerned with preoperative teaching programs which emphasize deep breathing and coughing

Patient Compliance with Medical Regimens

No studies were found in the literature which were concerned with patients' compliance with preoperative instructions during the immediate postoperative period. Research on patient compliance with health recommendations has been mainly concerned with the chronically ill patient and his pattern of conforming to a specific medication regimen. Davis (1966) states that his review of the literature demonstrated a patient noncompliance range from 15 to 93 per cent. He found that at least a third of the patients in most studies failed to comply with doctors' orders. In a seemingly exhaustive review of the literature relating to patient compliance with medical regimens, Marston (1970) found little or no consistent association between compliance behavior and sex, age, race, marital status, socio-economic status, religion, or education. With the exception of a small number of studies, severity of illness and knowledge concerning the illness and treatment did not seem to increase compliance. Another investigator found, however, that the urgency of acute illness may increase compliance (Davis 1966). Compliance also seemed to be increased when a regimen was less complex and contained fewer recommendations. Marston suggests that although several investigators have recognized the importance of communication and information within the physician-patient relationship in improving compliance, the nature of this relationship has not been clearly defined with the exception of a study by Davis (1968a, 1968b). Davis used Bales Interaction Process Analysis to code 223 taped doctor-patient interactions with an average reliability of 85 per cent. A compliance index was determined ftom patients' perceptions of their compliant behavior collected during interviews, doctors' perceptions of the patients' compliant behavior, and independent review of patients' medical records. Thirty-seven per cent of the patient group disregarded the physicians' recommendations or were noncompliant. Since the Bales listing did not give significant findings an extensive factor analysis was done on the interaction categories. This suggested that the first doctor-patient visit was not associated with patient compliance, however, certain revisit interactions were associated with compliance. Noncompliance was higher when there was evident tension in the relationship, when a physician passively accepted the participation of an authoritarian patient, when the physician sought information from the patient without giving feedback, or when the physician exhibited disagreement, formality, or rejection of the patient. Compliance was more frequent when patients expressed agreement with the physician, when attempts were made to seek the physician's opinion, or when the patient was able to release tension.

The role of threat or fear in motivating health behaviors has been reported by Leventhal (1965) who illustrated that if fear communications are accompanied by practical instructions for reducing or eliminating the threat, patients' motivation to obtain diagnostic and preventive health measures may increase. This author reported that after the patient had been presented with threatening communications about his health status specific instructions seemed to be the critical factor in maintaining and increasing behavior change. The relationship of emotions to measures of compliance or acceptance is still a new area of research. It may well be an important variable affecting the compliant behavior of postoperative surgical patients who have received preoperative instructions about health care measures.

These studies illustrate that the rate of compliance is quite low. Although there seems to be a relationship between the urgency of an illness and patient compliance, other variables have not demonstrated a consistent relationship.

Patient Teaching Strategies Used By Nurses

Although patient teaching is recognized and presented in the nursing literature as one of the most important functions of the professional nurse, few systematic studies of teaching strategies utilized by a nurse in any patient care setting have been reported.

Wandelt (1954) conducted a field investigation of patients in two tuberculosis hospitals to determine the effects of a planned, coordinated program of teaching versus incidental instruction. It was hypothesized that patients participating in a planned program of teaching, in contrast to patients who received only incidental instructions, would have better knowledge and understanding of their disease, its treatment, and their own part in this treatment. The "experimental" sanatorium utilized a planned, coordinated teaching program for all patients. The patients learned about their illness in an ongoing, individualized plan of teaching conducted by department members, who used oral instructions, radio, movies and printed material to supplement the teaching program. Patients at the "incidental" sanatorium were taught by those working with them only if the health team member recognized an individual need in the medical area in which they were working. Forty patients from each hospital, matched for ten attributes, were given an open-ended interview to determine knowledge, understanding, and attitude in relation to their disease. The number of correct or satisfactory replies to each open-ended question was determined. These answers were discussed practically; and if there was a difference, the chi-square test was used to determine whether this difference was significant. Sixty-five questions showed statistically significant differences between the two groups, with the experimental group answering more questions correctly. Since this was a static-group comparison (Campbell and Stanley, 1963) there is no assurance that the groups wouldn't have differed without the occurence of the planned teaching program. The investigation does suggest, however, that the planned program may have increased the patients' knowledge and understanding of their disease.

Bowen, Rich and Schlotfeldt (1961) sought to determine whether improvement in patient well-being could be demonstrated in a group of diabetic patients who had participated in a planned program of organized instruction. Medical clinic patients who had diabetes for at least two years and were using daily insulin injections, clinitest, and a diabetic diet were matched for comparable age and duration of illness. Twenty-eight patients acted as controls while 23 experimental patients received a planned program of instruction consisting of five 45-minute periods of instruction, demonstration, and patient questions. The dependent variables were knowledge of diabetes, skill in administering insulin, use of the clinitest equipment, attitudes toward diabetes, and well being over a 6 month period. Scores were subjected to a comparison of mean gain scores. Gain in total knowledge of their disease was significantly greater for the experimental group; however, this was primarily related to knowledge of insulin and personal hygiene. There were no statistically significant differences between the two groups in knowledge of diabetes or diet exchange. The experimental group showed significantly greater improvement in self-administration of insulin. Criterion measures of patient well-being, i.e., blood sugar, urinalysis for sugar and acetone, weight, and incidence of complications, did not differ significantly. The experimental group seemed to show less fluctuation in weight and had a smaller number who were assessed as in poor control by the physician.

Dalzell (1965) attempted to determine the effectiveness of three methods of teaching prenatal care by a public health nurse. The methods consisted of classes in the clinic setting, counseling sessions in the clinic, or counseling sessions in the home. A sample of 300 subjects were randomly assigned to the three experimental groups and a control group. The specific content of the teaching program is not included. Each patient received two half hour sessions. An objective-type test of patient knowledge or prenatal care was given after the teaching sessions. It is not clear why the investigators chose not to test the groups before and after the introduction of the experimental variable in order to partially control for the variables of history and selection with a before-after design (Campbell and Stanley, 1963). The knowledge of the experimental groups was found to be significantly greater than the control group. The groups that had counseling had significantly better scores than those participating in the class method. There were no significant differences between the two groups having individual counseling.

Gimble (1968) studied the effect of a planned educational program on patients' ability to learn, understand, and adhere to an oral medication regimen and related followup care after hospital discharge. Ten hospitalized patients over 65 years of age were divided into an experimental and a control group. The control group was studied before the initiation of the planned program in order to prevent inadvertent instruction to these patients. The teaching program consisted of instructions related to medication and principles of followup care. An "oral medication box" and "daily medication record" were used. The patient was considered to have met the observable objectives of this program when he was able to use these tools. One week following hospital discharge all patients were interviewed and their behavior observed. Patients taking part in the planned instruction made fewer "errors" than those having incidental instruction. The author's definition of what constitutes an "error" is not clear in the report.

Molen (1968) used a sample of hospitalized patients with a diagnosis of stasis dermatitis, leg edema, and ulceration to study the effects of a planned teaching program. Ten patients were matched for diagnosis, ulcer location, age, and level of education and then randomly assigned to an experimental or control group. All patients participated in an initial interview during which an observation tool and a structured interview schedule were used to measure knowledge, skills, attitudes toward the disease, and the extent of venous insufficiency. The experimental teaching program consisted of three 1 hour sessions emphasizing normal circulation and the pathophysiology of venous insufficiency, treatment and self-care measures, and preventive measures. After an average of 1 week the two groups were observed and participated in the same structured interview. Responses to the initial interview were essentially the same for both groups. In the post-interview the mean scores for the control group remained the same, while there was an increase in favorable responses in all three areas for the experimental group. No findings or conclusions were reported concerning the change in the extent of ulceration measured by a modification of Verhonick's Criterion Measure for Decubiti (1961).

Elwood (1967) developed a program of breathing exercises and investigated the ways in which the patients participating in the program differed in selected ventilatory measurements from control patients. Thirty males, aged 50 to 70 years and hospitalized with chronic obstructive pulmonary emphysema, were randomly assigned. Age, smoking habits, progression of disease, and the number receiving antibiotics, bronchodilators or a combination were found to be comparable in the two groups. All subjects received IPPB therapy. The planned teaching program consisted of instructing each individual in specific breathing exercises. For a two month period the investigator and a research assistant supervised patient practice three times a day. The control patients were visited at least once a day. Ventilatory function was measured by tests of forced vital capacity, one second vital capacity, and maximal voluntary ventilation. Mean baseline values of these ventilatory tests were determined from pre-experimentation tests conducted on 4 consecutive days. The pulmonary function tests were conducted on both groups every 2 weeks for two consecutive months. No significant differences were found between the mean baseline scores and mean values at the end of the two months for any of the ventilatory tests, nor was there any significant difference between the two groups in the mean change per week. Subjective data revealed that more experimental patients reported decreased dyspnea and increased tolerance for physical activity. Since the study took one year the possible confounding effects of history and maturation should be acknowledged.

In summary, studies concerned with patient teaching strategies conducted by nurses differ in type of sample, content, methodology, and teaching setting. In most instances patient knowledge seemed to increase after patients had been subjected to teaching; however, whenever data was available, this increase in knowledge was not accompanied by a change in physiological variables.

Patient's Active Participation and Decision-Making In Their Care

Few studies guided by the specific theory of patient active participation are found in the literature. The majority of clinical investigations involving patient decision-making have questioned the effect of the "experimental nursing process" purported by Orlando (1961).

Hallburg (1969) developed and tested a decision-making model as a teaching-learning strategy. A sample of 103 older patients attending a medical clinic was randomly assigned. The experimental group met with the nurse investigator who used the decision-making approach in teaching decisions related to following prescribed medication regimens. The control group received the usual approach used in the medical clinic. The criterion measures for medication-taking behavior were the number of deviations and serious errors and the proportion of patients who deviated and made serious errors in following the prescribed regimens. The number and kinds of medication deviations were determined by comparing structured interview data and observation in the home with medical records and labels of medication bottles.

There were no statistically significant differences found between the two groups, however, the author noted that fewer experimental patients deviated or made serious errors.

Active participation of the patient in his care has been studied by Tryon (1963) and Tryon and Leonard (1964, 1965). The problem studied was whether a pre-delivery enema is more effective if the nurse elicits the patient's acceptance and cooperation. Twenty maternity patients were randomly assigned to control and experimental groups. The experimental approach was nondirective and centered on the patient's definition of the situation, while the control approach was task-centered and directive. Measured by verbal statements of acceptance and average inflow time, patient acceptance of the enema was found to be greater in the experimental group. The effectiveness of the enema was significantly greater for the experimental group with retention and fluid intake demonstrating statistically significant results. In a later study Tryon (1966) hypothesized that the principle of patient participation increasing the receptiveness and effective outcome of care would apply to other areas of nursing care and attempted to study the principle with support measures used in labor. Thirty patients were randomly assigned. The control group received the usual care. The experimental approach focused on the patients behavior, thoughts, and feelings. This approach was used with comfort measures such as, back care, positioning, and breathing control. The effect of the use of support measures and command or suggestion on patient participation was inconclusive due to the lack of the use of support measures in the control group and the infrequent use of command in both groups. In a further analysis no significant differences were found between the two groups in their response to labor, however, the experimental group's total response was consistently lower in the degree of undesirable response. Due to the number of methodological problems the authors could only suggest that active participation by women in labor may decrease their stress.

Moss and Meyer (1966) hypothesized that relief of pain in patients with moderate pain can occur as a consequence of the nurse-patient interaction, if the interaction includes the following: (1) the nurse walks to the bedside, introduces herself, and asks how the patient feels, (2) discusses the pain and various measures to relieve this pain, and (3) allows the patient to decide on the method of relief. Fifty hospitalized patients were randomly assigned to an experimental or control group. The experimental treatment differed in that these patients defined the pain relieving measure to be used (Step 3). Using questionnaire items pertaining to the level of anxiety and pain relief it was found that relief of moderate pain was greater in the experimental group. Moss (1967) extended the earlier experiment with an exploratory investigation of the effect of repeated nurse-patient interactions on pain relief. Arranged situations allowed for repeated interactions with the investigator and 13 patients. The care during these interactions consisted of the steps described above and additional processes between the nurse and the patient. Twelve patients changed their response to pain from asking for medication to requesting nursing measures for pain relief. Since this was an exploratory study using no control group, it is difficult to ascertain whether these changes in behavior were due to the extended nurse-patient interactions or a confounding variable.

Bender (1968) studied the effect of experimental nursing support on the incidence of vomiting and level of distress during labor. In the first experiment 12 patients were randomly assigned. The experimental group was cared for by the research nurse who concentrated on the mother's behavior and attempted to help the mother become an active participant in her care. The control group was cared for by the regular nursing staff. Four non-participant observers used schedules to collect data on the type of verbal interactions between nurse and patient, the categorization of distress, time spent with the patient, recent food ingestion, medication administration, and incidence of nausea, retching, and vomiting. These observers reached a 95 to 100 per cent agreement for the rating of distress and frequency of vomiting, and 70 per cent agreement for the classification of nurse statements in trial interactions. Statistically significant differences were not found for the distress index or incidence of vomiting; however, nausea, retching, and vomiting occurred only in the control group. A second experiment was conducted using the same methodology except that before a random start 30 patients were matched for primigravidae or multigravidae. Significantly more control patients experienced retching or vomiting. With an improved coding of distress, the experimental nursing approach was found to reduce patients' distress more frequently. Twenty-seven per cent of the experimental patients compared with 67 per cent of the control patients were categorized in the highest distress classification. Patient interviews conducted 12 to 48 hours after delivery seemed to indicate that the experimental patients were more satisfied with the approach they received.

Chapman (1970) compared the effect of three different preoperative nursing approaches on the reduction of patient anxiety during a surgical experience. The individualized approach was characterized by the nurse being aware of the patients' problems, encouraging verbalization of fears and concerns, and attempting to alloy fears by stimulating the patient's active participation in dealing with his problems. The informative approach was that in which the nurse provided detailed unsolicited information about the total perioperative experience. The routine approach was that given by the regular nursing staff. A sample of 53 men undergoing inguinal herniorraphy were randomly assigned. Age was found to be significantly different in the three groups and was covaried when necessary. One group received individualized care for a 25 minute period the evening before and after surgery. The second group received informative care preoperatively for 25 minutes and was given 25 minutes of individualized care after surgery. The third group acted as controls and received only routine care. Tape recordings of the nurse-patient sessions were subjected to two judges' assessments of whether the particular approach was realized. The interrator reliability was 90 per cent for preoperative interactions and 58 per cent for postoperative interactions. Several criterion measures were used to define the dependent variables of psychological responses to stress, physiological responses to stress, and patient welfare. There were no significant differences in the level of anxiety as measured by Zuckerman's Affect Adjective Check List. Physiological responses to stress, plasma nonesterified fatty acids and circulating blood eosinophils, showed no significant differences. The patients' required analgesics, sedatives, and length of hospitalization were used to measure patient welfare. There were no significant differences found between the three groups in the number of sedatives required. The individualized and informative groups required significantly less analgesics and a significantly shorter hospital stay than the control group. It is interesting to note that there were no significant differences in any of the criterion measures between the informative and the individualized approaches.

A number of studies in the literature have examined the effect of Orlando's (1961) experimental nursing process. These investigations are included in this review because they demand decision-making, responsibility, and active participation on the part of the patient.

Dumas and Leonard (1963) studied the effects of greater patient involvement on postoperative patient welfare with a sample of 51 gynecological patients who were randomly assigned. The authors hypothesized that the experimental process would reduce the incidence of postoperative vomiting. The investigators used the process interaction suggested by Orlando to help the experimental patients attain a suitable psychological state for surgery. The process involved; "...(a) The nurse explores with the patient her observations of his behavior to determine whether he is experiencing distress. (b) The nurse explores further to find out what is causing the distress and to determine what is needed to relieve the distress. (c) The nurse uses the information elicited in the first two steps to select an appropriate course of action to relieve the distress. Following this action, (d) the nurse checks with the patient to ascertain whether this course of action did in fact relieve the patient's distress" (1963, p. 12). . The control group received the usual care by the hospital staff which was described as "task" oriented. Those who received this experimental nursing process had a statistically significant lower rate of postoperative vomiting than those patients who received the usual preoperative preparation from the hospital staff.

Elms (1964, 1965) conducted an exploratory study of the effect of three nursing approaches on patient stress indicators during the admission process to a large general hospital. On admission 30 gynecological patients were randomly assigned. One group received the experimental nursing approach defined by Orlando (1961). Acting as controls, the two other groups received either a nursing approach which allowed the patient to discuss whatever he wished, or the routine approach given by the usual nursing staff. Systolic blood pressure, pulse rate, and a post admission interview were used to measure the relief of stress and were measured before and after the admission procedure. A statistically significant greater reduction in the pulse rate was found for the experimental group. There were no differences in pulse rate between the two control groups. Although the results were in the predicted direction, no statistically significant differences were found between the three groups for changes in systolic blood pressure from before the admission procedure to after the procedure. An interview administered 2 to 5 hours after admission suggested that a greater percentage of patients in the group receiving the experimental approach were relieved of distress and satisfied by the nursing approach. Respiratory rate and temperature were added to the list of criterion measures used to define "patient distress" and an attempt was made to increase the reliability and validity of the independent and dependent variables in a later study of admission procedures by Elms and Leonard (1966). Seventy-five female patients admitted for gynecological surgery were assigned to one of three groups by block randomization. The three approaches previously described were used in this study as independent variables. The review and agreement of tape recorded transcripts by three judges and the patient's perceptions of the nurse's behavior on admission obtained from interviews were used to evaluate the validity and reliability of the three approaches. A non-participant observer recorded the physiological measurements. The patients' perceptions of the hospitalization and admission procedures were obtained in a structured post-admission interview conducted by an assistant unaware of patient assignments. The change in blood pressure from before to after the admission procedure for all three groups was not in the expected direction. Pulse rate did decrease, however, significant differences were found only between the experimental approach group and the control group admitted by the nurse investigator. Changes in respiratory rate showed significant differences between the two groups admitted by the research nurse and the group admitted by the nursing staff, but no differences were found between the two groups admitted by the nurse investigator. There were no significant differences in temperature change between the three groups. In the post-admission interviews more patients in the group receiving the experimental approach by the research nurse stated that the nursing care was the reason for relief of their pre-admission distress and that their expectations about nursing care had been surpassed. All groups expressed equal satisfaction with the admission procedure.

Greater nurse-patient communication and involvement of the patient in his care was studied by Anderson, Mertz, and Leonard (1965). The authors hypothesized that an experimental nursing process would have a greater positive effect on patient welfare during hospital admission than the usual task centered approach. Two experiments were conducted, one in the emergency room of a general hospital and one in a state mental hospital. Twenty-two patients in each study were randomly assigned. The nurse investigator cared for the experimental patients and used the experimental nursing process outlined by Orlando (1961). The control approach practiced by the regular nursing staff was described as task-oriented and less deliberate. Patient welfare was measured by changes in systolic blood pressure, pulse rate, and behavior indicating decreased stress. The measures were recorded after the patient entered the hospital and at the end of the admission procedure. The changes in behavior from before to after admission were evaluated for stress ranking by four judges. In both hospitals, the experimental groups had statistically significant greater decreases in mean systolic blood pressure than the control group. The pulse rate showed a statistically significant difference in the mean decrease between the two groups in the general hospital, but the difference in the mental hospital, although in the expected direction, was not significant. The change in the behavior distress index was statistically significant in both studies, with a greater decrease in stress for the general hospital experimental group.

In summary, the few studies investigating the effect of active participation of the patient in his own care vary greatly in settings, samples, controls, criterion measures, and findings. The results seem to indicate that giving the patient an opportunity to express his needs and to help in meeting these needs may have a positive effect on patients' physical and psychological welfare.

Programs for Prevention of Postoperative Complications

Complications following surgery continue to be a major health problem. Health professionals have adopted a variety of pre and postoperative measures which have been assumed to decrease these complications. Early ambulation, prophylactic antibiotics, breathing exercises, intermittent positive pressure on inspiration (IPPB), rebreathing of carbon dioxide and endotracheal suctioning are some of the varied techniques that have been used to decrease pulmonary complications. The literature, however, contains only a small number of systematic patient-centered studies concerned with planned treatment programs to prevent complications.

Investigations Concerned With External Breathing Aids

The following studies are representative of those investigations that have focused on the effect that external breathing aids may have on the incidence of pulmonary complications.

Becker et al. (1960) studied the effect of IPPB on the frequency of post-operative pulmonary atelectasis with a sample of 100 consecutive patients undergoing upper abdominal surgery who were alternately assigned to an experimental or control group. Both groups were found to be similar in sex, age, method and duration of anesthesia, and type of surgical procedure. The control group received no IPPB treatment. IPPB was administered to the experimental group once before surgery and 2 to 3 times daily for three postoperative days. A 40:60 oxygen-air mixture at a pressure of 10 to 15 cm. with 0.25 cc. of 1:200 isoproterenol and 2 cc. of alevaire were used for the treatment. There is no mention of the teaching strategy used by the trained technician who gave the treatments. Both groups received early ambulation, encouragement to cough and deep breathe, and instruction in moving from side to side. Appearance of atelectasis on chest X-ray taken on the first and fifth postoperative day was used to measure the effect of the treatment. It is not stated whether a preoperative X-ray was taken for baseline pulmonary status. There was no difference between the two groups in the incidence of atelectasis. Although all patients apparently received some encouragement and instruction to cough, deep breathe, and ambulate early, 51 per cent of the subjects still developed postoperative atelectasis on X-ray.

Sands et al. (1961) did not find significant differences in postoperative pulmonary function after the use of IPPB. Upper abdominal surgical patients were alternately assigned to treatment and control groups with each group consisting of 42 subjects. The IPPB treatment for the experimental group was begun within the first hour after surgery by a member of the inhalation therapy department. In a specified interval schedule for approximately four postoperative days a 40:60 oxygen-air mixture at a pressure of 15 cm. of water nebulized with tergemist was given for 10 minutes. A therapist was in attendance during the treatments and encouraged the patients to make a maximum respiratory effort, which was reported to be frequently unsuccessful due to the patient's pain. Chest X-rays, spirograms, and physician cardio-respiratory evaluations were conducted pre and postoperatively.

There were no differences found between the two groups in the frequency of postoperative pulmonary complications, time of return to normal vital capacity or timed vital capacity, days of hospitalization, or day of ambulation. The authors did not refer to a specific teaching strategy except for the therapist's request for maximum respiratory effort. The reason for the lack of preoperative administration of the respirator treatment was not discussed.

Anderson et al. (1963) attempted to determine whether IPPB would reduce the incidence of postoperative pulmonary complications. The sample consisted of 42 experimental and 160 control subjects. All patients underwent general anesthesia, were operated on by the same surgeon, and received the same pre and postoperative care except for the IPPB treatment. There were no statistically significant differences in sex, anesthetic, duration of surgery, type of operation, or pulmonary status between the groups, however, there was a significant difference between the two groups in those older than 60 years. The experimental group received instruction in IPPB therapy the day before surgery. The type of health personnel conducting the teaching is not reported. The treatment was continued immediately after surgery three times daily for 4 days. A 40:60 oxygen-air mixture was administered at a pressure of 20 cm. of water for 15 to 20 minutes with 2 cc. of isoproterenol at 1:200 dilution. The effectiveness of the treatment was measured by the frequency of pulmonary complications and the rate of return to preoperative values for the maximum breathing capacity and vital capacity. Pulmonary complications were measured by a surgeon's physical examination and the development of elevated temperature, pulse rate or presence of cough. Patients having clinical symptoms were subjected to chest X-rays for confirmation of the complications. The number of complications was significantly smaller for the experimental group with only one patient in the experimental group developing complications. However, while only 46 per cent of the treated group had maximum breathing capacities greater than 60 per cent, 82 per cent of the control group had capacities at or above this level. This difference was probably related to age. The authors attributed the significant differences found in this study to the use of a bronchodilator and pressure in excess of 15 cm. of water for a period of 15 to 20 minutes.

Traver (1968) compared the effect of two treatments, IPPB and the rebreathing tube, on tidal volume, incidence and productivity of coughing, and degree of autonomic activation. With a 2 hour interval separating the treatments, a sample of 20 abdominal surgical patients received both treatments in random order during the first 36 hours postoperatively. The IPPB treatment was a 40:60 oxygen-air mixture nebulized with saline at a pressure of 15 cm. of water for 15 minutes. The Dale-Schwartz rebreathing tube was administered for 3 to 5 minutes. The author does not mention whether the patients received preoperative instruction or if there was any attempt to control for intervening variables. The dependent variables were measured before and during the treatments. A significant increase in tidal volume was found for both procedures from before to during the treatment; however, this increase was not significantly different for the two treatments. Both the incidence and productivity of coughing were recorded as present or absent and were found to be significantly greater during the administration of the rebreathing tube. There were no significant differences between the two treatments in autonomic activation measured by the palmar sweat index. Vital capacity was measured in six patients before and after the treatments with no significant change found in this volume either after each treatment or between the two treatments.

In summary, only Anderson et al. (1963) found a decrease in pulmonary complications with the use of IPPB. The effects of IPPB therapy vary greatly with the type of nebulized medication, length of administration and amount of pressure. These investigations seem to give little attention to the variables that may promote the acceptance and subsequent effectiveness of the treatment for the patient, such as motivation, individual needs, readiness, feedback, or actual amount of patient understanding.

Investigations Concerned With Preoperative Teaching Programs Which Emphasize Deep Breathing And Coughing Exercises

Palmer and Sellick (1952) compared the effect of procaine penicillin and breathing exercises on the frequency of postoperative pulmonary complications. A sample of 160 males admitted for inguinal hernia repair were randomly assigned to four groups. Group 1 received 300,000 units of procaine penicillin intramuscularly twice before and 5 days after operation. Group 2 received both the penicillin regimen and breathing exercises twice daily for 5 days; starting 48 hours before the operation. Group 3 received only the breathing exercises. Group 4 acted as the control group and received none of the interventions. The specific teaching strategy or type of responsible personnel is not included in the report. Chest X-rays were taken on admission and after operation; it is not stated how long after operation these were taken. Definite X-ray abnormality, fever, cough, and sputum were used as evidence of pulmonary complications. No statistically significant differences were found in either X-ray abnormality or duration of postoperative symptoms between any of the four groups. In contrast to Thoren's study (1954) which used any abnormality of the X-ray as evidence of pulmonary complications, this study required definite findings of atelectasis. It is now known that atelectasis may occur without radiological evidence.

In two later investigations, Palmer and Sellick (1953) studied the effect of a variety of preventive measures on the incidence of atelectasis seen on X-ray. In the first study 180 males admitted to the hospital for inguinal herniorraphy or partial gastrectomy were randomly assigned to two groups. One group received postural drainage with clapping and vibrating and inhalation of 1 ml. of 1 per cent isoprenaline before and after surgery. The other group received only breathing exercises before and after operation. All patients were given procaine penicillin before and after surgery. The exact procedure for administration of the isoprenaline and postural drainage is described in the report. Briefly, in the preoperative period inhalation of isoprenaline was followed by 20 minutes of postural drainage with vibrating and clapping three times a day. This treatment was continued until no sputum was produced after tipping the patient. Postoperatively, isoprenaline inhalation was begun when consciousness was regained and postural drainage when the general condition of the patient permitted. Each of these treatments was administered every 6 hours for at least 5 days and until no sputum was produced on tipping the patient. The effect of these treatments was measured by changes in X-ray taken before and after surgery. It is not stated when the postoperative X-ray was taken, however, it is inferred that this was within the first 24 hours postoperatively, since the X-ray was portable and the authors noted that atelectasis is most likely to develop in the first 24 hours. X-rays were read by a radiologist, who was unaware of the treatment groups and accepted only definite evidence of atelectasis. The frequency of segmental atelectasis was found to be significantly less in the group receiving isoprenaline inhalation and postural drainage than in the group receiving only breathing exercises. In a second study to determine whether postural drainage with clapping and vibrating alone, or isoprenaline inhalation alone was effective in preventing atelectasis 160 males hospitalized for inguinal herniorraphy or partial gastrectomy were randomly assigned to four groups. Before and after operation Group 1 received isoprenaline inhalation, Group 2 received both isoprenaline inhalation and postural drainage, Group 3 received only postural drainage, and Group 4 received only breathing exercises. All patients were given procaine penicillin and were examined radiologically before and after surgery. Statistically significant differences in frequency of segmental atelectasis were found between Group 2 and the other groups. The combination of both postural drainage and inhalation of isoprenaline decreased the incidence of segmental atelectasis, however, neither of these treatments alone was more effective than breathing exercises in preventing the complication. The variables of anesthesia, analgesics, location of patients, teaching content and strategies, or the type of health team member administering the variety of treatments were not discussed in these reports.

Thoren (1954) studied the effect of a physiotherapy program on the incidence of postoperative pulmonary complications. Over a one year period 343 cholecystectomy patients were randomly assigned to three groups. The treatment program included diaphragmatic breathing on both sides, cough exercises with wound support, and postural drainage. Group 2 received this treatment once or twice daily after the operation for 4 days unless X-rays or complications necessitated treatment for 2 to 4 more days. Group 1 received the same treatment as Group 2 with the exception that their treatment was initiated 2 days preoperatively. Group 3 acted as controls and did not receive the physiotherapy. The physiotherapeutic treatment was primarily done by physiotherapists, although nurses were also instructed to help the patients practice the exercises several times a day. No mention is made of a specific teaching strategy except that the patients "practiced." All patients received chest examinations before surgery and again on the fourth or fifth postoperative day. Changes in X-ray demonstrating pulmonary complications, elevated temperature, and length of hospitalization were used to measure pulmonary status postoperatively. The investigator considered even the smallest changes in the X-ray as pulmonary complications. When no physiotherapy was given in the control Group 3, 42 per cent of the patients had radiographic evidence of either atelectasis or pneumonia. This incidence was reduced to 27 per cent when physiotherapy was given after surgery in Group 2 and to 12 per cent when physiotherapy was given before and after surgery in Group 1. Thus, the percentage of complications was significantly lower in Group 1 than in the control group. Significant differences in temperature elevation were also found between Group 2 and the control Group 3, but no significant differences in temperature were found between the groups receiving treatment. No significant differences were found in length of hospitalization. The author reported the effect of age, sex, and weight on pulmonary complications. Although this investigation lacked adequate control of a variety of confounding variables, as a beginning clinical exploratory study it does suggest that preoperative and postoperative breathing exercises with postural drainage influence the postoperative status of the pulmonary system.

White and Ussher (1961) reported the effect of a pre and postoperative assisted method of coughing on the need for endotracheal suctioning. Preoperative patient instruction included demonstration of the site of the chest incision, methods for splinting the incision, and explanation of the importance of deep breathing and coughing. All patients received analgesics and medicated inhalations to facilitate coughing. The teaching program combined with manual splinting was used with

150 thoracotomy patients over a one year period. It was found that this planned cooperative program carried out by the physicians, physical therapists and nursing staff decreased the need for postoperative endotracheal suctioning. The criterion measures used in determining the need for endotracheal suctioning are not clear in the report.

A planned program of preoperative instruction was conducted by Withum (1963) to investigate its effect on active participation in postoperative activities. Two patients with a diagnosis of bronchiectasis admitted in sequence to the hospital for thoracotomy procedures were subjected to the program. The content and strategy of the teaching program are well defined and included the demonstration and patient redemonstration of coughing; diaphragmatic and segmental breathing; arm, shoulder, and leg exercises; and positioning. Although the information was not initially in the teaching plan, the patients were informed of the postoperative use of an oxygen tent, chest tubes, and possible discomforts. The instructions and practice were given daily in three 1 hour periods beginning 2 days before surgery and ending at the time of discharge. Active participation was measured by the patients' postoperative ability to cooperate in performing selected extremity exercises, to begin breathing exercises at the desired time, and to cough forcefully. Degrees of exercise activity, cooperation, and characteristics of the coughing ability were recorded on a guide for appraisal developed for the study. After each execution of the selected activity by the patient the investigator recorded her observations on this guide. Postoperatively, both patients were able to cooperate in performing exercises, beginning diaphragmatic breathing at the time proposed, and coughing forcefully even with pain; however, segmental breathing exercises had to be postponed to a later time than expected for both patients. Despite active participation in this vigorous program, one patient developed postoperative complications. The value of this study emerges from the almost complete lesson plan for teaching patients the principles of coughing, deep breathing, and extremity exercise. It must, however, be viewed as a one-shot case, which is lacking in control or comparison except for inferences that can be made from past experience (Campbell and Stanley, 1963).

Egbert et al. (1964) studied the effect of instruction, suggestion, and encouragement on postoperative pain. Patients hospitalized for elective abdominal operations were randomly assigned. Fifty-one control patients were visited by an anesthetist who explained the preparation for anesthesia, duration and time of operation, and recovery room but did not mention postoperative pain. Forty-six patients in the experimental group received this information and additional "special care". These patients were informed "...where they would feel pain, how severe it would be and how long it would last and reassured that having pain was normal after abdominal operations" (p. 825). They were also advised as to the reasons for the pain, methods of pain alleviation, ways of turning and relaxation, and the use of the trapeze. The experimental group was visited postoperatively until they no longer required narcotics. During these visits the anesthetist reiterated his teaching, listened to their breathing while encouraging deep breathing, and reminded them to request medication whenever they were not tolerably comfortable. The number of narcotics needed, discharge time, and observations by an independent observer were used as criterion measures. Statistical differences between the two groups were not found in the amount of narcotics used on the day of operation; however, for the next 5 days the experimental group did require significantly less narcotics. The experimental subjects were discharged an average of two and seven-tenths days earlier than the control group. This finding was statistically significant. The independent observer grading the pain of the patients found the experimental patients to be more comfortable and in better physical and emotional condition. The type of observations constituting these categorizations is not clear. Since pain perception differs with each patient it might be questioned how the anesthetist could adequately know the severity, location, or time period of the pain experience for each individual to assure him of these variables preoperatively.

Reiker (1967) investigated the effect of preoperative planned instruction on patients' postoperative responses to deep breathing and IPPB therapy. It was questioned whether the experimental program of instruction decreased postoperative resistance to the treatments, increased patient participation, or resulted in a more rapid return to preoperative vital capacity levels. Six upper abdominal surgical patients were alternately assigned to experimental and control groups. There is no mention of control of high risk variables. During three preoperative visits by the nurse investigator the experimental patients were given a list of principles and explanation concerning the respirator and practiced deep breathing exercises. The control patients were visited by the investigator, but were only told that they would be required to have respirator treatment and to breathe deeply after surgery. Postoperatively, the experimental patients progressed more rapidly to their pre-operative baseline vital capacity than the control group and their average vital capacity after the respirator in the immediate postoperative period was higher than the controls. Postoperative resistance was measured by the frequency of negative comments. The experimental patients voiced only six negative comments during 3 postoperative days, while 26 negative comments were made by the control group. Active participation was measured by the subjective observations of the investigator who felt that active participation was promoted, since in her opinion the experimental patients seemed more concerned and responsible in taking the respirator treatments even with obvious pain. It also seemed to the investigator that the experimental patients developed more trust in the investigator and were less reluctant to vary their postoperative therapy. Although this exploratory study utilized a small sample and lacked adequate controls, measurement, and reliability, it does suggest that there may be a correlation between the amount and quality of preoperative teaching and the frequency with which patients actively participate in postoperative measures designed to prevent pulmonary complications.

The effects of preoperative instruction and followup on patients' postoperative recovery was studied by Healy (1968). Over a four month period 181 patients hospitalized for elective surgery were given a planned program of preoperative instruction with postoperative followup. The 140 control patients admitted on particularly busy evenings were given the same care and reassurance, but did not receive the instructions. The experimental teaching program consisted of instruction in deep breathing techniques, body mechanics, leg exercises, and explanation of medications and drainage tubes. Postoperative followup included family conferences, regular use of analgesics, deep breathing, and ambulation scheduled according to the condition of the patient. The effectiveness of the experimental program was measured by the number of required narcotics, length of hospitalization, and frequency of complications. More experimental patients received oral narcotics earlier in the postoperative period. Compared with three control patients, 135 experimental patients went home 3 to 4 days prior to the expected date of discharge. Three experimental and 16 control patients developed complications. This exploratory study lacks adequate controls and reliability; however, until recently it was the one example of a nursing study which suggested that preoperative instruction with postoperative followup may effect patients' rate of complications and need for analgesics.

Mezzanotte (1970) developed a preoperative instruction program for small groups of patients. In a 30 minute class the evening before surgery six groups of 4 patients were instructed in the technique of deep breathing, coughing, and exercising; control of pain; activities that would facilitate recovery; and hospital policies concerning these patients. The classes were supplemented with an instruction sheet and time for patient questions. The effectiveness of the program was measured with an interview conducted by the same investigator usually 5 to 7 days following surgery. Twenty-three patients stated that the group instruction had been beneficial and 15 subjects felt that they had gained the ability to participate in postoperative activities. Twelve patients stated that they "had received answers to their questions," while the same number believed this instruction had helped them to learn how to improve their recovery. Two patients stated that the sessions had lessened their anxiety. Possible experimenter bias and the use of a one-shot case (Campbell and Stanley, 1963) limit the results of the study.

Collart and Brenneman (1971) evaluated the effectiveness of the following four deep breathing methods: IPPB with a 40:60 oxygen-air mixture nebulized with saline for 10 minutes at a pressure of 15 cm. of water; blow bottles requiring displacement of 900 cc. of water; the Dale-Schwartz rebreathing tube for 3 minutes with 4 liters of oxygen added to the distal end of the tube; and 10 consecutive deep breaths interrupted by a 1 minute rest taken by the patient. Preoperatively a sample of 24 thoracotomy patients practiced coughing and the four methods of deep breathing. Then the subjects were randomly assigned to one of 24 possible treatment combinations. When the patient was awake and his vital signs stable he received each treatment at

1 hour intervals. Significant confounding variables were recorded, but not controlled. It is noted that analgesics were administered before the treatments, however, the type and amount is not specified. Effectiveness of the treatments was measured by the differences in tidal volume before and after treatments; cough productivity, which was evaluated by lung sounds and frequency of secretions; and the presence of involuntary, uncontrolled coughing. Analysis of tidal volume demonstrated a statistically significant difference between the IPPB and the rebreathing tube with the rebreathing increasing the volume more. However, when analysis of covariance was used to determine the differences in improving tidal volume there were no significant differences between the four methods. There were also no significant differences found between the treatments in their ability to increase the incidence of productive or involuntary coughing, and there was no cumulative effect of the treatments on the amount of tidal volume or involuntary coughing.

Lindeman and Van Aernam (1971) compared the effect of structured and unstructured preoperative teaching upon postoperative ventilatory function. A static group pretest-posttest design was used with a sample of all surgical patients, 15 years and older, who were admitted over two 1 month periods in the same year for elective surgery (except EENT patients). None of the patients received IPPB therapy and the variables of sex, age, and incision site were not significantly different in the two groups. There is no mention of whether the preoperative pulmonary function tests or the smoking patterns were the same for the two groups. The 135 control patients received unstructured preoperative teaching administered by the staff nurses prior to initiation of the structured program. The unstructured teaching was described as a few inconsistent and vague general statements about deep breathing and coughing. Five months later 126 patients in the experimental group received structured preoperative teaching administered by nurses who were regularly assigned to the units and had participated in a retraining program concentrating on areas of respiratory control, teaching principles, and the stir-up regime. The structured teaching, which consisted of 24 sound slides giving the importance of and instructions in diaphragmatic breathing, effective coughing, turning, and leg exercises, was given the evening before surgery either individually or in groups. Patients were encouraged to return the demonstration and were given a pamphlet explaining the instructions. Postoperative pulmonary function was measured by the differences in ventilatory function tests administered preoperatively and 24 hours postoperatively, the length of hospital stay, and the number of analgesics required. The lung function tests were administered by the staff of the respiratory therapy department. Since the t test values for significance of the difference between means for the vital capacity, one-second forced expiratory volume, and maximum expiratory flow rate showed a significantly greater gain for the experimental group after surgery the hypothesis that structured preoperative teaching will significantly increase the surgical patient's ability to cough and deep breathe was accepted. The t value obtained for length of hospital stay was also significant with a shorter stay for the experimental group; therefore, the hypothesis that structured preoperative teaching will reduce the average length of hospital stay was accepted. The t value for mean number of analgesics administered was not significantly different between the two groups. This investigator questions why the authors did not utilize the available data to include the dependent variable FEV_1/FVC%, a significant measure of flow rate. Since the research was conducted on the two groups at different times during the year the effect of the internal variable of history, which may have included changes in personnel, differences in postoperative nursing care or differences in measuring devices, must be considered in reviewing this investigation. There is no mention of the number of surgical wards utilized or of staff nurses conducting the instruction program.

In a more recent investigation Lindeman (1972) compared the effects of group and individual preoperative instruction on ventilatory function, length of hospitalization, number of required analgesics, and length of learning time. Using the same selection criteria as in the previous study, over a 15 week period all surgical patients admitted to a general hospital during the same week were randomly assigned as a group to either individual or group instruction. It is unfortunate that since many of the patients did not meet all the criteria during their hospitalization, the sample of 351 patients was only half of the number initially instructed. The instructional content was the same for both groups and did not differ from that described in the first study. The teaching process is described fully in the report and was the same for the two groups except that individual instruction was on a one-to-one basis in the patient's room. With a second session included for practice of exercises this process seemed to emphasize more patient redemonstration than in the previous investigation. Thirty-one nurses from five surgical units were retrained in the stir-up regime and provided the instruction. The same tests as in the previous study, i.e., vital capacity, one-second forced expiratory volume, and maximum expiratory flow rate, were used to measure pulmonary function. These tests were administered by the respiratory therapy department preoperatively before the instruction and 24 hours after surgery. There were no significant differences between the two groups in the change in pulmonary function tests, length of hospital stay, or number of analgesics required. Length of learning time, defined as the practice time necessary for successful performance of the exercises, was significantly less for those patients receiving group instruction. There is no mention of the criteria used to measure "successful" performance of the exercises. The author used a 2 x 2 x 3 x 3 factorial experiment to provide data on the main and interactional effects of age, smoking, and site of incision. Contrary to that reported in the literature (Dripps and Deming, 1946; Klug and McPherson, 1959; Bendixen et al., 1965), age did not significantly affect postoperative ventilatory function; however, subjects 60 years and older did require a significantly longer hospital stay and significantly fewer analgesics. This may reflect the health professional's pattern of behavior to order fewer analgesics and to require a longer hospitalization for older patients. The finding that smoking history had no significant effect on any of the dependent variables also differs from that described by Morton (1944) and Bendixen et al., (1965). The site of incision was found to significantly affect the ventilatory function and need for analgesics. As presented in previous literature (Stein et al., 1962; Sands et al., 1961), upper abdominal patients had the lowest ventilatory function scores and received more analgesics than lower abdominal patients, who received more analgesics and had lower ventilatory scores than patients having "other" surgery. Since 31 staff nurses conducted the instruction program it would be of value if the author had included more information relating to the reliability of the independent variable. Since the investigator had such a large sample and staff available to her for this study, it is regrettable that she did not use more precise measures of pulmonary status to evaluate the presence of atelectasis, such as, X-ray, arterial blood gases, or venous-to-arterial shunting.

Berecek and Janson (1972) investigated the differences in postoperative lung function and performance of coughing and deep breathing exercises between:

1) patients who received preoperative teaching, 2) patients who received preoperative teaching and positive suggestion during level three of recovery from anesthesia, and 3) patients who were taught only during level three of recovery from anesthesia. A sample of 52 surgical patients between the ages of 16 and 70 were stratified on the basis of sex and type of surgery and randomly assigned to one of the three treatment groups. Expected length of postoperative hospitalization, previous teaching of coughing and deep breathing, and IPPB therapy were controlled by selection. There were no significant differences in age or smoking pattern between the three groups; however, there were significant differences between the three groups in preoperative lung volumes and flow rates with a predominance of abnormal lung function in the group taught only during level three of recovery. The first group received preoperative instruction in taking a deep breath and coughing after a deep breath. They were advised to perform these exercises whenever the staff requested. The second group received this instruction plus positive suggestion during recovery from anesthesia, which consisted of a statement repeated three times that upon waking they would take a deep breath and cough when the staff instructed them to do so. The third group received the same instruction as the first but only during level three of recovery from anesthesia. Postoperatively, when the patients were fully awake, they were asked to perform the exercises. Lung volumes and flow rates were also obtained. Performance of the exercises was evaluated on the basis of inclusion, manner, and sequence of the steps previously taught. Interobserver reliability of the two investigators in rating the performance of the exercises was reported as 100 per cent. The patients were also evaluated on the fourth postoperative day. Lung volumes, flow rates, chest X-ray, temperature pattern, lung sounds, presence of cough, respiratory rate and necessity for external breathing aids were

recorded. No statistically significant differences were found among the three groups in the preoperative to postoperative change in flow rates (one second forced expiratory volume, maximal mid-expiratory flow rate, and maximum expiratory flow rate), the presence of infiltrates on X-ray, or performance of the coughing and deep breathing exercises. As suggested by the authors, it is unfortunate that there were differences in preoperative lung function between the three groups and that the study lacks a control group with no teaching. If the authors had included a control group that at least was receiving the "usual" preoperative nursing care this study would have been a valuable approximate replication of the studies by Healy (1968) and Lindeman and Van Aernam (1971). The implication of this study that patients can be taught and perform exercises just as efficiently during times other than the suggested preoperative period is a significant one.

In summary, there have been few systematic, controlled studies of the effect of preoperative instruction of deep breathing and coughing exercises on pulmonary complications with most authors relying on the results obtained by Thoren (1954). Recently studies have advanced from the exploratory stage with the length of hospitalization or required analgesics as the major dependent variables to more controlled experimental or quasi-experimental investigations using lung volumes and flow rates as additional criterion measures. The majority of these studies have found that a breathing exercise program does have a positive effect on a variety of criterion measures used to assess the patient's physiological status postoperatively. Although the studies by Lindeman and Van Aernam (1971) and Lindeman (1972) may lack rigid laboratory controls and completely reliable interventions, at the present time they seem to be the most significant clinical studies in this area and the most convincing arguments for the value of preoperative instruction.

CHAPTER IV

METHODOLOGY

The problem for study was to determine if there were differences in post-operative ventilatory capacity between elective upper abdominal surgical patients who experienced a teaching program emphasizing deep breathing and coughing and those who received the nursing approach currently used. This problem was examined by measuring variables commonly used in the physiological assessment of a patient's pulmonary system. Both the mechanical and gas exchange capabilities of the lung were determined by using the variables of lung volume, flow rate through the airways, and the partial pressures of oxygen and carbon dioxide. The additional variable of percentage of venous-to-arterial shunting was used in order that the exact physiological mechanism causing hypoxemia could be determined. Although there are other variables which could have been used to measure the effect of teaching patients on postoperative ventilatory capacity, these variables were chosen because they were the most valid criterion measures available to the investigator for determining the postoperative status of the pulmonary system.

The chapter begins with the definition of terms. The methodological problems are described in the sections on criteria for sample selection; criterion measures and instrumentation; and procedures. The validity and reliability of the design and the independent and dependent variables are then discussed. Finally, the limitations of the study and the type of statistical methods chosen for the data analysis are presented.

Definition of Terms

Elective Upper Abdominal Surgical Patients: patients admitted for previously scheduled operative procedures at the participating agency from September 8, 1971 to January 16, 1972. The operative procedures included in this category were: cholecystectomy, gastric resection, gastrostomy, aortic aneurysm, splenectomy, hiatus herniorraphy, ventral herniorraphy, vagotomy, bowel resection, abdominal perineal resection. This categorization is similar to that used by Lindeman and Van Aernam (1971).

Differences: dissimilarities in postoperative ventilatory capacity that are found to be significant for a two-tailed test at the .05 level by appropriate statistical testing.

Teaching Program Emphasizing Deep Breathing and Coughing: a teaching-learning strategy designed to facilitate the active participation of the patient in his care using the processes of modeling, demonstration, and reinforcement. It is a set of actions that engage the learner in a situation from which he can acquire new behavior or changes in behavior (McDonald, 1965). The entire experimental teaching program is included in Appendix A. The outline was followed as written with the exception that if the patient needed nursing assistance during the session this was given by the investigator.

The program for each patient included one preoperative and two postoperative sessions each approximately 30 minutes in length. Preoperatively, the patient was instructed by the investigator either in the pulmonary laboratory or in the ward treatment room. The patient had previously met the investigator while he signed the consent form and was given tests of ventilatory capacity. The intermittent variable-ratio schedule was used because it has been found to be the most powerful in sustaining behavior. The following major areas of content were included in the session:

I. Introduction of program

II. Exploration of patient concerns and questions about the perioperative experience

III. Discussion of the patient as a participator in his care

IV. Description of the pulmonary system

- A. Assessment of patient's present knowledge
- B. Description of the function and importance of the pulmonary system

V. Demonstration and Practice

- A. Preferred method of diaphragmatic breathing
- B. Preferred method of coughing
- C. Methods to alleviate discomfort during exercises
  1. panting before cough
  2. incisional splinting
- D. Optimum position for relaxation and effective breathing exercises
- E. Deep breathing exercises with emphasis on lower lobe expansion and diaphragmatic control
- F. Breathing in the supine position with incisional splinting
- G. Coughing in the supine position with incisional splinting
- H. Position changes with practice of exercises

VI. Patient Questions and Summary

Postoperatively, the patients were instructed at the bedside by the investigator for 30 minutes on two consecutive postoperative days. Nurse modeling, patient demonstration and practice were again used with the following content:

1. Exploration
2. Position and deep breathing with incisional splinting
3. Cough with panting and incisional splinting
4. Deep breathing with emphasis on lower lobe expansion and diaphragmatic control
5. Changes in position with breathing and coughing practice
6. Summary and Patient Questions

Nursing Approach Currently Used: the usual processes followed in the preoperative preparation and postoperative followup related to the lung function of elective upper abdominal surgical patients. Instruction of the patient seemed to vary with each individual and with the staff that was concerned with the care of that particular patient. Preoperatively, patients were informed of those procedures which would be necessary prior to surgery by an anesthesiologist who visited the evening before surgery. The chief resident physician also described the preparation and operative procedure and usually mentioned that the patient would be expected to cough after surgery. The investigator did not observe any formalized preoperative or postoperative teaching plan emphasizing deep breathing or coughing written or utilized by the nursing staff. Postoperatively, most of the patients received IPPB therapy and blow bottles alternating every two hours in the recovery room the evening and night of surgery. On the ward most patients received IPPB therapy and blow bottles every four hours throughout the study period. The method of administration and time scheduled varied with each practitioner and patient. If the patient developed a temperature elevation the frequency of IPPB and blow bottle treatments increased and the patients were assisted in coughing every 1 to 2 hours.

Postoperative: three consecutive days after the day of the surgical procedure.

Ventilatory Capacity: the ability of the patient's pulmonary system to perform the primary function of supplying body tissue cells with adequate oxygen and removing carbon dioxide from these cells. In this study this concept was considered to be synonymous with the commonly used label "pulmonary function." The following variables were used as measures of the ventilatory capacity. These variables were divided into mechanical variables, which measure flow and volume, and variables of gas exchange, which measure the lungs capability to exchange gases with the environment.

Mechanical Variables

Forced vital capacity expressed as a percentage of the predicted value (FVC % predicted); the volume of gas after a maximal inspiration that is expired as rapidly and completely as possible. This volume of gas in liters is expressed as a percentage of the forced vital capacity predicted for the age, sex, and height of the subject from published prediction nomograms (Kory et al., 1961). FVC % predicted is derived from FVC actual/ FVC predicted x 100.

One second forced expiratory volume expressed as a percentage of the predicted value (FEV_1 % predicted): the volume of gas after a maximal inspiration that is exhaled by forceful effort over the first second of expiration during the performance of a forced vital capacity. This volume of gas in liters per second is expressed as a percentage of the predicted one second forced expiratory volume for the sex, age, and height from published nomograms (Kory et al., 1961). The FEV_1 % predicted is derived from FEV_1 actual/ FEV_1 predicted x 100.

One second forced expiratory volume expressed as a percentage of the forced vital capacity (FEV_1/FVC %): the volume of gas after a maximal inspiration that is exhaled by forceful effort over the first second of expiration during the performance of a forced vital capacity. This volume of gas in liters per second is expressed as a percentage of the forced vital capacity in liters. FEV_1/FVC % is derived from FEV_1 actual/FVC actual x 100.

<u>Forced maximum mid-expiratory flow corrected for the forced vital capacity</u> ($MMF_{25-75\%}/FVC$): the volume of gas exhaled over the middle two quarters of the forced vital capacity. This mean flow between 25 and 75 per cent of the forced vital capacity expressed in liters per second was corrected for the forced vital capacity to adjust for lung sizes (Lapp and Hyatt, 1967; Gazioglu et al., 1968). The ratio is derived by dividing the $MMF_{25-75\%}$ by the FVC.

<u>Variables of Gas Exchange</u>

<u>Oxygen partial pressure in arterial blood</u> (Pa_{O2}): the pressure exerted by oxygen gas in blood in equilibrium with a gas mixture containing this gas at this pressure. The unit of measure is millimeters of mercury (mm.Hg).

<u>Alveolar-arterial oxygen pressure difference on air</u> ($A\text{-}aDO_2$): the difference in partial pressure between oxygen in the alveolar air (P_{AO2}) and oxygen in the arterial blood (Pa_{O2}). The unit of measure is millimeters of mercury (mm.Hg).

<u>Carbon dioxide partial pressure in arterial blood</u> (Pa_{CO2}): the pressure exerted by carbon dioxide gas in blood in equilibrium with a gas mixture containing this gas at this pressure. The unit of measure is millimeters of mercury (mm.Hg).

<u>Percentage of venous-to-arterial pulmonary shunt</u> ($\dot{Q}s/\dot{Q}_T$%): that fraction of the cardiac output from the right side of the heart that does not take part in gas exchange in the pulmonary capillary bed and so passes unchanged into the arterial circulation. This venous-to-arterial pulmonary shunt consists of: (1) anatomic shunts of bronchial, pleural, and thesbian veins and pulmonary arteriovenous anastomoses distal to the pulmonary capillaries; and (2) slight deviations in the ventilation-perfusion ratio from the ideal value. The anatomic shunts remain constant, however,

the deviations in the ventilation-perfusion ratio can increase significantly due to collapse or reopening of avleoli and smaller airways of the lung. An increase in the percentage of shunt is used synonymously with the definition of atelectasis. The characteristic feature of the venous-to-arterial shunt is that it can not be reversed by breathing 100 per cent oxygen.

pH: the symbol commonly used in expressing H^+ion concentration, the measure of alkalinity and acidity. It signifies the logarithm to the base 10 of the reciprocal of the H^+ion concentration in gram molecules per liter of solution.

Method

Sample Selection

The sample consisted of 22 elective upper abdominal surgical patients selected from the operative schedule of a large medical center of the United States Army. During the 5 month period of study the sample was selected from the weekly surgical schedule. The investigator met with those patients who met the criteria established for sample selection and requested their permission to participate in the experiment. After a random start the patients were alternately assigned to the control or experimental group. General surgical patients were admitted to two wards, one female and one male.

Criteria for sample selection. The following variables were controlled by criteria for the selection of the sample:

1. Scheduled for elective upper abdominal surgery with general anesthesia
2. 15-60 years of age
3. Not more than 20 per cent overweight according to the Metropolitan Height / Weight Tables (1969)

4. English speaking and able to communicate with investigator
5. High school education
6. No history of pre-existing cardiac or pulmonary disease
7. No respiratory infection at time of hospitalization
8. No history of allergic respiratory reactions to medications
9. No history of long term corticosteroid, phenothiazine or rauwolfia drug therapy unless appropriate withdrawal or supplementary schedule is ordered prior to surgery
10. No restrictive dressings expected postoperatively
11. Not admitted to the intensive care unit postoperatively

Since postoperative changes in lung volumes and flow rates, and the percentage of pulmonary complications has been shown to be related to the site of the incision (Stein et al., 1962; Pecora, 1969; Lindeman, 1972), the sample was chosen from those patients undergoing surgery which was confined to one operative area. The sample was restricted to elective procedures in order to include preoperative teaching sessions and measurement of pulmonary function one day before surgery.

Because there are changes in arterial oxygen partial pressure, alveolar-arterial pressure difference, percentage of venous-to-arterial shunt, diffusing capacity, compliance, and lung volumes with advancing age (Kanber et al., 1968; Sorbini et al., 1968; Craig et al., 1971), and those patients over 60 years of age have been found to develop postoperative pulmonary complications three times more frequently than younger subjects (Bendixen et al., 1965), the sample was restricted to patients below 60 years of age. Disturbances in pulmonary mechanics and blood-gas relationships found in patients more than 20 per cent overweight (Said and Banerjee, 1963; Bates and Christie, 1964) have resulted in an increase in postoperative complications for this group (Thoren, 1954; Latimer et al., 1971) and, therefore, patients found to be 20 per cent overweight were not included.

Preoperative pulmonary impairment resulting from pre-existing cardiac or pulmonary disease or a current respiratory infection is probably the most important variable responsible for an increase in postoperative pulmonary complications (Bendixen et al., 1965; Stein et al., 1962; Latimer et al., 1971), therefore, patients with preoperative pulmonary impairment were not accepted. If the patient had a history of medication allergy that might possibly affect the function of the pulmonary system he was not included in the study.

Although different physiological mechanisms are responsible, a regular schedule of cortiocosteroids, phenothiazines, or rauwolfia drugs can decrease compensatory mechanisms for hypoxemia (Bendixen and Laver, 1965). Therefore, patients taking these drugs regularly were not accepted unless the appropriate withdrawal or supplemental schedule was ordered prior to surgery. It was not usual for upper abdominal surgical patients to need dressings that restricted chest motion, however, since restricting dressings can cause a reduction in arterial oxygen pressure and an increase in respiratory complications (Caro, Butler, and DuBois, 1960; Horner, 1967) patients with restrictive dressings were eliminated.

Coherent communication with the investigator was necessary if the objectives of the teaching program were to be reached, therefore, only English speaking patients with high school education were selected. The sample was restricted to those patients who returned directly to the surgical ward from the recovery room.

Randomization. The following variables were controlled by randomization:

1. Variables that can affect the teaching-learning process.

Those individual differences which may affect learning include the following: motivation, mental and physical readiness, intellectual and physical development, social history, occupational history, educational history, level of anxiety and stress, previous reinforcement patterns, vicarious and direct reinforcement in the hospital, family interactions, interactions with other patients, perception and resulting interaction with the investigator, previous hospitalizations, perception of hospital personnel as models, and previous knowledge of pulmonary system or prevention of respiratory complications.

2. Variables that can affect ventilatory capacity:

   a. Sex

   b. Smoking history

   c. Preoperative days in hospital

   d. Surgical ward and staffing pattern

   e. Type and length of anesthesia

   f. Type and number of sedatives and narcotics

   g. Preoperative medications

   h. Inhalation therapy treatments

   i. Antibiotic therapy

   j. Pain experienced

   k. Time in recovery room

   l. Time of ambulation

It has been reported that males develop postoperative pulmonary complications more than three times that of females (Thoren, 1954; Bendixen et al., 1965), however, a more recent study by Latimer et al., (1971) found no differences in the complication rate between the sexes. It is also suspected that the heavier smoking history of men was the reason for the previous difference in complication rate between men and women. At the present time disagreement also exists as to the effect of smoking on postoperative pulmonary function. Although smokers have been found to have abnormal volumes and gas exchange (Strieder, Murphy, and Kazemi, 1969; Craig et al., 1971) recently Pecora (1969) and Lindeman (1972) found no differences in postoperative lung volumes or flow rates between smokers and non-smokers.

Although in the past the type of anesthesia was reported to affect the incidence of pulmonary complications (King, 1933; Dripps and Deming, 1946), recent studies have shown that if the same recovery room care is given and the patient is awakened early after a carefully administered anesthesia the type of general anesthesia has no effect on postoperative pulmonary function (Hamilton, 1961; Bendixen et al., 1965). The duration of anesthesia does seem to have some effect on the development of post-operative complications with longer time periods resulting in a greater percentage of pulmonary complications (Meneely and Ferguson, 1961; Latimer et al., 1971). The number and type of preoperative medications, narcotics, and sedatives was noted, however, the particular medications for each patient had to be controlled by randomization. Moderate doses of barbituates and opiates can cause a decrease in periodic hyperinflation of the lung and coughing which have been shown to cause atelectasis (Egbert and Bendixen, 1964; Bendixen and Laver, 1965). The effect of preoperative atropine is uncertain (Tomlin, Conway and Payne, 1964; Nunn and Bergman, 1964).

The effect of inhalation therapy on pulmonary complications may not be as great as previously suspected (Rudy and Crepeau, 1958; Noehren, Lasry and Legters, 1958). Although Anderson et al., (1963) did find significant decreases in pulmonary complications with the use of inhalation therapy, two previous studies found no apparent advantage in giving these treatments (Becker et al., 1960; Sands et al., 1961). The pain experienced by the individual patient may prevent effective deep breathing and coughing, thus, producing atelectasis (Egbert and Bendixen, 1964). The type of care received and the amount of ambulation has been found to affect pulmonary function (Bendixen et al., 1965; Bates and Christie, 1964). All patients in the study spent approximately the same time in the recovery room and were ambulated at similar times.

Pilot Study

The investigator spent one month in the pulmonary function laboratory of the medical center developing the skills of arterial puncture, blood gas analysis, spirometry, and calculation of the spirometry and gas readings. After this period a pilot study was conducted using four upper abdominal surgical patients who were not included in the final sample. With these patients the investigator practiced the method of approaching and obtaining the patient's permission to be included in the investigation, the teaching program with demonstration and reinforcement, and the technical skills necessary for measuring the dependent variables. The pilot study provided an opportunity for the investigator to choose the location for the teaching program and the measurement of pulmonary function, to assess the possible use of a tape recorder, to test the equipment for proper functioning and validity, and to determine the appropriate time schedules for instruction and measurements. Because of the close proximity of control and experimental patients and the difficulty in conducting the measurements in the recovery room the decision was made to begin the measurement of the dependent variables after the patients had returned to the ward. The procedures for measuring the percentage of venous-to-arterial shunting were not practiced during the pilot study because it was not known that it would be possible to include this variable.

Criterion Measures and Instrumentation

The criterion measures used to determine the effect of the experimental teaching program on ventilatory capacity included measurements which demonstrated both the mechanical state of the lungs and their capability for gas exchange. The measures were chosen for their sensitivity and validity in determining the extent and etiology of postoperative hypoxemia and atelectasis.

Mechanical Variables. Lung volume was determined by the forced vital capacity (FVC % predicted), whereas flow within the airways was measured by the variables of one second forced expiratory volume (FEV_1/FVC %) and forced maximum mid-expiratory flow between 25 and 75 percent of the forced vital capacity ($MMF_{25-75\%}$ / FVC). The 13.5 Liter Collins water-sealed spirometer was used. During the forced expiration the pen of the spirometer draws a curve of changing volume against time on a rotating drum covered with unlined graph paper moving at a constant rate. Large Collins rubber mouthpieces and rubber tipped noseclips were used during the testing. The forced vital capacity, the one second forced expiratory volume, and the forced maximum mid-expiratory flow between 25 and 75 per cent of the forced vital capacity were calculated from the forced spirogram. The volume obtained in millimeters per minute was converted to liters per minute and then to liters per second. The volumes were then corrected to body temperature and pressure, saturated with water vapor (BTPS) (Comroe et al., 1962, p. 334). The forced vital capacity and one second forced expiratory volume were divided by the predicted values (Kory et al., 1961), and multiplied by 100 to obtain the percentage of the predicted value. Because the one second forced expiratory volume and the forced maximum mid-expiratory flow are dependent on lung volume, especially notable in the postoperative period, both volumes were divided by the forced vital capacity to correct for lung size. The one second forced expiratory volume was divided by the forced vital capacity and multiplied by 100 to obtain the percentage. The forced maximum mid-expiratory flow between 25 and 75 per cent was divided by the forced vital capacity to obtain a ratio. Although it is preferable to divide this measurement by the total lung capacity (TLC) to correct for different lung sizes (Hyatt, 1965) the forced vital capacity has been reported as an adequate substitute for the total lung capacity (Lapp and Hyatt, 1967; Gazioglu et al., 1968).

Variables of Gas Exchange. The effect of the experimental teaching program on the postoperative ventilatory capacity was measured further by the following variables: (1) arterial oxygen partial pressure (Pa_{O2}); (2) alveolar-arterial oxygen pressure difference on air (A-aDO_2); (3) arterial carbon dioxide partial pressure (Pa_{CO2}); percentage of venous-to-arterial pulmonary shunt ($\dot{Q}s/\dot{Q}_T$ %); and (5) arterial pH (pH). The arterial oxygen pressure difference on air and the arterial oxygen partial pressure were used to quantify the extent of hypoxemia. Arterial hypoxemia in patients at sea level and breathing ambient air can be caused by: (1) venous-to-arterial shunting; (2) ventilation-perfusion abnormalities, i.e., maldistribution; (3) failures in diffusion from the alveoli to the arterial blood; and (4) alveolar hypoventilation. The arterial oxygen partial pressure and the alveolar-arterial oxygen pressure difference on air measured the combined effect of the first three mechanisms, while the measurement of the arterial carbondioxide partial pressure measured the extent of the fourth. Since the third mechanism, diffusion abnormalities, is almost never severe enough to cause hypoxemia, any hypoxemia, if not due to hypoventilation, is assumed to be caused by ventilation-perfusion abnormalities or venous-to-arterial shunting (atelectasis). To differentiate between these two mechanisms the percentage of venous-to-arterial shunting on oxygen was measured. The oxygen partial pressure (Pa_{O2}), carbon dioxide partial pressure (Pa_{CO2}) and pH were corrected for patient temperature and recorded directly from the Blood-Gas Analyzer (IL 113).

The alveolar-arterial oxygen pressure difference on air ($A\text{-}aDO_2$) was obtained utilizing the following equation (Comroe, 1965):

$$P_{AO_2} = F_{IO_2}\ (P_B) - P_{ACO_2}\left[F_{IO_2} + \frac{1-F_{IO_2}}{R}\right]$$

Where:

P_{AO2}	= mean alveolar P_{O2}
P_{ACO2}	= mean alveolar P_{CO2}
F_{IO2}	= fraction of O_2 in inspired air
R	= respiratory exchange quotient
P_B	= barometric pressure

This formula was simplified by estimating the P_{ACO_2} from the measured arterial blood (Pa_{CO2}) and assuming R=1 (CO_2 added to alveolar gas / min. = O_2 absorbed / min.). Using these assumptions the alveolar P_{O2} (P_{AO2}) becomes the P_{O2} of moist inspired gas (tracheal gas) minus the alveolar P_{CO2}. Using a F_{IO_2} of 0.2093 for oxygen in room air and the barometric pressure at the time of analysis, the following mathematical calculation was performed to determine the alveolar oxygen pressure (P_{AO_2}).

1. Example:

$$\underset{P_B}{(756} - \underset{P_{H_2O}}{47)}\ \underset{F_{IO_2}}{0.2093} - \underset{Pa_{CO_2}}{40} = \underset{P_{AO_2}}{108}$$

The measured arterial oxygen partial pressure (Pa_{O2}) was then subtracted from the alveolar oxygen pressure (P_{AO_2}) to obtain the alveolar-arterial oxygen pressure difference ($A\text{-}aDO_2$).

1. Example:

$108 - 90 = 18$

P_{AO_2} Pa_{O2} $A\text{-}aDO_2$

The percentage of venous-to-arterial shunt ($\dot{Q}s/\dot{Q}_T\%$) was calculated using S.T. Chiang's (1968) nomogram. The derivation of this nomogram is discussed in Appendix C. Using the $A\text{-}aDO_2$ Chiang prepared a nomogram to calculate the percentage of venous-to-arterial shunt from the following equation:

$$\frac{\dot{Q}s}{\dot{Q}_T} = \frac{P_{AO_2} - Pa_{O2}}{(P_{AO_2} - Pa_{O2}) + 1,670}$$

As for the samples on air the $A\text{-}aDO_2$ was obtained by:

$$P_{AO_2} = (P_B - P_{H_2O}) - P_{ACO_2}$$

$$A\text{-}aDO_2 = P_{AO_2} - Pa_{O2}$$

The $\dot{Q}s/\dot{Q}_T\%$ was then obtained by the following procedure illustrated in the example presented below.

1. Example: A patient at a barometric pressure of 755 mm. Hg. breaths 100 per cent oxygen for 15 minutes, his Pa_{O2} is 595 mm. Hg. and Pa_{CO2} is 40 mm. Hg. The P_{AO_2} is then (755 - 47) - 40 = 688 mm. Hg. and $P_{AO_2} - Pa_{O2}$ = 688 - 595 = 73 mm. Hg. Therefore, the $A\text{-}aDO_2$ = 73 mm. Hg. Using Chiang's nomogram the $\dot{Q}s/\dot{Q}_T$ % is 4.2 % of the total cardiac output.

Procedure

Initial permission to conduct the investigation in the participating hospital was obtained from the hospital's Research Committee, the Director of Nursing Services, and

the Director of the Pulmonary Function Laboratory. These members of the administrative staff were aware of the independent and dependent variables included in the study. Additional permission was solicited from the Chief of the General Surgical Department, the Chief of Anesthesiology, the Chief Resident of the Surgical Service, the Surgical Nursing Supervisor, and the Head nurses of the two participating wards. These staff members were told only that the investigator would be measuring preoperative and postoperative pulmonary function. Since special equipment had to be brought to the ward to conduct the postoperative measurements, the nursing staff was told that the investigator was measuring lung function parameters before and after surgery. With the exception of the Research Committee, the Director of Nursing Services, and the Director of the Pulmonary Function Laboratory, none of the hospital personnel were told that the study concerned the effect of a teaching program on pulmonary function. No one except the investigator was aware of the group assignment of patients. Throughout the study the investigator was dressed in a white uniform and official school nursing cap.

Every Friday during the study period the investigator reviewed the surgical schedule for the following week outlined by the Chief Surgical Resident. When patients scheduled for upper abdominal surgical procedures were admitted to the ward the investigator determined the patient's eligibility for inclusion in the sample by examining the medical chart. Permission was then obtained from the head nurse to include the subject in the study. If the patient could be included in the study his bed assignment was noted by the investigator since it was established that if a patient was assigned to a grouping of eight beds in which there was another sample subject, the new patient would be assigned to the same group as the sample subject in an attempt to control for discussion between the control and experimental subjects. It was not necessary to use this procedure.

The experimenter approached the patient and introduced herself as a nurse doing research concerned with the care of surgical patients. The investigator told the patient that she was conducting a study specifically concerned with patients' lung function before and after surgery and that she would appreciate the patient's permission to include him in the study. It was emphasized that participation in the study would be beneficial to him since measurement of lung function is important before and after surgery and the tests included in the study would help the doctors to know his progress after surgery. The procedures necessary for collecting the blood samples and conducting the spirometry were described. If he wished to participate the patient was asked to read and sign the Patient Consent Form (Appendix B). There were no refusals to participate in the study. After a random start the patients were alternately assigned to the control or experimental group and scheduled for an appointment in the pulmonary function laboratory.

Preoperative

1. Dependent Variables. The investigator conducted most of the measurements of the dependent variables. One pulmonary technician, unaware of group assignments, performed random arterial punctures when the investigator found it difficult to obtain a blood sample. Random measurements were also made by the consulting physician to control for experimenter bias. When the patients arrived at the pulmonary function laboratory they were met by the investigator, weighed, and asked questions pertaining to the variables included on the Patient Information Guide (Appendix B).

a. Mechanical Variables. The purpose and nature of the spirometry testing was explained to the patient. He was told, ' "This test shows us the volume of air you have in your lungs, how much of that air you can blow out, and how fast.

It is a good way to see if you have any obstruction in the airways of your lungs or if there are secretions blocking the air passages." The method of testing was explained while emphasizing that it was important for him to work hard and give his best effort since the test results depended on his effort and cooperation. The following three guidelines were emphasized: (1) he should keep his lips tightly around the mouthpiece; (2) he should take the deepest breath possible; and (3) he should breathe out as quickly and as hard as possible. The subject was then instructed to breathe normally for a few seconds, to take the deepest breath that he could when directed to do so, and to hold this breath until the investigator asked him to blow out as fast and as hard as possible. After a demonstration by the investigator the patient practiced the procedure. Any questions were answered at this time. All preoperative spirometry tests were performed while the patient was sitting in a chair at a 90 degree angle; this position closely approximated the postoperative high fowler's position in bed. The patient's name, date, and temperature of the spirometer were recorded on the drum paper. The drum of the spirometer was moved five times to rinse the spirometer system with room air and to provide true vertical orientation of the unlined drum paper. After a large rubber Collins mouthpiece was inserted by the patient, rubber tipped noseclips were placed on the patient and checked for leakage. With the spirometer at the slow speed of 32 mm. / min. the patient breathed quietly into the spirometer to obtain a baseline of normal breathing. Then the patient took a deep breath and when the position of maximal inspiration was reached the spirometer was switched to a fast speed of 160 mm. / min. and the patient blew out as fast and as hard as possible until a straight line was evident on the drum paper. The maneuver was repeated three times with the best tracing being used for later calculation of the forced vital capacity (FVC), the one second forced expiratory volume (FEV_1), and the forced maximum mid-expiratory flow ($MMF_{25-75\%}$).

b. Variables of Gas Exchange. Following the spirometry the investigator explained the purpose and procedure for drawing arterial blood samples. She stated, "This one blood sample tells us the kind of job the lungs are doing and if they are adequately oxygenating your blood." The patient was told that one blood sample would be drawn while he breathed air and another while he breathed oxygen. The drawing of the arterial blood sample was described as similar to that of the usual venous samples which were drawn on the ward: "You will feel a little stick at your wrist (or upper arm) while I am taking the sample. While I apply pressure to the site for five minutes the sample will be placed in ice. Since this is an artery and has more pressure than a vein I will ask you to continue to apply pressure while I analyze the sample. It is very important to continue holding the site with moderate pressure until I return and tell you to stop." All arterial blood samples were drawn from the radial or brachial artery with the patient in a 45 degree Fowler's position. A standard 10 cc glass Air-Lock syringe was prepared with Heparin by aspirating sufficient Heparin Sodium (Lipo-Heparin 1:1,000 units/ml.) to fill the dead space and attached to a disposable 23 gauge 3/4 inch needle. The area over the artery was cleaned with alcohol. Local anesthesia was not used since during the pilot study this additional procedure seemed to increase apprehension and painful stimuli. While the patient was attempting to breathe normally the artery was palpated and after expressing the Lipo-Heparin, so as not to alter the pH of the sample, the needle was advanced at a 45 to 90 degree angle until pulsation of arterial blood was evident in the syringe. When 5 cc. of blood had been obtained by letting the blood pulsate into the syringe over a one minute period the syringe was withdrawn, capped with a B-D adapter, and submerged in an ice bath while moderate pressure was applied to the site. After another five minutes, the approximate time interval which would be needed postoperatively to return to the pulmonary laboratory from the patient's bedside, the blood was analyzed for hemoglobin, Pa_{O2}, Pa_{CO2}, and pH. The patient was then told that he would breathe oxygen for 15 minutes, after which another blood sample would be drawn using the same method. The subject was told it was important for him to remain on the mouthpiece. If he felt that for any reason he had to come off the mouthpiece he was to raise his hand. The 100 per cent oxygen was delivered to the patient using a small Collins rubber mouthpiece attached to a free-breathing Hans-Rudolph plastic valve. Rubber tipped noseclips were placed on the patient and checked for air leakage. The wall oxygen was delivered through a Puritan Bennett flow meter and a rubber bag connected to the free-breathing valve. The oxygen was humidified with distilled water and given at a flow calculated from an estimated tidal volume. The patient took deep breaths during the 15 minutes and 10 deep breaths before the withdrawal of the sample to insure that all nitrogen had been washed out of the lungs. The blood sample was drawn using the same procedure and analyzed for Pa_{O2} and Pa_{CO2}.

2. Independent Variable. The investigator visited all sample patients for 30 minutes the evening before surgery. Control patients were seen for this time period in an attempt to control for the "Hawthorne Effect." The conversation with the control patients was limited to topics believed to be unrelated to postoperative pulmonary function; family, places of residence, occupational experiences, previous surgeries, and symptoms before admission to the hospital. Experimental patients received the preoperative instruction included in the planned experimental teaching program (Appendix A). Preoperatively, the teaching was given in the pulmonary laboratory or ward treatment room. The investigator introduced herself again and explained the

program. There was an exploratory period during which questions such as the following were raised: "How are you feeling?", "Do you have any questions about your operation that I can answer for you?". This was followed by a discussion of those areas of concern to the patient. During the teaching period questions were acknowledged as they arose. The preoperative session also included a discussion of how the patient could participate in his care and a description of the pulmonary system based on the patient's previous knowledge. The maneuvers included in the preoperative teaching plan were described and modeled by the investigator. These exercises were demonstrated and practiced by the patient with positive reinforcement given by the investigator. The session was concluded with a question period for the patient.

Postoperative

1. Dependent Variables. Patient temperatures and number of narcotics administered were recorded from the medical chart on each postoperative day but were not subjected to statistical analysis. Measurement of the dependent variables was accomplished as close as possible to 24, 48, and 72 hours after the termination of the surgical procedure and between the hours of 9 a.m. and 12 noon. All measurements were done at the patient's bedside with the curtains drawn. If the patient was receiving IPPB therapy the measurements were scheduled at least one hour after these treatments. Forced spirograms preceded the sampling of arterial blood.

With the exception that the patients were in a sitting position in bed at a 90 degree angle instead of in a chair, the instruction and procedures for conducting and recording the forced spirograms were the same as those described in the preoperative phase. It was not possible to measure all dependent variables for all 22 sample patients on all three postoperative days. On Postoperative Day 1 forced spirograms were recorded on all sample patients (N=22); this number was reduced to 19 (Control N=9 and

Experimental N=10) on Postoperative Days 2 and 3.

The procedures and instructions for drawing arterial blood samples on air and on 100 per cent oxygen were the same as described preoperatively, except that the patient was in his bed with the head at a 45 degree angle. The oxygen supply used for the measurement of venous-to-arterial shunting was brought to the bedside via a portable E cylinder tank. On Postoperative Day One 20 sample patients (Experimental N = 10 and Control N = 10) were measured for percentage of venous-to-arterial shunt using 100 per cent oxygen. On Postoperative Day Two 17 patients (Experimental N = 9 and Control N = 8) and on Day Three 18 patients (Experimental N = 10 and Control N = 8) were measured for Pa_{O2}, A-aDO_2, Pa_{CO_2} and pH on room air.

2. Independent Variable. Postoperatively, all patients were visited at their bedside for 30 minutes during the afternoon of the first and second postoperative day. Again, the discussion with the control patients was limited to areas believed to be unrelated to postoperative pulmonary function and included questions about visitors, time in the recovery room, ambulation, and meal progression. The experimental patients received the teaching plans for Postoperative Day One and Two (Appendix A). The discussion during the exploratory periods differed with the concerns and questions of each individual patient, however, the exercises, modeling, practice, and positive reinforcement followed the planned schedule.

Validity and Reliability

The design chosen for this study, the experimental pretest-posttest control group design in which equivalent groups are achieved by randomization, provides for internal validity. There is not adequate control for external validity (Campbell and Stanley, 1963), therefore, the effects of pre-testing and reactive arrangements on the manipulated independent variable restrict the generalization of the findings to other populations. The sample patients had to be informed of their participation in the experiment and preoperative baseline measurements were necessary. Although arterial blood sampling and spirometry are characteristic hospital procedures, these measurements were not done routinely in the care of upper abdominal surgical patients and attracted considerable attention from both patients and staff. The teaching program and the measurement of dependent variables were conducted at different periods in the day in order to minimize the relationship between the independent and dependent variables.

Independent Variable

Before initiating the study, the teaching program was reviewed by nursing experts for content and was conducted with four patients during the pilot phase. Although the interactions were not taped to be examined for validity and reliability, with the exception of the individualized exploratory and question periods the experimental program was followed in detail. To increase reliability by minimizing interruptions, preoperatively the teaching program was conducted in the pulmonary laboratory or ward treatment room. Postoperatively, patient needs were fulfilled before the session was initiated and curtains were drawn around the bed. The conduction of both the teaching program and measurements by the investigator controlled for the confounding variable of individuality, e.g., the effects of several personalities conducting the teaching.

Dependent Variables

Mechanical Variables. The mechanical function of the lungs and thorax is an important aspect of ventilatory capacity (Comroe et al., 1962). Outside the laboratory situation the following tests have been found to be valid measurements of total mechanical function of the lungs and the thorax: the forced vital capacity (FVC), the timed vital capacity (FEV_t), and the maximal mid-expiratory flow ($MMF_{25-75\%}$) (Meneely and Ferguson, 1961; Comroe et al., 1962; Hyatt, 1965). All these tests were used in an effort to increase reliability by adding more items of equal kind and quality (Kerlinger, 1965). Miller, Johnson and Wu (1956) reported that a decrease in the forced one second expiratory volume (FEV_1) correlated well with both an increase in residual volume and a decrease in intrapulmonary gas mixing. Patients with post-operative complications have been found to have significant decreases in 0.5 and 1 second forced expiratory volumes (Wang and Howland, 1958; Stein et al., 1962; Palmer and Gardiner, 1964). The validity of these measures is jeopardized in that they require the cooperation of the patient and they measure several properties of the lungs simultaneously. The one second forced expiratory volume (FEV_1/FVC %) and the forced maximum mid-expiratory flow ($MMF_{25-75\%}$/FVC) were used in this study because they require less effort and depend less on the free use of the abdominal and muscular apparatus.

The maximum mid-expiratory flow ($MMF_{25-75\%}$) has recently been reported to be an even more valid and sensitive indicator of obstruction, especially in the smaller airways, than the FEV_1% (Hyatt, 1961; Gelb and Zamel, 1973a). Although both measurements of flow are naturally effort dependent, while the $MMF_{25-75\%}$ is calculated at a low lung inflation and is little affected by variation in effort and more sensitive, the FEV_1% being measured at a greater lung volume and closer to total lung capacity (TLC) has been found to be more dependent on patient effort and more sensitive to changes in extrathoracic airway resistance (Hyatt, 1965). If one is attempting to quantify expiratory flow retardation due to intrathoracic events it has been stated that the most direct approach should be the measurements of flow at a specific volume over the lower two-thirds of the vital capacity. Thus, patient cooperation is minimized, reproducibility is good, and flow is primarily determined by intrapulmonary mechanics (Hyatt 1965).

Lung volumes decrease greatly in the postoperative period, therefore, the measurements of flow, FEV_1 and $MMF_{25-75\%}$, which are partially dependent on lung volume, were corrected for lung size to further increase their validity.

The validity and reliability of the forced spirogram could have been affected by the spirometer and procedures used for the study or, the person conducting the tests. Some authors (Horton and Phillips, 1959; Sheiner et al., 1970) have reported that the accuracy of the more simple and easily portable McKesson Vitalor is comparable to that of the Collins spirometer in the measurements of timed vital capacity and maximal expiratory flow. The investigator, however, in a comparison study of the forced spirograms of 8 patients using the McKesson Vitalor and the 13.5 Liter Collins spirometer found the Vitalor to be less valid and reliable over time than the more sensitive Collins spirometer. The spirometer was initially and periodically checked with the tissot available in the laboratory for patient exercise studies by introducing a known volume of air into both instruments. Reliability was increased by conducting the tests in the same location with all patients in the sitting position. Airtight noseclips were used and specific instructions given to each patient. Practice by the patient and the use of the best effort of three spirograms also enhanced the reliability of these variables. The validity of the spirograms could have also been affected by errors either in the measurement of the FVC, FEV_1, and $MMF_{25-75\%}$ from the original forced spirogram or in the mathematical calculation of the final criterion measures of FVC % predicted, FEV_1 % predicted, FEV_1/FVC %, and $MMF_{25-75\%}$/FVC. A consulting physician and pulmonary technician, unaware of patient grouping, randomly observed the investigator for accuracy in the performance of the spirometry testing and checked the calculations to reduce error and the possibility of experimenter bias.

<u>Variables of Gas Exchange.</u> The most important function of the lungs is to supply tissue cells with enough oxygen and to remove carbon dioxide from these cells. Measurements of flow and volume or analysis of venous blood are no longer considered valid or reliable tests of the lung's capacity to exchange oxygen and carbon dioxide. The validity of these measurements is decreased for the following reasons: (1) measurements of flow only measure the amount of obstruction or restriction in the lungs, they do not indicate the amount of or mechanism causing the hypoxemia that may be present: (2) efforts to warm earlobes and extremities for drawing venous samples are time consuming and only approximations of the oxygen in arterial blood (Comroe et al., 1962; Petty, Bigelow and Levine, 1966). The measurement of the Pa_{O2}, $A\text{-}aDO_2$, pH and the $\dot{Q}s/\dot{Q}_T$ % by arterial blood sampling provides far more accurate quantitative data than the procedures described above. Direct arterial puncture avoids the approximations and complexities of indirect estimations of arterial blood gases. It is not only an accurate procedure, but also a simple and safe one (Petty, Bigelow, and Levine, 1966). The $A\text{-}aDO_2$ and the $\dot{Q}s/\dot{Q}_T$% provided the opportunity for the investigator not only to accurately measure the degree of postoperative hypoxemia, but also to validly ascertain the physiological mechanisms producing the hypoxemia. To increase the validity and reliability of drawing arterial blood, the following guidelines were strictly adhered to in the collection of blood samples for all patients:

1. Postoperative samples were drawn between the hours of 9 a.m. and 12 noon and at least one hour after IPPB therapy.
2. All patients maintained a 45 degree Fowler's position.
3. Patients were instructed to breathe normally throughout the procedure.

4. Lipo-Heparin was used to fill the dead space of the Air-Lock syringe and expressed before inserting the needle.

5. Five cc's of arterial blood were allowed to pulsate into the syringe over a one minute period.

6. All samples were capped immediately with a B-D adapter and placed in an ice bath to minimize the rate of oxygen consumption. All samples were analyzed after five minutes.

In addition, the following guidelines were maintained during the sampling of the arterial blood on 100 per cent oxygen:

1. Oxygen was delivered through an air-tight system using the Hans-Rudolph free-breathing valve and rubber tipped noseclips.

2. Instead of requesting the patient to breathe normally, to insure nitrogen washout, the patients breathed 100 per cent oxygen for 15 minutes with intermittent deep breaths before the sample was drawn.

Validity and reliability were further increased by having all instruments initially calibrated by professional personnel in the pulmonary laboratory and randomly examined throughout the study period for accuracy. The CO-Oximeter used for the analysis of hemoglobin was randomly checked with the instrument in the main laboratory of the medical center. The IL 113 S-1 Blood Gas and Micro pH Analyzer is designed to heighten accuracy and reliability by the use of rugged and durable electrodes, maintaining an environment of constant temperature, and having all but a few operations automatically maintained. Original calibration of this instrument had been accomplished with certified tank gases of 5% and 10% CO_2, and 12.15% O_2 purchased from Precision Gas Company. These gas mixtures are analyzed three times by the company to a guaranteed accuracy of $\pm$ 0.03%. The gases were scholandered by the pulmonary technician in charge of the laboratory and examined by tonometry with blood samples containing known amounts of gas. The analyzer was sloped three times a day by the pulmonary technician and balanced by the investigator before each analysis. Two additional IL 113 Blood Gas Analyzers available in the laboratory were used to randomly check the validity and reliability of the system used for this study. Every fourth sample was subjected to analysis by all three machines to insure accurate measurement of the variables.

The calculations of the $A\text{-}aDO_2$ and the $\dot{Q}s/\dot{Q}_T\%$ were generally accomplished by the investigator, however, to diminish the possible effect of experimenter bias a consulting physician and a pulmonary technician unfamiliar with the patient assignments randomly conducted or repeated analyses of the samples and the subsequent calculations from the raw data.

Limitations

Sample

The sample used for this study was selected from the population of patients admitted to one acute care hospital for elective upper abdominal surgery during a five month period. The results, therefore, can not be generalized to patients undergoing another type of surgery or to upper abdominal surgical patients admitted to other institutions or to this hospital during a different time period. Since the study was conducted in a medical center administered by the armed forces the patients were either employed by the armed services or dependents of employees of these services. The population admitted and the health care administered in an army hospital may have differed from that of another population receiving treatment in a civilian hospital.

The quality of care may have differed on the wards utilized for the study or with each individual nurse or physician responsible for the treatment of each individual patient. It was not feasible for the investigator to control or record the amount of interaction or teaching administered by the staff members in contact with the sample patients. It is possible that the subjects in one group received greater instruction about or attention to pulmonary hygiene than the other group.

The intervening variables of smoking and inhalation therapy, which may have been operating in the perioperative period, could not be controlled by sample selection and had to be controlled by randomization. The investigator could not obtain accurate information about the exact smoking pattern of the patients or the frequency, length, and patient effort given to blow bottles or IPPB treatments. The possible effects of these two variables are examined in the statistical analyses.

Criterion Measures

It was not possible to include the dependent variables of lung compliance, maximum expiratory flow volume curve, or postoperative radiological examination. These physiological indices combined with measurement of: (1) all dependent variables the evening following surgery; (2) partial pressure of oxygen on air on the first postoperative day; and (3) venous-to-arterial shunts on the second and third postoperative days would have provided additional data with which to determine the status of the cardio-pulmonary systems of the sample.

Although it was not always practicable to measure the dependent variables at the same exact time on the three postoperative days for all sample patients, the postoperative measurements were accomplished during the same time inverval of 9 a.m. to 12 noon. Patients were admitted to the ward during the early afternoon of the day prior to surgery. Because the preoperative measurements and teaching program for this study had to be conducted after numerous scheduled preoperative tests and interviews had been accomplished by the hospital personnel, these measurements were often delayed until the evening when the pulmonary laboratory was closed to other patients and were sometimes interrupted for a necessary procedure on the ward. Both situations seemed to increase patient anxiety.

The necessity of reporting the research study with incomplete data for certain patients is another limitation of the study. In one instance measurement was not obtained because of patient refusal. Other missing data resulted from the following circumstances: (1) the opportunity for measuring venous-to-arterial shunting was not available until two subjects had been studied; (2) after 3 patients had been completed it became evident that measurement of the dependent variables was needed on the second day; and (3) acute vasoconstriction or other physiological phenomena occasionally made it impossible for the investigator or consulting physicians to obtain a blood sample. Thus, the use of different subjects within the experimental and control groups and varied group numbers for each postoperative day limited the use of the data for establishing possible trends.

Because qualified personnel were not available at the time of the study to assist in measuring the dependent variables, the measurements and calculations had to be conducted by the investigator. Although a physician and laboratory technician unaware of patient grouping conducted random checks on the measurements and calculations, it is possible that experimenter bias could have affected the results.

The reactive arrangements may have been an additional limitation of the study. Although most of the staff were informed of the nature and responsibilities of the research nurse, the investigator was questioned about her status, her availability for nursing duties, or the procedures and equipment utilized on the ward. Sometimes these inquiries had to be answered while the patient was in attendance. This questioning atmosphere seemed to enhance some patients' belief that the measurements were unique and not necessary in the usual perioperative care. Some patients experienced pain or discomfort if the investigator had difficulty in obtaining an arterial blood sample. A few patients also complained of being uncomfortable during the administration of 100 per cent oxygen for 15 minutes. These patient complaints increased in the post-operative period when most subjects were also experiencing incisional pain and were being treated with naso-gastric tubes, intravenous, or other equipment. It was the investigator's opinion that the pain experienced by the patients was partially heightened by their knowledge that the measurements were not usual hospital routine and that they were participating in a research study. For several patients interest in the pulmonary exercises and active participation in their care seemed to be subordinate to the anxiety prompted by their thoughts of the possible pain they might experience during the measurement of the dependent variables after surgery.

The difficulties a nurse encounters while conducting research in the clinical setting have been well documented (Malone, 1962; Davis, 1968; Eisler, 1972). These difficulties become even greater when the nurse is not employed by the institution and the research study requires bringing unusual equipment to the ward, extended periods of time with the patient preoperatively, and invasive techniques.

Independent Variable

It was not feasible to tape the teaching sessions or have the sessions judged by other professional nurses for actual performance of the established program or the consistency of the teaching program over time.

Postoperatively the teaching sessions had to be conducted at the bedside. Individual beds were divided by curtains. Patients not included in the sample may have overheard the conversation during the teaching sessions or made inquiries about the study during visits with other patients. Information may have been relayed to sample subjects. The special measurements on the wards may have heightened the interest, and therefore, the frequency of conversation between the patients. Postoperatively, the teaching program and practice sessions were occasionally interrupted for necessary treatments administered by the hospital staff. These interruptions may have varied patient attention and concentration.

A final limitation of this study is that the teaching program and positive reinforcement could only be given once before surgery and two times in the postoperative period.

Data Analysis

The descriptive data was examined by calculating the means and standard deviations of the raw scores for all dependent variables Preoperatively and on Postoperative Day 1, 2, and 3. In addition, the investigator calculated the means and standard deviations of the individual change scores for all dependent variables from day to day.

The design of the study would usually require the use of an analysis of variance for repeated measures or alternatively a multivariate analysis of variance. These parametric tests, however, require a normally distributed population and equality of variances and covariances. It was not possible for the data as collected to meet the above requirements. The data did meet the assumptions of distribution-free or non-parametric tests. The observations were drawn randomly and independently from the population and the dependent variables did have underlying continuity. It has been reported that a non-parametric test is superior to a parametric test in statistical efficiency when both tests are applied under conditions where all assumptions of a distribution-free test are met, but some of the assumptions of the parametric test are not met (Bradley, 1968). Because of the difference in relative importance of the dependent variables measured it was the investigator's decision to employ the most powerful alternative non-parametric test, the Wilcoxen Rank Sum Test (Bradley, 1968, p. 105). When compared to the two sample t test for unmatched data the Wilcoxen Rank Sum Test has a relative efficiency of 0.955. If the population is skewed the efficiency is equal to or above that of the t test (Bradley, 1968).

The Wilcoxen Rank Sum Test was used for all possible pairwise comparisons of interest. This test was used to determine any statistically significant differences between groups in the raw scores of the dependent variables preoperatively, on each postoperative day, and in the change scores from day to day. The Wilcoxen Rank Sum Test required ranking the individual measurements for both the experimental and control group. The individual ranks were then summed to obtain a total rank sum for each group and the smaller group sum was entered into the appropriate table according to the numbers within the groups (Bradley, 1968, p. 318). If the smaller of the two sums was greater than the critical value listed, the appropriate alpha level was used. If the smaller sum was less than the critical value listed, it was rejected and concluded that there were no differences between the groups. It was not always possible to measure each variable for each patient at all times. The table used allowed for a different number in each group.

For further insight into the data the investigator also analyzed the individual change scores from preoperative to each postoperative day, from Postoperative Day 1 to Day 2 and 3, and from Postoperative Day 2 to Day 3. Individual change scores were ranked and summed for each group as described above.

After each variable was examined separately by the Wilcoxen Rank Sum Test, Bradley's recommended treatment of data for testing main effects among several variables was used to examine in a univariate manner the total difference between the experimental and control groups (1968, p. 138). The method advocated by Bradley for data which can be ranked is a summation method which reduces a complex design to a simpler design. This manipulation is possible because, instead of using the raw measurement, the ranking method utilizes only the relative position of each subject within the total measurements for one group. Although ranking has been reported to discard information, the very act of discarding allows manipulation of the data which would ordinarily be suspect if it were performed on the raw data. In this manipulation only the numbers were used to establish rank, the label of the variables, i.e., per cent, mm. Hg. etc., were disregarded. Originally the data was reviewed in the following manner:

<u>Postoperative Day 1</u>

		Variable 1	Variable 2	Variable 3....	Variable K
EXPER.	S_1				
	S_2				
	. . S_n				
CONTROL	S_1				
	S_2				
	. . S_n				

Using Bradley's summation method the above complex of by subject multiple variables matched within subjects is reduced to the following simple paradigm:

	Experimental	Control
S_1	T_r	T_r
S_2		
$\vdots$		
S_n		

T_r = Sum of ranks over all variables

The summed data per subject which contain the relative position within all variables is re-ranked for simplicity and the Wilcoxen Rank Sum Test performed to detect differences between total groups.

This analysis was followed by a non-parametric multivariate method developed by Rosenthal and Ferguson (1965) for small samples based on Hotelling's T^2 (Li, 1964) to determine if differences on each postoperative day could be detected when all variables were examined simultaneously. Rosenthal and Ferguson have derived a rank analog to Hotelling's T^2 which measures differences between two groups on multiple simultaneous variables. This rank analog can be used for small samples and is designed to be used for a series of rankings of a number of individuals or subjects and allows for the covariance between variables measured on the same subjects. The test statistic derived by Rosenthal and Ferguson is a complex one involving the inversion of a K-variate variance-covariance matrix. The calibration of this statistical test, however, is not necessary since these authors have also derived a method of post-hoc comparisons based on the method reported by Scheffe (1956). The logic of using the post-hoc comparisons without computing the test statistic is the same as that used with the analysis of variance. If the test statistic is significant, it follows that at least one of all possible post-hoc comparisons will also be significant. If none of the post-hoc comparisons is significant, it logically follows that the test statistic is not significant.

Since only one comparison per time period is of interest to the investigator it is only necessary to perform one comparison to determine if it achieves significance. If the comparison does not achieve significance the computation of the test statistic is unnecessary since the test statistic would not be significant. If the comparison is significant then it logically follows that if the test statistic were computed it would have been significant (Marascuilo, 1971). With this model the Rosenthal and Ferguson analog to Scheffe's theorem is the following: The probability is $(1-\alpha)$ that all confidence intervals of the general form:

$$\hat{\psi} - \sqrt{C}\sqrt{SE^2_{\hat{\psi}}} < \psi < \hat{\psi} + \sqrt{C}\sqrt{SE^2_{\hat{\psi}}}$$

Where: $\hat{\psi}$ = Psi

$$C = \frac{(K-1)\ (N-1)}{(N-K+1)} F_{K-1,\ N-K+1}{}^{(1-\alpha)}$$

$$SE^2 = \frac{1}{N} S^2_{RK} + S^2_{RK'} - 2\, r_{KK'}\, S_{RK}\, S_{RK'}$$

The general form of the contrasts is given by: $\hat{\psi} = \bar{R}_K - \bar{R}_{K'}$ where $\bar{R}_K$ is the rank average of the Kth condition. Both the variances (S^2) and the covariances $(r_{KK'}S_{RK}S_{RK'})$ of the contrasts were estimated directly from the ranked data.

Further insight into the accumulated raw data was obtained by performing rank correlations for Postoperative Days 1 and 2 between the variables of interest using the total sample. It is acknowledged that correlation is a statistical procedure which has been developed primarily for large samples and its validity is limited with small samples. The rank-correlation coefficient $r_2 = 1 - \frac{6\ (\sum d_i^{\,2})}{N(N^2-1)}$ was used since it has the advantage that no assumptions are made about the distributions of the variables. The two variables are ranked separately and then subtracted from one another to obtain the difference (d_i). The significance of the correlation was determined by entering the rank correlation coefficient into the appropriate table (Dixon and Massey, 1969, p. 569). The rank correlation coefficient (r_2) is similar to the correlation coefficient in that its values range from -1 to 1.

Following the analyses of the main effect of the teaching program the possible intervening effects of smoking history and IPPB therapy were examined. The Wilcoxen Rank Sum Test was used to statistically analyze raw scores for each day and change scores from day to day for 1) smokers and non-smokers between and within the experimental and control groups, and 2) those patients receiving IPPB therapy and those not receiving IPPB therapy between and within the experimental and control groups.

The additional variables of postoperative temperature, narcotics received, and day of discharge were then examined for statistically significant differences using the Wilcoxen Rank Sum Test.

The probability of a Type I error was set at the .05 level. A two-tailed test was selected to enable the investigator to determine if the teaching program had a harmful effect on postoperative ventilatory capacity and if the effect was statistically significant. It has been reported that teaching before surgery may increase fear and anxiety to the extent that it interferes with postoperative recovery (Janis, 1958; Johnson, 1972).

CHAPTER V

RESULTS OF THE STUDY

The results of the study will be described in five sections. The first section illustrates the nature of the 22 sample patients. Intervening variables controlled by sample selection or randomization are examined for equivalence between the two groups and manipulated statistically whenever the data allows. The preoperative measurements of the dependent variables chosen to assess ventilatory capacity are examined for normality and compared for equivalence.

The second section discusses the findings related to the specific hypotheses. Descriptive data are presented for the dependent variables on three postoperative days and for changes in the measurements over time. The findings related to each dependent variable are analyzed statistically for differences between the groups. Finally, all the variables used to measure ventilatory capacity are examined simultaneously.

The third section presents the rank correlations conducted with the available data on Postoperative Day 1 and 2.

The fourth section examines the intervening variables of smoking and IPPB therapy for the possible effect of these variables on the findings of the study.

The final section discusses the dependent variables of temperature, narcotics received, and length of hospitalization. These variables were not included in the hypotheses but are frequently used as measures of postoperative recovery.

Nature of the Sample

The sample for study consisted of 22 subjects who were selected over a five month period from the operative schedule of elective upper abdominal surgical procedures and randomly assigned to either the experimental or control group.

Variables Controlled by Criteria for Sample Selection

The experimental and control groups were equal regarding those variables controlled by selection. All patients were between the ages of 15 and 60 years, were English speaking, had completed high school, and had an upper abdominal surgical incision. No patients had a history of pulmonary or cardiac disease, respiratory infection or respiratory allergic manifestations. Also no patients required admittance to the ICU or restrictive dressings. All patients were under 20% overweight and those who were on previous medication were supplemented during the surgical procedure.

Variables Controlled by Randomization

Sex. There were 7 women and 4 men in the control group and 8 women and 3 men in the experimental group.

Age. All sample subjects were under 60 years of age with a range from 17 to 58 years, a mean age of 33.36 years, and a S. D. of 11.49 for the total sample. The mean age of the control group was 30.27 years with a S. D. of 10.85, that for the experimental group was 36.54 years with a S. D. of 11.75. The difference in ages was not statistically significant with a Rank Sum of 147.5 for experimentals and 105.5 for controls.

Smoking History. The intervening variable of smoking was controlled by randomization which produced 7 smokers and 4 non-smokers in the experimental group, and 6 smokers and 5 non-smokers in the control group. The preoperative baseline measurements of the dependent variables were statistically analyzed to determine if there were any significant differences in ventilatory capacity between smokers and non-smokers. No statistically significant differences were found either between the combined groups or within each group (Appendix D). The effect of the variable of smoking is further examined in the fourth section of this chapter.

Surgical Ward and Staffing Pattern. With the exception that all patients remained in the recovery room for 24 hours after the operative procedure, the subjects were admitted to and remained on two surgical wards. The experimental group consisted of 8 patients on Ward I and 3 patients on Ward II, while the control group had 7 patients on Ward I and 4 patients on Ward II.

Preoperative Days in the Hospital. All subjects were admitted to the hospital during the early afternoon one day before the surgical procedure.

Preoperative Medication. Preoperatively all patients received atropine sulfate and either meperidine hydrochloride or morphine sulfate. If morphine sulfate 10 mg. is considered equal to meperidine hydrochloride 80-100 mg. (Goodman and Gilman, 1968) there is little difference in medication received by the two groups.

TABLE 1

Frequency Distribution of Preoperative Medications

Medication	Amount	Number of Subjects	
		Experimental	Control
Atropine Sulfate	0.4 mg.	6	4
	0.5 mg.	2	5
	0.6 mg.	3	2
Meperidine Hydrochloride	50 mg.	2	4
	75 mg.	4	3
	100 mg.	2	0
Morphine Sulfate	8 mg.	0	2
	10 mg.	3	2
Hyroxine Hydrochloride (Vistaril)	75 mg.	4	6

Type of Surgery. All sample patients underwent an elective upper abdominal surgical procedure conducted under general anesthesia. The selected surgical procedures are listed in Table 2.

TABLE 2

Frequency Distribution of Surgical Procedures

Type of Surgery	Number of Subjects	
	Experimental	Control
Cholecystectomy	4	2
Cholecystectomy with Incidental Appendectomy	3	8
Splenectomy	2	1
Cholecystectomy with Hiatal Herniorraphy	1	0
Pyloroplasty, Vagotomy with Incidental Appendectomy	1	0

Operative Time. The average operative time for the experimental group was 2 hours and 38 minutes with a range from 2 hours to 4 hours, while that for the control group was 2 hours and 21 minutes with a range from 1 hour and 45 minutes to 3 hours. Differences between the groups were not significant.

TABLE 3

Means, Standard Deviations and Rank Sums of Operative Time For Comparison of Groups

Experimental			Control			Total		
N	Mean	S. D.	N	Mean	S. D.	N	Mean	S. D.
11	157.72 min.	27.33	11	141.36 min.	27.03	22	149.54 min.	27.80

Anesthesia Agents. All sample patients received intravenous sodium pentathol and succinylcholine. Curare and Innovar were also used, with 7 experimental and 6 control patients receiving curare, and 6 experimental and 5 control subjects receiving innovar. All subjects were maintained on oral nitrous oxide and oxygen. Two experimental and 3 control patients received penthrane, 1 experimental and 2 control patients received halothane, and 1 experimental and 1 control patient received fluothane.

Time in the Recovery Room and Ambulation. All subjects returned to the recovery room immediately after surgery and remained there until the next morning. The transfer times to the ward differed by only 15 to 30 minutes for the sample patients. The care in the recovery room was similar to that found in most surgical intensive care units. The patients spent 24 hours in the recovery room where inhalation therapy procedures and ambulation were begun. All patients ambulated in the recovery room the morning of the first postoperative day.

Antibiotic Therapy. None of the subjects required antibiotic therapy during the perioperative experience.

Inhalation Therapy. Blow bottle treatments were ordered for all sample patients every four hours. The investigator observed that the frequency and duration of the blow bottle treatments differed with each patient, the hour of the day, and the staff member caring for the patient. In the recovery room the treatments were administered every four hours by a member of the staff. On the wards some patients accepted the responsibility for self administration of the treatments and seemed to give their best effort, while others were less enthusiastic and waited until a staff member initiated the treatment. It was not possible for the investigator to observe or record the frequency, duration, or effort afforded the treatments for each individual patient.

Intermittent positive pressure breathing treatments (IPPB) were controlled by randomization. Each group had 9 subjects who received IPPB treatments and 2 subjects who did not receive this therapy. A positive pressure respirator was humidified with 2 cc. of a 5 per cent solution of normal saline and mucomyst every 4 hours for 15 minutes. During the 24 hours in the recovery room all patients who had IPPB received the treatment every four hours with a staff member in attendance. On the wards the frequency and duration of these treatments were observed by the investigator to differ with each patient. Two inhalation therapists were responsible for the teaching and administration of the IPPB treatments. The preoperative teaching was given exclusively by the therapists, while the postoperative treatments were administered by the therapists, the nursing staff, or the patient himself. Some patients had the IPPB equipment by their bedside, while others had to share this equipment with other patients on the ward. As with the blow bottle treatments, the investigator observed some patients taking full responsibility for their treatments, while others waited until this treatment was initiated by the staff. Again, it was not possible for the investigator to determine the actual patient effort, frequency, or duration of each treatment for the individual patients.

Preoperative Measurement of Dependent Variables

Only patients having no history of pulmonary or cardiac abnormality were chosen for the study. It was expected, therefore, that preoperative baseline pulmonary function tests would be within normal range. The preoperative means, standard deviations, and rank sums for the measurements are illustrated in Table 4.

Mechanical Variables

1. Forced vital capacity expressed as a percentage of the predicted value (FVC % predicted): The experimental group's mean FVC % predicted was 95% with a

range from 78 to 113%, while the control group's mean was 86% with a range from 72 to 104%. Two subjects in the experimental group and three controls had measurements lower than 80% predicted which may be characteristic of mild restrictive disease. Although the control group's mean FVC % predicted was slightly lower than the experimental group this difference was not statistically significant. These preoperative measurements were considered normal and equal for the two groups.

2. One second forced expiratory volume expressed as a percentage of the predicted value (FEV_1% predicted): The FEV_1% predicted of 100% for the experimental group was slightly higher than 94% for the control group. The measurements ranged from 85 to 121% in the experimental group and from 88 to 115% in the control group. There was no significant difference between the groups and the measurements were within normal range.

3. One second forced expiratory volume expressed as a percentage of the forced vital capacity (FEV_1/FVC%): The following criteria were used to determine the normality of preoperative measurements of FEV_1/FVC%:

"1. A value greater than 80% rules out airway obstruction.
2. A value less than 70% indicates mild airway obstruction.
3. A value less than 60% indicates moderate airway obstruction.
4. A value less than 50% indicates severe airway obstruction."

(Carman et al., 1969)

The mean FEV_1/FVC% for the experimental group was 84% with a S. D. of 5.91; the mean of the control group was 88% with a S. D. of 4.07. The FEV_1/FVC% for the total sample ranged from 70 to 93%. One patient in the experimental group had a FEV_1/FVC % lower than 80%. The difference in the rank sums between the groups was not significant and the measurements for the total groups were considered in normal range.

TABLE 4
Preoperative Descriptive Data and Rank Sums of Dependent Variables For Normality and Differences Between Groups

Variable	Experimental				Control				Total		
	N	Mean	S.D.	Rank Sum[a]	N	Mean	S.D.	Rank Sum	N	Mean	S.D.
FVC %pred.	11	95%	11.49	155.5	11	86%	9.90	97.5	22	90%	11.50
FEV_1 %pred.	11	100%	11.72	142.5	11	94%	7.75	110.5	22	97%	10.21
FEV_1/FVC %	11	84%	5.91	105.5	11	88%	4.07	147.5	22	86%	5.23
MMF/FVC $\frac{(L/sec)}{L}$ 25-75%	11	0.95	0.22	106.5	11	1.16	0.30	146.5	22	1.06	0.28
Pa_{O2} (mm.Hg)	11	80	7.54	123.0	11	81	8.12	130.0	22	81	7.68
A-aDO_2(mm.Hg)	11	31.24	9.73	122.0	11	32.14	7.71	131.0	22	31.69	8.58
Pa_{CO_2} (mm.Hg)	11	36	4.65	135.5	11	34	5.14	117.5	22	35	4.83
$\dot{Q}s/\dot{Q}_T$%	10	7.2%	2.03	102.0	10	7.3%	2.02	108.0	20	7.2%	1.97
pH	11	7.45	0.05	131.5	11	7.45	0.03	121.5	22	7.45	0.04

Note.--- Critical lower-tail level of Rank Sum for N=11 and N=11 is 96
Critical lower-tail level of Rank Sum for N=10 and N=10 is 78

[a]Wilcoxen Rank Sum Test with .05 level of significance for a two-tailed test

3. Forced maximum mid-expiratory flow corrected for the forced vital capacity ($MMF_{25-75\%}$/FVC): The normal range of this ratio was considered to be from 0.67 to 1.29 (Lapp and Hyatt, 1967, p. 476). The same patient in the experimental group who had a low FEV_1/FVC% was the only patient who had a $MMF_{25-75\%}$/FVC below normal (0.54). The mean preoperative ratio for the experimental group was 0.95, while that for the control group was 1.16. These preoperative measurements are essentially normal. Although the experimental group mean was lower than that of the control group the difference was not statistically significant.

Variables of Gas Exchange

1. Oxygen partial pressure in arterial blood (Pa_{O2}): Although it has been reported that at sea level the normal Pa_{O2} is between 90 and 100 mm. Hg (Comroe et al., 1962), it has recently been recognized that these values are based on studies using young males and that the definitions of normal values of Pa_{O2} without regard for age, smoking history and position during the procedure are hardly justified (Mellemgard, 1966; Sorbini et al., 1968). The preoperative mean Pa_{O2} for the total sample was 81 mm. Hg with the range from 66 to 94 mm.Hg and a S. D. of 7.68. The experimental group's mean was 80 mm.Hg with a S. D. of 7.54 while that of the control group was 81 mm.Hg with a S. D. of 8.12. In both the experimental and control groups 4 patients had a Pa_{O2} below 80 mm.Hg and 1 patient had a Pa_{O2} below 70 mm.Hg. The base-line tests were low for both groups and there were no statistically significant differences between the groups. It must be acknowledged that the values found in this study are generally lower than usually reported (Mellemgard, 1966; Filley, Gregoire and Wright, 1954; Streider and Kazemi, 1967), however, the lower values may be due to the age and smoking history of the subjects and the supine position assumed during the procedure. Eleven patients were over 30, 2 patients over 40, and 3 patients above

50 years of age. A marked inverse relationship between Pa_{O2} and age has been found (Filley, Gregoire and Wright, 1954; Ward et al., 1966c; Sorbini et al., 1968). Approximately linear decreases in Pa_{O2} with age have been reported. These vary from 0.24 mm.Hg per year (Raine and Bishop, 1963) to 0.43 mm.Hg per year (Sorbini et al., 1968). It has been shown that increasing age brings a progressive reduction in vital capacity with an increase in residual volume (Boren, Kory, and Syner, 1966), a reduction in pulmonary compliance (Sandqvist and Kjellmer, 1960), an increase in uneven ventilation or maldistribution (Bates and Christie, 1950), and a reduced diffusing capacity (Cohn et al., 1954; Pierce and Ebert, 1958). Recently, however, the decrease in Pa_{O2} with advancing age has primarily been attributed to an increase in maldistribution, i.e., increased ventilation-perfusion impairment, resulting from an increase in premature airway closure with age during quiet breathing (Holland et al., 1968; LeBlanc, Ruff, and Milic-Emili, 1970). The sample for study also included 13 patients with a history of smoking. Impairment of gas exchange and a resulting lower Pa_{O2} has been found in asymptomatic cigarette smokers (Strieder and Kazemi, 1967). Again, impairment of ventilation-perfusion ratios related to chronic cigarette smoking has been the etiological mechanism attributed to this decrease in Pa_{O2} (Ross et al., 1967). Finally, the position an individual assumes can have a significant effect on the lung's capability of gas exchange. It has been found that premature airway closure occurs in normal supine subjects breathing at a resting tidal volume primarily because of a reduction in functional residual capacity (LeBlanc, Ruff and Milic-Emili, 1970). Using a sample of 100 elderly subjects Ward et al., (1966c) found a mean Pa_{O2} of 77 mm.Hg in the supine position compared with a mean of 85 mm.Hg in the sitting position.

2. Alveolar-arterial oxygen pressure difference on air ($A\text{-}aDO_2$): The mean preoperative $A\text{-}aDO_2$ for the experimental group was 31.24 with a S. D. of 9.73, while that for the control group was 32.14 with a S. D. of 7.71. As would be expected with the tendency toward low Pa_{O2} for the total sample, these preoperative values of $A\text{-}aDO_2$ were higher than the 15 mm.Hg usually reported as normal. As the Pa_{O2} decreases with age, the $A\text{-}aDO_2$ has been found to increase with age. An increase in the alveolar-arterial oxygen pressure difference with increasing age has been found in studies by Cole and Bishop (1963), Raine and Bishop (1963) and Kanber et al. (1968). Craig et al. found an increase in $A\text{-}aDO_2$ from 19.3 to 33.8 mm.Hg with an increase of 28 years in age (1971, p. 719). Not unlike the Pa_{O2}, the $A\text{-}aDO_2$ is greater in smokers than non-smokers and even greater in the smoker in the supine position (Strieder, Murphy, and Kazemi, 1969; Craig et al., 1971). This increase in $A\text{-}aDO_2$ is also thought to be due to premature airway closure which increases maldistribution. Although the measurements were high for the total sample there was no significant difference in the rank sums between the groups.

3. Carbon dioxide partial pressure in arterial blood (Pa_{CO2}): At sea level the normal range of Pa_{CO2} is quite narrow, from 36 to 44 mm.Hg (Bendixen et al., 1965). Preoperative measurements for the sample were slightly lower than might be expected with a total mean Pa_{CO2} of 35 mm.Hg and a S. D. of 4.83. The experimental group mean was 36 mm.Hg with a S. D. of 4.65 and the control group mean was 34 mm.Hg with a S. D. of 5.14. Although the patients were instructed to breathe normally, this hypocapnia may have been produced by hyperventilation during the drawing of the blood sample. This hyperventilation, however, should lead to an elevated Pa_{O2} rather than the decreased arterial oxygen pressures previously discussed. Ward et al. (1966c) in their study of 100 elderly patients also found a depressed Pa_{CO2} accompanying a

decreased Pa_{O2} in the supine position. These authors suggest that in a supine position the patient hyperventilates (as demonstrated by the low Pa_{CO2}) to compensate for the maldistribution resulting from a decrease in volume and premature airway closure, however, hyperinflation of ventilated alveoli does not compensate for the additional number of alveoli that are closing or becoming atelectatic. The tendency toward lower Pa_{CO2} values was consistent for both groups and no significant difference was found between the groups.

4. Percentage of venous-to-arterial pulmonary shunt ($\dot{Q}s/\dot{Q}_T\%$): The preoperative mean $\dot{Q}s/\dot{Q}_T\%$ for the total sample was 7.2% with a S. D. of 1.97. The experimental mean was 7.2% and the control mean was 7.3%. Although these preoperative values tend to be high, they were considered to be within normal limits (Comroe et al., 1962). They are higher than reported by Davidson, Glazier and Murray (1973), Said and Banerjee (1963) and Fritts et al. (1960), but are lower than those published by Craig et al. (1971) and Ward et al. (1966a). When patients were separated according to position and age, Craig et al. found a mean increase of 2.4% from the sitting to supine position and a mean increase from 6.9% to 15.0% when older patients were grouped separately. Davidson, Glazier and Murray (1972) found the measured shunt fraction to be approximately equal to the observed $A\text{-}aDO_2$ for their normal subjects and concluded that a large part of the observed $A\text{-}aDO_2$ may be due to the percentage of venous-to-arterial shunt rather than the previously described increase in maldistribution. These authors suggest that the use of the supine position, the substitution of Pa_{CO2} for the alveolar P_{CO2}, and the variation of the oxyhemoglobin dissociation curve in the high percentage range may account for the over-estimation of the influence of the percentage of venous-to-arterial shunt on the $A\text{-}aDO_2$. There was no significant difference between the rank sums of the groups.

pH: The preoperative mean pH for both experimental and control group was 7.45. This pH is above the normal range of 7.36 to 7.44 and indicates slight alkalemia. Seven patients in the experimental group and 5 in the control group had a pH above 7.44. This apparent tendency toward alkalemia is consistent with the suspected patient hyperventilation reflected by the low mean Pa_{CO2} for the total sample. The tendency toward alkalemia was similar for both groups and there was no significant difference between the groups.

Summary

The experimental and control groups were equal in those variables controlled by selection and any differences in postoperative lung function would not be due to differences in these variables.

The groups were similar in the additional nominal variables which could not be subjected to statistical analysis: sex, preoperative days in the hospital, surgical ward and staff, preoperative medication, specific type of upper abdominal surgical procedure, anesthetic agents, time in the recovery room, ambulation time, antibiotic therapy, smoking history, and IPPB. It was, therefore, concluded that any differences in the dependent variables would not be due to differences in these variables. No statistical differences in preoperative ventilatory function were found between smokers and non-smokers either between or within groups. Those variables that could be subjected to statistical analysis were studied. There were no significant differences in age or operative time between the two groups, therefore, it was concluded that differences in postoperative dependent variables could not be due to differences in these variables.

The preoperative baseline measurements of the dependent variables chosen to measure the ventilatory status of the patient were all within normal limits for the patients selected and the position assumed during the procedures. The normality of

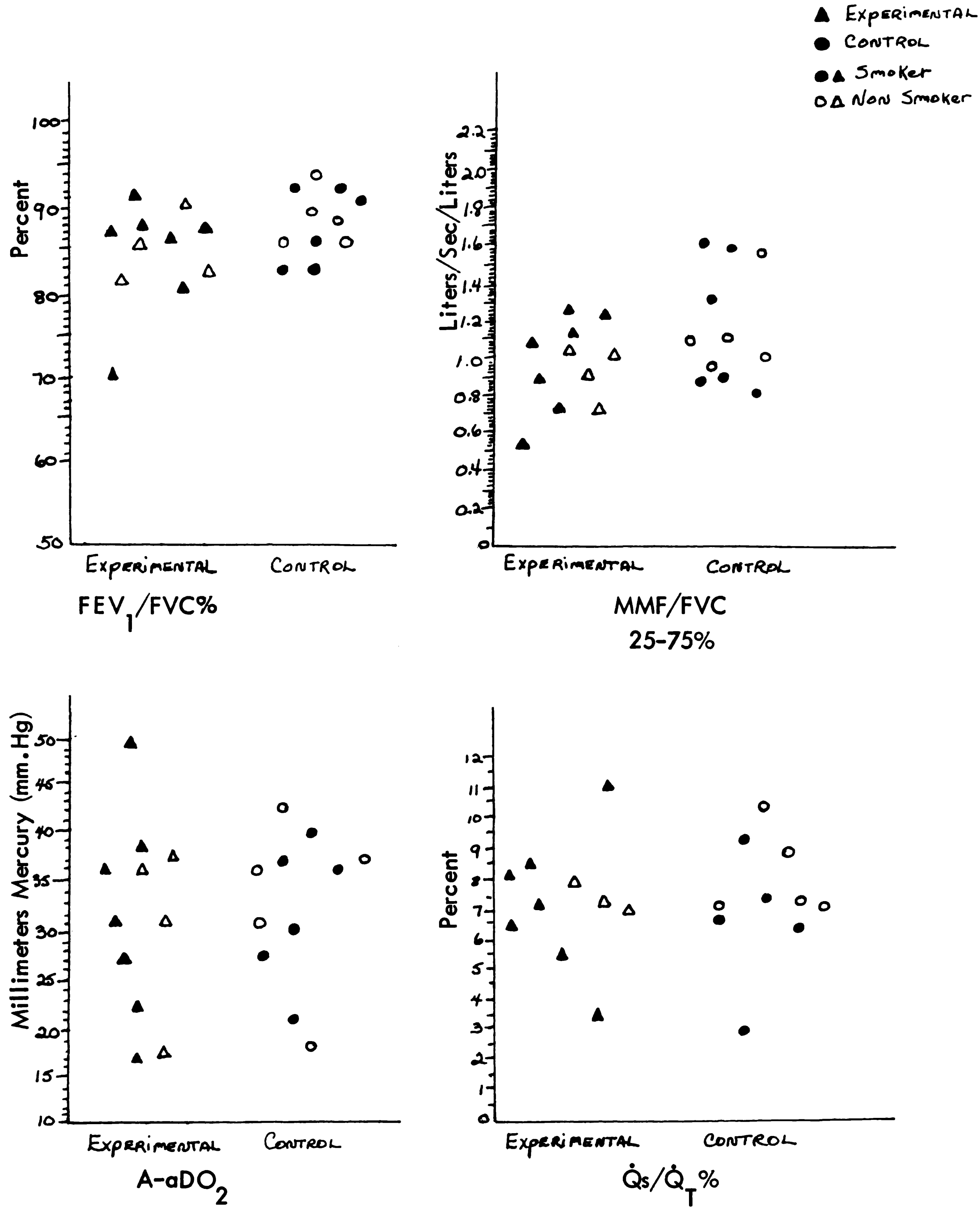

Figure 1. Preoperative Individual Measurements of Selected Variables for Demonstration of Normality of Sample and Equivalence Between Groups

the sample and equivalence between groups for selected variables is illustrated in Figure 1. Preoperatively, no significant differences were found for any of the variables between the experimental and control groups.

Findings Related to Proposed Hypotheses

The descriptive and statistical data relating to the Null Hypotheses I through IX is presented following the statement of each hypothesis. Tables 5 and 6 illustrate the means, standard deviations, and rank sums of the measurements of the dependent variables on each postoperative day. Tables 7 through 9 present the means, standard deviations, and rank sums of the change in these measurements over time. It is important to acknowledge that all subjects were not measured on every day, therefore, the number in each group available for examination of change scores over time differed from the group number utilized for the analysis on each day. Because of this difference in group numbers the mean of the individual change scores from day to day differed from that found if the mean of the raw scores for one day was subtracted from another day. The Wilcoxen Rank Sum Test was used for all comparisons necessary to reject or accept Null Hypotheses I through IX. Following the discussion of the individual hypotheses the statistical data related to the General Null Hypothesis is presented. Bradley's (1968) recommended treatment of data for testing main effects among several variables and Rosenthal and Ferguson's (1965) non-parametric multivariate method for determining differences when all variables are analyzed simultaneously were used for this analysis.

Null Hypothesis I

The first hypothesis predicted that measurements on three consecutive post-operative days of forced vital capacity expressed as a percentage of the predicted value (FVC % predicted) would demonstrate no significant differences between those who experience a teaching program emphasizing deep breathing and coughing and those who receive the nursing approach currently used. This hypothesis was accepted.

Following surgery the forced vital capacity expressed as a percentage of the predicted value was reduced for all sample patients (N=22) with a total sample mean of 41% of predicted on Postoperative Day 1, which represented a mean decrease of 50% from the preoperative measurement. The experimental group's mean FVC % predicted was 45% with a range from 20 to 61% and a S. D. of 13.54. The control group's mean was 37% with a range from 20 to 56% and a S. D. of 11.02. On Day 2 the total sample mean FVC% predicted increased to 50% with the experimental mean increasing to 54% and the control mean to 45%. With the available patient sample the change scores indicated a 10% increase for the experimentals (N=10) and a 7% increase for the controls (N=9) from Day 1 to Day 2.

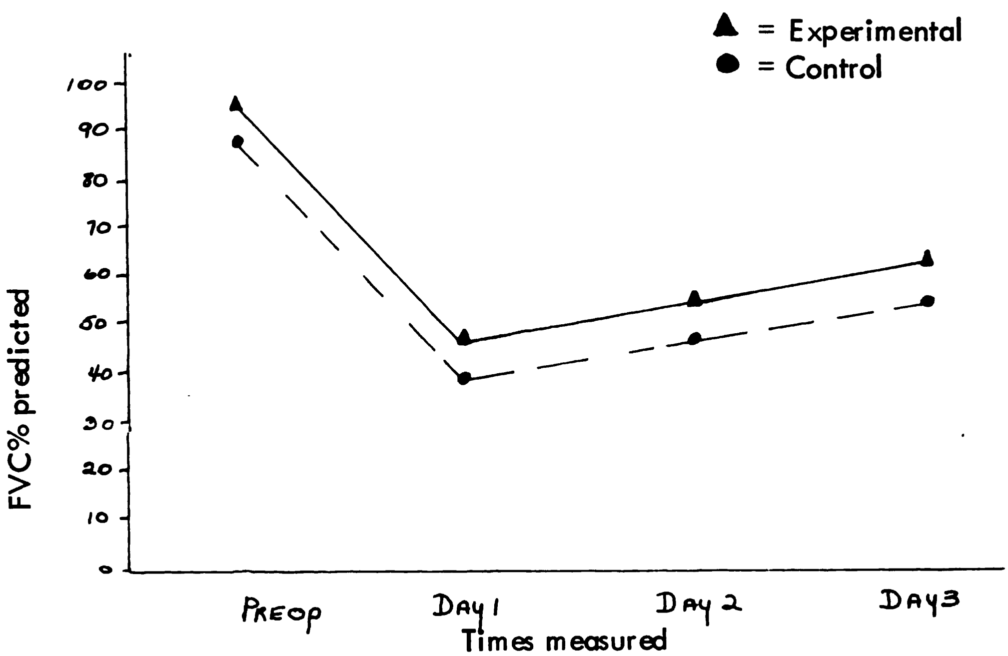

Figure 2. Comparison of Group Mean Scores of Forced Vital Capacity expressed as a percentage of predicted value.

TABLE 5

Descriptive Data and Rank Sums of Dependent Variables

Preoperative and Postoperative Day 1

Variable	Experimental				Control				Total		
	N	Mean	S.D.	Rank Sum[a]	N	Mean	S. D.	Rank Sum	N	Mean	S. D.
Preoperative											
FVC %pred.	11	95%	11.49	155.5	11	86%	9.90	97.5	22	90%	11.50
FEV_1 %pred.	11	100%	11.72	142.5	11	94%	7.75	110.5	22	97%	10.21
FEV_1/FVC %	11	84%	5.91	105.5	11	88%	4.07	147.5	22	86%	5.23
MMF/FVC $\frac{(L/sec)}{L}$ 25-75%	11	0.95	0.22	106.5	11	1.16	0.30	146.5	22	1.06	0.28
Pa_{O2}(mm.Hg)	11	80	7.54	123.0	11	81	8.12	130.0	22	81	7.68
A-aDO_2(mm.Hg)	11	31.24	9.73	122.0	11	32.14	7.71	131.0	22	31.69	8.58
Pa_{CO2}(mm.Hg)	11	36	4.65	135.5	11	34	5.14	117.5	22	35	4.85
$\dot{Q}s/\dot{Q}_T$%	10	7.2%	2.03	102.0	10	7.3%	2.02	108.0	20	7.2%	1.97
pH	11	7.45	0.05	131.5	11	7.45	0.03	121.5	22	7.45	0.04
Postoperative Day 1											
FVC%pred.	11	45%	13.54	150.0	11	37%	11.02	103.0	22	41%	12.80
FEV_1 %pred.	11	49%	14.35	152.0	11	38%	11.36	101.0	22	43%	13.76
FEV_1/FVC %	11	87%	8.57	134.5	11	86%	7.62	118.5	22	87%	7.97
MMF/FVC $\frac{(L/sec)}{L}$ 25-75%	11	1.07	0.27	136.0	11	1.02	0.24	117.0	22	1.04	0.25
$\dot{Q}s/\dot{Q}_T$%	10	10.6%	3.82	92.0	10	11.2%	2.73	118.0	20	10.9%	3.25

Note.---Critical lower-tail level of Rank Sum for N=11 and N=11 is 96
Critical lower-tail level of Rank Sum for N=10 and N=10 is 78

[a]Wilcoxen Rank Sum Test with .05 level of significance for a two-tailed test

TABLE 6

Descriptive Data and Rank Sums of Dependent Variables

Postoperative Day 2 and Postoperative Day 3

Variable	Experimental				Control				Total		
	N	Mean	S. D.	Rank Sum[a]	N	Mean	S. D.	Rank Sum	N	Mean	S. D.
Postoperative Day 2											
FVC % pred.	10	54%	15.03	116.5	9	45%	11.24	73.5	19	50%	13.89
FEV_1% pred.	10	58%	17.56	120.0	9	43%	12.92	70.0	19	51%	16.76
FEV_1/FVC %	10	84%	3.86	111.0	9	79%	9.91	79.0	19	82%	7.49
MMF/FVC $\left(\frac{L/sec}{L}\right)$ 25-75%	10	0.92	0.15	103.5	9	0.82	0.32	86.5	19	0.90	0.24
Pa_{O_2} (mm.Hg)	9	66	7.18	88.0	8	64	7.06	65.0	17	65	6.96
A-aDO_2 (mm.Hg)	9	45.54	9.79	71.5	8	49.31	5.84	81.5	17	47.32	8.16
Pa_{CO_2} (mm.Hg)	9	36	4.17	90.5	8	34	4.11	62.5	17	35	4.14
pH	9	7.45	0.024	72.5	8	7.46	0.018	80.5	17	7.45	0.020
Postoperative Day 3											
FVC % pred.	10	61%	14.86	115.5	9	53%	11.86	74.5	19	57%	13.73
FEV_1% pred.	10	66%	17.03	118.0	9	54%	10.13	72.0	19	61%	15.11
FEV_1/FVC %	10	86%	4.44	107.5	9	85%	6.51	82.5	19	85%	5.39
MMF/FVC $\left(\frac{L/sec}{L}\right)$ 25-75%	10	1.01	0.17	113.0	9	0.96	0.25	77.0	19	0.99	0.21
Pa_{O_2} (mm.Hg)	10	74	6.41	105.5	8	71	10.44	65.5	18	72	8.28
A-aDO_2 (mm.Hg)	10	38.48	6.23	86.5	8	39.91	9.23	84.5	18	39.12	7.49
Pa_{CO_2} (mm.Hg)	10	35	4.21	84.0	8	37	2.98	87.0	18	36	3.78
pH	10	7.46	0.035	99.0	8	7.45	0.022	72.0	18	7.46	0.029

Note.---Critical lower-tail values for: N of 9 and N of 10 = 65; N of 8 and N of 9 = 51; N of 8 and N of 10 = 53

[a]Wilcoxen Rank Sum Test with .05 level of significance for a two-tailed test

TABLE 7
Descriptive Data and Rank Sums of
Dependent Variable Change Scores
Preoperative to Postoperative Day 1 and 2

Variable	Experimental				Control				Total		
	N	Mean	S. D.	Rank Sum[a]	N	Mean	S. D.	Rank Sum	N	Mean	S. D.
Preoperative to Postoperative Day 1											
FVC % pred.	11	-50%	10.77	133.5	11	-49%	15.49	119.5	22	-50%	13.03
FEV_1% pred.	11	-51%	13.35	139.0	11	-56%	15.70	114.0	22	-54%	14.47
FEV_1/FVC%	11	+3%	7.93	143.5	11	-2%	7.42	109.5	22	+1%	7.78
MMF/FVC $\left(\frac{L/sec}{L}\right)$ 25-75%	11	+0.12	0.32	154.5	11	-0.14	0.28	98.5*	22	-0.01	0.32
$\dot{Q}s/\dot{Q}_T$%	10	+3.42%	2.90	101.0	10	+3.86%	2.76	109.0	20	+3.64%	2.77
Preoperative to Postoperative Day 2											
FVC % pred.	10	-40%	10.72	99.0	9	-40%	11.68	91.0	19	-40%	10.87
FEV_1% pred.	10	-44%	13.95	111.0	9	-48%	12.30	79.0	19	-46%	13.03
FEV_1/FVC%	10	-1%	2.26	112.0	9	-5%	8.60	78.0	19	-3%	7.55
MMF/FVC $\left(\frac{L/sec}{L}\right)$ 25-75%	10	-0.08	0.24	119.5	9	-0.24	0.29	70.5	19	-0.16	0.27
Pa_{O_2} (mm.Hg)	9	-15	8.56	81.0	8	-15	7.44	72.0	17	-15	7.80
A-aDO_2 (mm.Hg)	9	+16.31	8.07	83.0	8	+14.51	6.41	70.0	17	+15.46	7.16
Pa_{CO_2} (mm.Hg)	9	-1	3.71	78.5	8	0	4.60	74.5	17	-0.65	4.06
pH	9	+0.006	0.042	82.0	8	+0.002	0.034	71.0	17	+0.004	0.037

Note.---Critical lower-tail values at .05 level for: N of 11 and N of 11 = 96; N of 10 and N of 10 = 78; N of 9 and N of 10 = 65; N of 8 and N of 9 = 51

[a]Wilcoxen Rank Sum Test with .05 level of significance for a two-tailed test

*$p < .10$.

TABLE 8

Descriptive Data and Rank Sums of Dependent Variable Change Scores

Preoperative to Postoperative Day 3 and Postoperative Day 1 to Postoperative Day 2

Variable	Experimental				Control				Total		
	N	Mean	S. D.	Rank Sum[a]	N	Mean	S. D.	Rank Sum	N	Mean	S. D.
Preoperative to Postoperative Day 3											
FVC % pred.	10	-34%	13.00	106.5	9	-32%	7.89	83.5	19	-33%	10.54
FEV_1 % pred.	10	-33%	16.47	113.5	9	-38%	9.05	76.5	19	-35%	13.40
FEV_1/FVC %	10	+2%	5.75	122.0	9	-3%	4.12	68.0*	19	-0.05%	5.47
MMF/FVC $\frac{L/sec}{L}$ 25-75%	10	+0.07	0.21	135.0	9	-0.21	0.20	55.0**	19	-0.06	0.24
Pa_{O2} (mm.Hg)	10	-6	8.95	105.0	8	-10	10.78	66.0	18	-8	9.18
$A\text{-}aDO_2$ (mm.Hg)	10	+5.90	9.24	94.0	8	+5.53	9.84	77.0	18	+5.73	9.83
Pa_{CO2} (mm.Hg)	10	+0.20	4.52	74.0	8	+4	4.71	97.0	18	+2	4.94
pH	10	+0.004	0.061	99.5	8	-0.004	0.036	71.5	18	+0.001	0.050
Postoperative Day 1 to Postoperative Day 2											
FVC % pred.	10	+10%	8.38	114.5	9	+7%	9.51	75.5	19	+9%	8.89
FEV_1 % pred.	10	+9%	9.30	114.5	9	+5%	11.41	75.5	19	+7%	10.30
FEV_1/FVC %	10	-5%	3.45	94.5	9	-6%	9.58	95.5	19	-6%	6.83
MMF/FVC $\frac{L/sec.}{L}$ 25-75%	10	-0.20	0.15	80.5	9	-0.09	0.26	109.5	19	-0.15	0.17

Note.---Critical lower-tail values at .05 level for: N of 9 and N of 10 = 65; N of 8 and N of 10 = 53

[a]Wilcoxen Rank Sum Test with .05 level of significance for a two-tailed test

*$p < .10$

**$p < .01$

TABLE 9

Descriptive Data and Rank Sums of Selected Dependent Variable Change Scores
Postoperative Day 1 to Postoperative Day 3 and Postoperative Day 2 to Postoperative Day 3

Variable	Experimental				Control				Total		
	N	Mean	S. D.	Rank Sum[a]	N	Mean	S. D.	Rank Sum	N	Mean	S. D.
Postoperative Day 1 to Postoperative Day 3											
FVC % pred.	10	+17%	10.39	108.5	9	+14%	11.11	81.5	19	+15%	11.02
FEV_1 % pred.	10	+19%	12.56	111.5	9	+14%	12.26	78.5	19	+17%	12.37
FEV_1/FVC %	10	-1%	6.70	101.0	9	-3%	3.96	89.0	19	-2%	5.48
MMF/FVC $\frac{(L/sec.)}{L}$ 25-75%	10	-0.04	0.25	104.5	9	-0.07	0.23	85.5	19	-0.05	0.23
Postoperative Day 2 to Postoperative Day 3											
Pa_{O2} (mm.Hg)	8	+8	8.14	73.0	7	+3	6.59	47.0	15	+5	7.58
A-aDO_2 (mm.Hg)	8	-8.39	7.27	56.5	7	-5.44	8.58	63.5	15	-7.01	7.77
Pa_{CO2} (mm.Hg)	8	+1	3.06	55.5	7	+3	3.27	64.5	15	+2	3.17
pH	8	-0.005	0.029	61.5	7	-0.011	0.011	58.5	15	-0.008	0.022

Note.---Critical lower-tail values at .05 level for: N of 9 and N of 10 = 65; N of 7 and N of 8 = 38

[a]Wilcoxen Rank Sum Test with .05 level of significance for a two-tailed test

By the final measurement on Day 3 the total sample (N=19) had regained approximately 2/3 of their preoperative FVC % predicted with a mean of 57%. The experimental mean (N=10) was 61% with a range from 41 to 81%. The control group's mean (N=9) on Day 3 was 53% with a range from 35 to 70%.

On all three postoperative days the control group's mean FVC % predicted was lower than that of the experimental subjects, however, it must be acknowledged that preoperatively the control group's mean was 9% lower than the experimental mean. There were no statistically significant differences between the groups either in the raw scores on each postoperative day or in the change scores from day to day.

Null Hypothesis II

It was predicted that measurements on three postoperative days of one second forced expiratory volume expressed as a percentage of the predicted value (FEV_1 % predicted) would demonstrate no significant differences between upper abdominal surgical patients who experience a teaching program emphasizing deep breathing and coughing and those who receive the nursing approach currently used. The hypothesis was accdepted.

As expected with the large decrease in lung volume postoperatively, there was a consistent decrease in one second forced expiratory volume for all subjects. On Postoperative Day 1 the total sample mean (N=22) was 43% of predicted with a S. D. of 13.76. The experimental group's mean FEV_1 % predicted was 49% with a S. D. of 14.35, while the control group's mean was 38% with a S. D. of 11.36. Compared to preoperative values this was a mean reduction of 51% for the experimentals and 56% for the controls. As the lung volume increased over time so did the forced expiratory volume in one second. On Day 2 both groups increased their mean FEV % predicted; the experimental group's mean increased to 58% and the control group to 43%. From

Day 1 the experimentals (N=10) had gained 9% while the controls (N=9) gained 5%. On Day 3 the experimental mean was 66% and the control group mean was 54%.

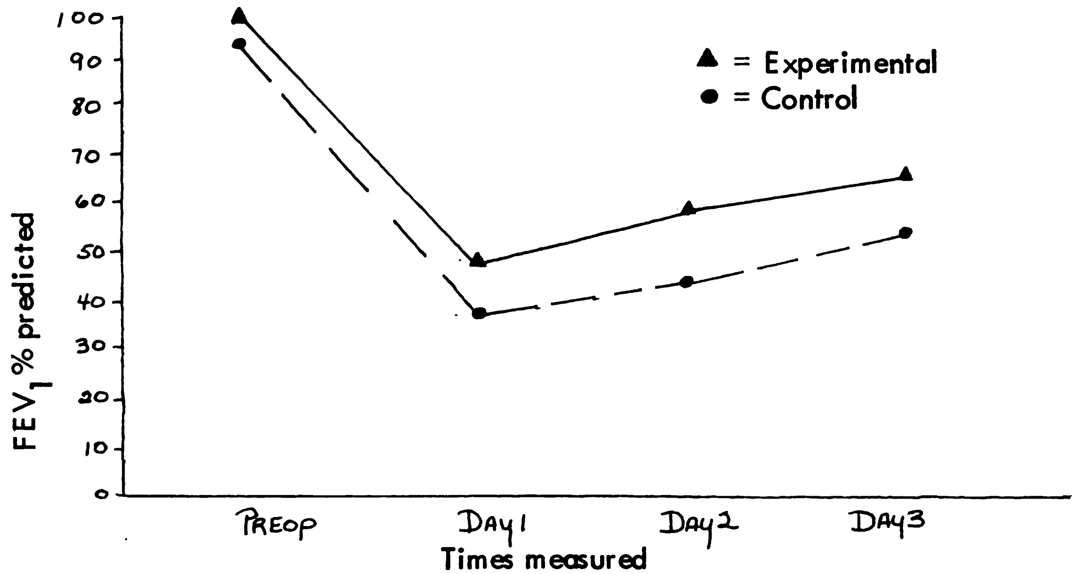

Figure 3. Comparison of Group Mean Scores of One Second Forced Expiratory Volume expressed as a Percentage of Predicted Value.

Again, preoperatively the control group had a lower mean FEV_1% predicted and this relationship remained in the postoperative measurements. Although the experimental group had a slightly greater increase in FEV_1% predicted over time postoperatively, there were no statistically significant differences between the groups in the change scores from day to day or the raw scores on each of the three days.

Null Hypothesis III

It was predicted that measurements on three consecutive postoperative days of one second forced expiratory volume expressed as a percentage of the forced vital capacity (FEV_1/FVC%) would demonstrate no significant differences between upper abdominal surgical patients who experience a teaching program emphasizing deep breathing and coughing and those who receive the nursing approach currently used. This hypothesis was accepted.

Postoperatively, there were only slight changes in the one second forced expiratory volume expressed as a percentage of the forced vital capacity. On Day 1 the mean $FEV_1/FVC\%$ for the total sample (N=22) was 87%, an increase of 1% from the preoperative measurement. The mean $FEV_1/FVC\%$ for the experimental group was 87% with a range from 68 to 97% and a S. D. of 8.57. The control group's mean $FEV_1/FVC\%$ was 86% with a range from 70 to 94% and a S. D. of 7.62. From the preoperative measurements the experimental group increased their mean $FEV_1/FVC\%$ by 3%, whereas the control group mean decreased by 2%. Four patients, two patients in each group, had flow rates below 80% on the first postoperative day.

On Day 2 the control group's $FEV_1/FVC\%$ (N=9) continued to decrease to 79% and the experimental group (N=10) decreased to 84%. Using the available subjects who were measured on both Day 1 and Day 2, there was a mean reduction of 6% for the controls and 5% for the experimentals. On Postoperative Day 3 the control group's $FEV_1/FVC\%$ (N=9) increased to 85% but remained 3% lower than the preoperative value. The experimental group (N=10) increased to 86% and was 2% higher than the preoperative value. Despite the fact that the experimental group had slightly better flow rates postoperatively there were no statistically significant differences in the raw scores on the three postoperative days. Although none of the differences reached the level selected for this study, there was a difference between the groups ($p < .10$) in the change scores from Preoperative to Postoperative Day 3 with the control group having the lower measurements.

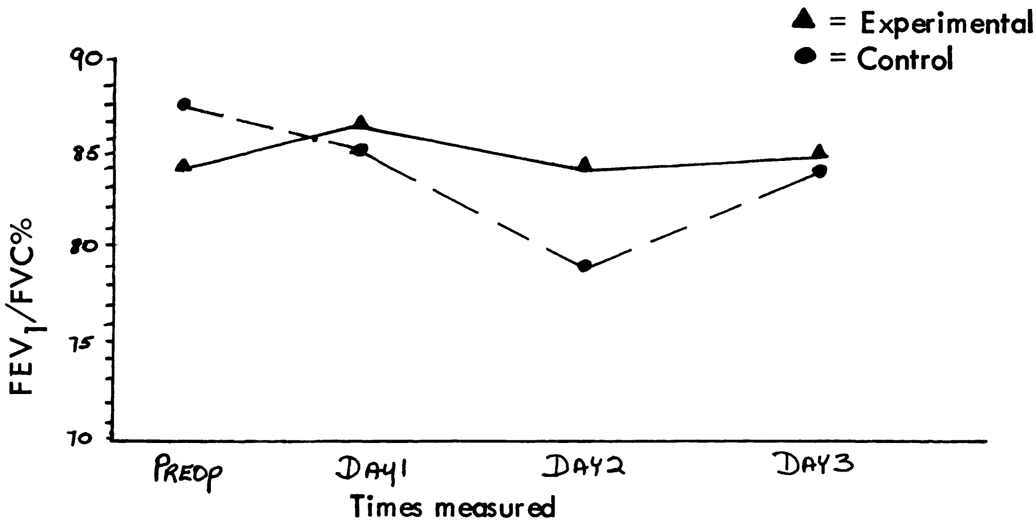

Figure 4. Comparison of Group Mean Scores of One Second Forced Expiratory Volume expressed as a Percentage of the Forced Vital Capacity.

Null Hypothesis IV

It was predicted that measurements on three consecutive postoperative days for the forced maximum mid-expiratory flow corrected for the forced vital capacity and expressed as a ratio ($MMF_{25-75\%}$ / FVC) would demonstrate no significant differences between upper abdominal surgical patients who experience a teaching program emphasizing deep breathing and coughing and those who receive the nursing approach currently used. Although differences between groups from Preoperative to Postoperative Day 1 approached significance and from Preoperative to Postoperative Day 3 were significant, because no statistically significant differences were found in the raw scores on any postoperative days, the hypothesis was accepted.

The decrease in the postoperative measurements of FEV_1/FVC% for the control group was more apparent in this more sensitive measure. On Day 1 the total for the two groups (N=22) remained within normal limits with a mean $MMF_{25-75\%}$ / FVC of 1.04 and a S. D. of 0.251. The mean for the experimental group was 1.07 with a range from 0.54 to 1.36 and a S. D. of 0.268. The control group's mean was 1.02 with a range from 0.58 to 1.38 and a S. D. of 0.244. As in the FEV_1/FVC%, when compared to the preoperative values, the mean $MMF_{25-75\%}/FVC$ for the experimentals increased on Day 1, while that for the controls decreased. The experimental group's ratio increased by 0.12 and the control group decreased by 0.14. The only patient found to have an abnormal $MMF_{25-75\%}/FVC$ on the first postoperative day was the same patient in the experimental group who had an abnormal measurement before surgery.

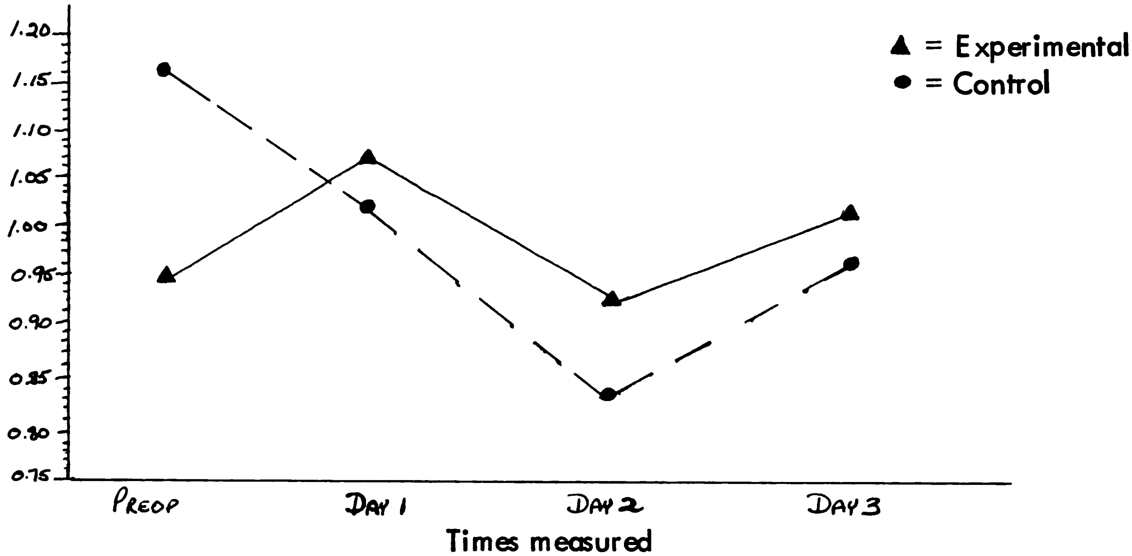

Figure 5. Comparison of Group Mean Scores of Forced Maximum Mid-Expiratory Flow corrected for the Forced Vital Capacity.

On Day 2 the flow rates for both groups decreased from Day 1. The experimental group mean (N=10) decreased to 0.92 and the control group mean (N=9) to 0.82. One patient in the control group had a $MMF_{25-75\%}/FVC$ below the normal range. The mean ratio for both groups increased on Day 3 the experimental group (N=10) increasing to 1.01 and the control group (N=9) to 0.96. There were no significant differences found between the groups in the raw scores on either of the three postoperative days, however, there were statistically significant differences in the change scores. From Preoperative to Day 1 the group differences approached significance ($p. < .10$) with the control group having a greater decrease in $MMF_{25-75\%}/FVC$. From Preoperative to Day 3 the control group's $MMF_{25-75\%}/FVC$ decreased more than the experimental group, with significance at the .01 level. Although these differences were found, because they were not evident in the raw data on each postoperative day and were not present for

three consecutive days, the null hypothesis of no differences was accepted.

Null Hypothesis V

This hypothesis which predicted that measurements on the second and third postoperative days of the partial pressure of oxygen in arterial blood (Pa_{O2}) would demonstrate no significant differences between upper abdominal surgical patients who experience a teaching program emphasizing deep breathing and coughing and those who receive the current nursing approach was accepted.

The measurements of Pa_{O2} following surgery were quite similar for the two groups. Postoperative Day 2 the mean Pa_{O2} for the total sample (N=17) was 65 mm. Hg with a S. D. of 6.96. This was a mean decrease of 15 mm.Hg from the preoperative measurements. The experimental group (N=9) had a mean Pa_{O2} of 66 mm.Hg with a range from 52 to 75 mm.Hg and a S. D. of 7.18. The control subjects (N=8) had a mean of 64 mm.Hg with a range from 53 to 74 mm.Hg and a S. D. of 7.06. Both groups had a mean decrease of 15 mm.Hg from the preoperative value.

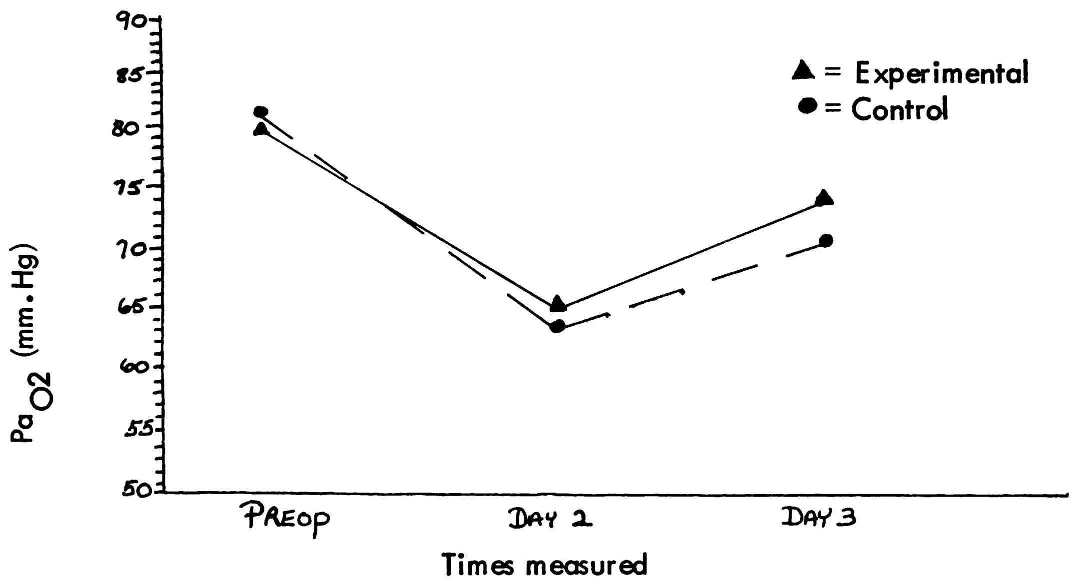

Figure 6. Comparison of Group Mean Scores of the Partial Pressure of Oxygen in Arterial Blood.

On Postoperative Day 3 the total sample (N=18) mean increased to a Pa_{O2} of 72 mm.Hg with a S. D. of 8.28. This represented a decrease of 8 mm.Hg from preoperative and an increase of 5 mm.Hg from Day 2. The experimental group (N=10) had a mean of 74 mm.Hg with a range from 63 to 84 mm.Hg and a S. D. of 6.41. The control group (N=8) had a mean of 71 mm.Hg with a range from 59 to 87 mm.Hg and a S. D. of 10.44. The decrease in Pa_{O2} from Preoperative to Day 3 was slightly greater for the control group, i.e., the mean change for the experimentals was -6 mm.Hg, while that for the control group was -10 mm.Hg. Using the change scores available (N=15) from Day 2 to Day 3 the mean Pa_{O2} increased for both groups with the increase of +8 mm.Hg for the experimental group (N=8) being slightly greater than the +3 mm.Hg for the control group (N=7).

Although the control group had a slightly greater decrease in Pa_{O2} from Preoperative to Postoperative Day 3 there were no statistically significant differences found between the groups either for the change scores or the raw scores on the two postoperative days.

Null Hypothesis VI

This hypothesis predicted that measurements on the second and third postoperative days of the alveolar-arterial difference on room air ($A\text{-}aDO_2$) would demonstrate no significant differences between upper abdominal surgical patients who experience a teaching program emphasizing deep breathing and coughing and those who receive the nursing approach currently used. The hypothesis was accepted.

On Postoperative Day 2 the mean alveolar-arterial gradient on room air for the total sample (N=17) was 47.32 mm.Hg. The control group (N=8) mean of 49.31 mm.Hg with a S. D. of 5.84 was slightly higher than the experimental group's mean (N=9) of 45.54 mm.Hg with a S. D. of 9.79. The experimental group increased by 16.31 mm.Hg while the control group increased by 14.51 mm.Hg.

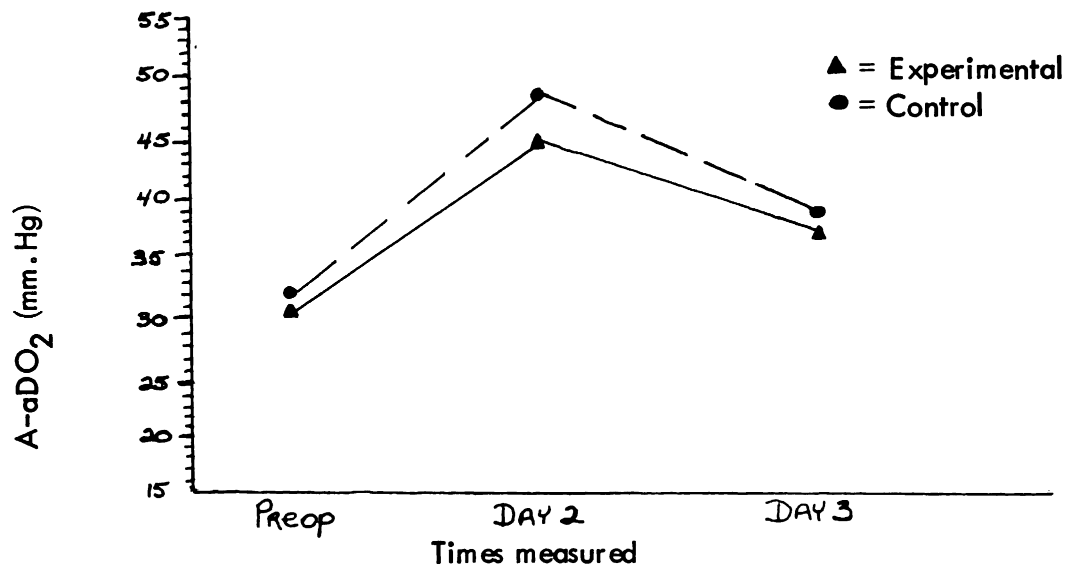

Figure 7. Comparison of Group Mean Scores of the Alveolar-Arterial Difference on Room Air.

As reflected in the increased Pa_{O2}, the third postoperative day the $A\text{-}aDO_2$ decreased for both groups. The total sample mean (N=18) was 39.12 mm.Hg. The experimental group (N=10) decreased to 38.48 mm.Hg with a S. D. of 6.23 and the control group (N=8) to 39.91 mm.Hg with a S. D. of 9.23. This represented a decrease from Day 2 of 8.39 mm.Hg for the experimentals (N=8) and 5.44 mm.Hg for the controls (N=7). Although the experimental group had a slightly greater improvement from Postoperative Day 2 to Day 3, there were no statistically significant differences in the scores between the groups.

Null Hypothesis VII

It was predicted that measurements on the second and third postoperative days of the partial pressure of carbon dioxide in arterial blood (Pa_{CO2}) would demonstrate no significant differences between upper abdominal surgical patients who experience a teaching program emphasizing deep breathing and coughing and those who receive the nursing approach currently used. The hypothesis was accepted.

Hypocapnia continued into the postoperative period. The mean Pa_{CO2} for the total sample (N=17) on Postoperative Day 2 was 35 mm.Hg with a S. D. of 4.14. The experimental group (N=9) had a mean Pa_{CO2} of 36 mm.Hg with a range from 30.5 to 44 mm.Hg and a S. D. of 4.17, while the control group (N=8) had a mean of 34 mm.Hg with a range from 30 to 40 mm.Hg and a S. D. of 4.11. The changes in this measurement from preoperative were minimal with no change in the control group mean and a decrease of 1 mm.Hg for the experimental group. On Postoperative Day 3 the mean Pa_{CO2} for the total sample (N=18) was 36 mm.Hg with a S. D. of 3.78. The experimental mean (N=10) was 35 mm.Hg with a S. D. of 4.21 and the control mean (N=8) was 37 mm.Hg with a S. D. of 2.98. From Postoperative Day 2 these measurements represented an increase of 1 mm.Hg for the experimental subjects (N=8) and 3 mm.Hg for the control group (N=7). There were no statistically significant differences between the two groups.

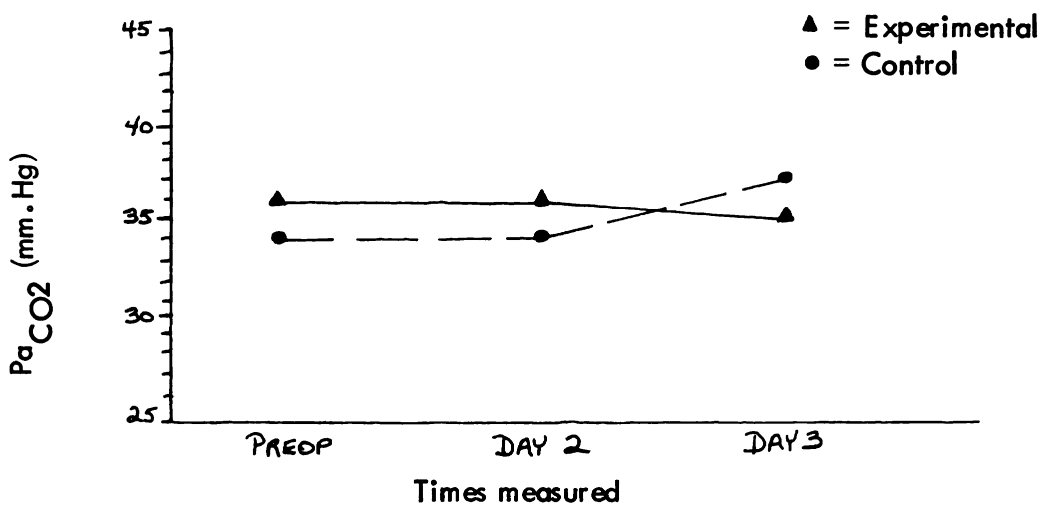

Figure 8. Comparison of Group Mean Scores of the Partial Pressure of Carbon Dioxide in Arterial Blood.

Null Hypothesis VIII

It was postulated that measurements on the first postoperative day of the percentage of venous-to-arterial shunt ($\dot{Q}s/\dot{Q}_T\%$) would demonstrate no significant differences between upper abdominal surgical patients who experience a teaching program emphasizing deep breathing and coughing and those who receive the nursing approach currently used. The hypothesis was accepted.

The total sample (N=20) mean of the percentage of venous-to-arterial shunt on Postoperative Day 1 was 10.9% with a S. D. of 3.25. The experimental group (N=10) mean $\dot{Q}s/\dot{Q}_T\%$ increased to 10.6% with a range from 7.0 to 18.8% and a S. D. of 3.82. The control group mean (N=10) $\dot{Q}s/\dot{Q}_T\%$ increased to 11.2% with a range from 7.8 to 16.8% and a S. D. of 2.73. Four experimental patients and 7 control patients had a $\dot{Q}s/\dot{Q}_T\%$ above 10%. The mean increase for the total sample from Preoperative to Postoperative Day 1 was 3.6% with the experimental group increasing by 3.4% and the control group by 3.9%.

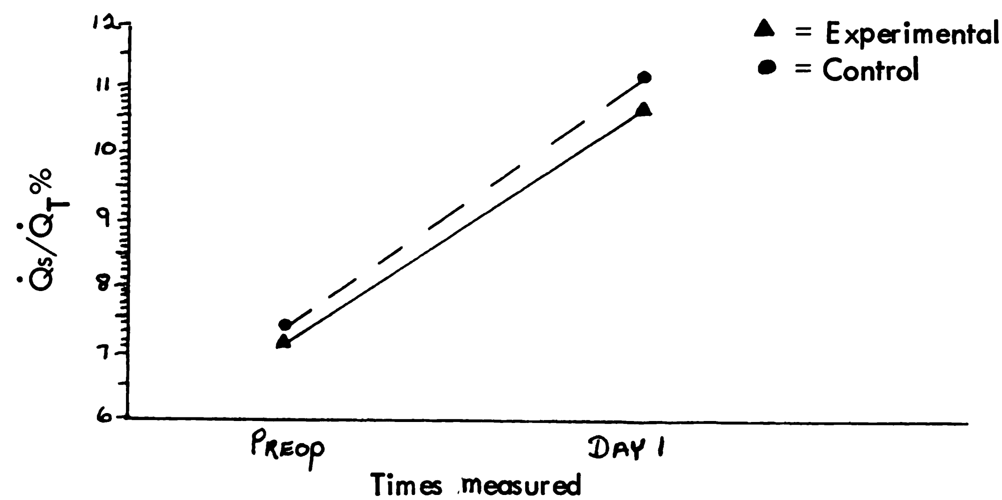

Figure 9. Comparison of Group Mean Scores of the Percentage of Venous-to-Arterial Shunt.

Although the control group had a slightly greater percentage of venous-to-arterial shunt than the experimental subjects on the first postoperative day, there were no statistically significant differences between the groups in these scores or the change scores.

Null Hypothesis IX

It was predicted that measurements on the second and third postoperative days of the pH of arterial blood would demonstrate no significant differences between upper abdominal surgical patients who experience a teaching program emphasizing deep breathing and coughing and those who receive the nursing approach currently used. The hypothesis was accepted.

Changes in the pH of arterial blood were small. The tendency toward alkalemia for the total sample preoperatively remained in the postoperative period. On Postoperative Day 2 the arterial pH for the total sample (N=17) was 7.45 with a S. D. of 0.020. The experimental (N=9) mean arterial pH was 7.45 with a range from 7.40 to 7.48 and a S. D. of 0.024. The control group (N=8) mean was 7.46 with a range from 7.43 to 7.48 and a S. D. of 0.018.

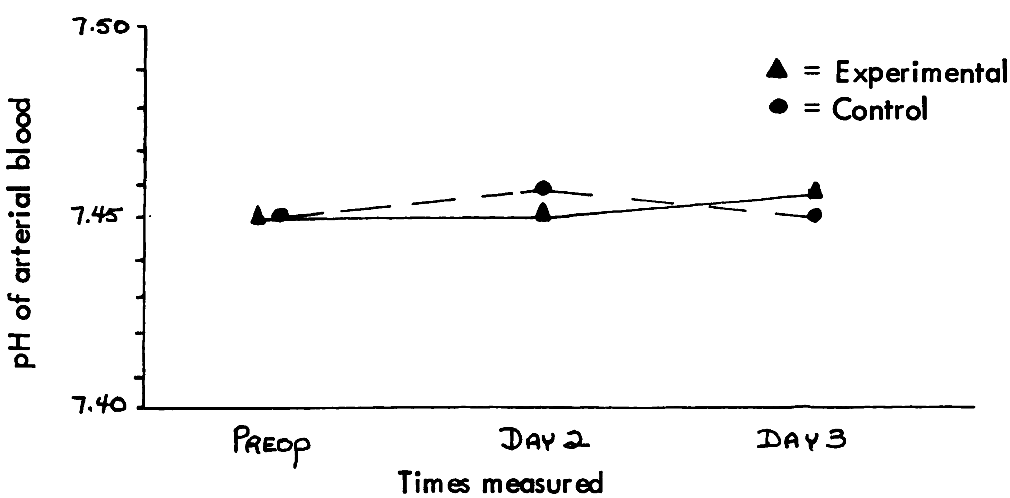

Figure 10. Comparison of Group Mean Scores of the pH of Arterial Blood.

On Postoperative Day 3 the measurements continued to be essentially the same as on Day 2. The mean arterial pH for the total sample (N=18) and the experimental group (N=10) was 7.46, while that for the control group was 7.45. No statistically significant differences were found between the two groups.

General Null Hypothesis

This hypothesis predicted that there would be no significant differences in postoperative ventilatory capacity measured on three consecutive postoperative days between upper abdominal surgical patients who experience a teaching program emphasizing deep breathing and coughing and those who receive the nursing approach currently used. The hypothesis was accepted.

Two statistical tests were used to examine all variables simultaneously for possible significant differences between groups. The first analysis utilized Bradley's (1968) method for testing main effects among several variables. This analysis was followed by the use of Rosenthal and Ferguson's (1965) non-parametric comparisons test based on Hotelling's T^2 (Li, 1964). Because there were no statistical differences between the two groups in the preoperative measurements it was only necessary to use the raw scores on each postoperative day.

The described statistical tests used only the numbers to rank the variables. The labels of the variables were disregarded. For a greater understanding of the statistical results related to the general hypothesis it is important to note the physiological meaning of the relative position or rank of each dependent variable. On a health-disease physiological continuum the higher ranking of FVC% predicted, FEV_1% predicted, FEV_1/FVC%, $MMF_{25-75\%}$/FVC and Pa_{O2} is preferred and nearer to normality. In contrast, the lower ranking of A-aDO_2 and $\dot{Q}s/\dot{Q}_T$% are closer to the normal range. Since there was only minimal change in the Pa_{CO2} and pH, these two variables were considered to have no effect on the ranking of the variables simultaneously. Since a higher ranking of the first five of the seven remaining variables would denote increased ventilatory capacity, it was assumed that when the variables were ranked simultaneously a higher rank would reflect a more normal pulmonary function. All the dependent variables that were used to measure ventilatory capacity were considered in the analysis of the variables simultaneously.

On Postoperative Day 1 the Rank Sum for the experimental group (N=11) was 147.5 and for the control group (N=11) 105.5. In order to obtain an N of 11 for both groups the average percentage of venous-to-arterial shunt ($\dot{Q}s/\dot{Q}_T\%$) for the total sample was used for the one subject with missing data in each group. The test statistic indicated no significant difference between the two groups for the total of variables on the first postoperative day.

The data on Day 2 resulted in Rank Sums of 92 for the experimental group (N=9) and 44 for the control group (N=7). There was no statistically significant difference between the groups on Day 2.

The Rank Sums on Postoperative Day 3 were 98 for the experimental group (N=10) and 55 for the control group (N=7). These results indicated no statistically significant difference between the groups at this time.

The dependent variables were also examined simultaneously by using a rank analog to Hotelling's T^2 test described in Chapter IV. The general form of the contrasts is given by: Psi $\hat{\psi} = \bar{R}_K - \bar{R}_{K'}$, where $\bar{R}_K$ is the rank average of the Kth condition.

On Postoperative Day 1 the contrast scores across all available variables between the experimental and control groups resulted in the following contrast:

$$\hat{\psi}_1 = 3.82 \pm 4.09$$

Variables = 5
Experimental N = 11
Control N = 11
$\widehat{Psi} = \bar{R}_{Ex} - R_{Control}$

Since this contrast covers O it is not significant and provides no predictive information.

On Postoperative Day 2 the results of the contrast across all available variables between the experimental and the control group were the following:

$$\hat{\psi}_2 = 3.93 \pm 3.49$$

Variables = 8
Experimental N = 9
Control N = 7
$\widehat{Psi} = \bar{R}_{Ex} - \bar{R}_{Control}$

This contrast does not cover O, therefore, it can be stated with 95% probability that the experimental group ranked higher for these simultaneous measures than did the control group. This may be written in the following manner:

$$P = \left[.44 < \bar{R}_{Ex} - \bar{R}_{Control} < 7.42 \right] = .95$$

On Postoperative Day 3 this significant difference between the groups disappeared. The contrast across all available variables between the experimental and control group resulted in the following:

$$\hat{\psi}_3 = 1.59 \pm 3.71$$

Variables = 8
Experimental N = 10
Control N = 7
$\widehat{Psi} = \bar{R}_{Ex} - \bar{R}_{Control}$

Rank Correlations

The available dependent variables and the variables of age and length of surgery were used to perform rank correlations for Postoperative Day 1 and 2. The rank correlations for Postoperative Day 1 are presented in Table 10. The average $\dot{Q}s/\dot{Q}_T\%$ of the total sample for the two subjects missing this measurement was used to obtain

TABLE 10
Rank Correlation Matrix of Selected Variables
on Postoperative Day 1 (N=22)

	Age	Surgery Length	FVC% pred.	FEV_1% pred.	FEV_1/FVC%	MMF/FVC 25-75%	$\dot{Q}s/\dot{Q}_T$%
Age	X						
Surgery Length	-.02	X					
FVC% pred.	-.29	-.02	X				
FEV_1% pred.	-.46*	+.13	+.91**	X			
FEV_1/FVC%	-.18	+.27	-.10	+.20	X		
MMF/FVC 25-75%	-.27	+.34	-.04	+.26	+.83**	X	
$\dot{Q}s/\dot{Q}_T$%	+.27	-.08	+.18	+.07	+.30	-.24	X

*p $<$ .05
**p $<$ .001

an N of 22. With the exception of the known strong relationships between the variables which measure the same physiological phenomenon or are partially determined by the same physical attributes, there were no statistically significant relationships found in this treatment of the data.

When age was compared with the variables included in the matrix the only statistically significant relationship found was with the FEV_1% predicted of -46. This finding would be expected since the predicted values for the FEV_1% are dependent on age and height. The strong positive relationship between the FVC % predicted and the FEV_1% predicted (+.91) is also in agreement with available knowledge since the measure of FEV_1 is dependent on lung volume (FVC). A significant relationship of +.83 was found between the two measures of flow rate corrected for the forced vital capacity. Since these two criterion measures, FEV_1/FVC % and $MMF_{25-75\%}/FVC$, are indices of the same physiological phenomenon this relationship was expected. Principles described in the theoretical framework of this study would predict a strong negative relationship between the $\dot{Q}s/\dot{Q}_T$ and the FVC % predicted, however, this relationship was not found.

The rank correlations for Day 2 are presented in Table 11. The significant relationship between age and FEV_1% predicted did not remain. The statistically significant relationships between the measures of flow (+.87), and between the FVC % predicted and FEV_1% predicted (+89) were again evident on Day 2. A-aDO_2 and the Pa_{O2} measure the same physiological phenomena, the amount of oxygen in the arterial blood, therefore, one would predict the strong negative relationship found between these two variables (-.78). Although they did not reach significance three remaining relationships are evident on Day 2. Pa_{O2} decreased with an increase in age. As predicted by the accepted principle of hypoventilation, the Pa_{CO2} increased as the

TABLE 11
Rank Correlation Matrix of Selected Variables
on Postoperative Day 2 (N=18)

	Age	Surgery Length	FVC% pred.	FEV_1% pred.	FEV_1/FVC%	MMF/FVC 25-75%	Pa_{O2}	Pa_{CO2}	$A\text{-}aDO_2$
Age	X								
Surgery Length	-.01	X							
FVC% pred.	+.04	-.20	X						
FEV_1% pred.	-.06	-.13	+.89***	X					
FEV_1/FVC%	-.08	+.20	+.30	+.64**	X				
MMF/FVC 25-75%	-.03	+.10	+.26	+.60**	+.87***	X			
Pa_{O2}	-.43*	+.25	+.29	+.21	+.23	+.12	X		
Pa_{CO2}	-.02	-.20	-.30	-.34	-.34	-.45*	-.15	X	
$A\text{-}aDO_2$	+.35	-.24	-.21	-.04	-.05	-.25	-.78***	-.23	X

*p < .10
**p < .01
***P < .001

measurements of $FEV_1/FVC\%$ and $MMF/FVC_{25-75\%}$ decreased.

Analysis of Intervening Variables: Smoking History and IPPB Therapy

Following the analyses of the main effect of the experimental teaching program, the possible effects of smoking history and IPPB therapy were examined. Although these variables were controlled by randomization, the investigator was interested in any possible effect these significant variables may have had on postoperative pulmonary function. Because no statistically significant effects were found for the teaching program it was possible to examine the differences in dependent variables between and within groups preoperatively, for each postoperative day, and for change scores from day to day. This data is presented in Appendix D.

Smoking History

The analysis of the raw data on each postoperative day illustrated no statistically significant differences between the smokers and non-smokers across the two groups. Examination of the difference scores from preoperative demonstrated one statistically significant difference ($p < .01$) with the smokers having a greater increase in alveolar-arterial difference on air from Preoperative to Postoperative Day 2. This difference was not reflected in the measurement of Pa_{O2} on that day nor was it continued on Day 3. The examination of the effect of smoking on the variables of pulmonary function within each group on each postoperative day resulted in one statistically significant difference. The control smokers had a significantly lower pH ($p < .05$) on Postoperative Day 2 than the control non-smokers. The mean pH for both control groups, however, were within normal limits.

IPPB Therapy

The analysis of the raw data on each postoperative day and the change scores from day to day resulted in no statistically significant differences at the .05 level in total rank sums between those receiving IPPB therapy and those not receiving the treatments either across the groups or within the groups.

Analysis of Dependent Variables Not Included in Proposed Hypotheses

The dependent variables of temperature elevation, narcotics required, and length of hospitalization, although not included in the hypotheses of the study, were recorded and subjected to the Wilcoxen Rank Sum Test whenever possible. These variables have previously been reported as valid measures of postoperative recovery (Thoren, 1965; Healy, 1968; Egbert et al., 1964).

Seven patients in each group had a temperature elevation above 99 degrees Farenheit postoperatively. The temperature elevation remained over three postoperative days for one control and four experimental patients. One experimental and one control patient reached an elevation of 102 degrees Farenheit on Postoperative Day 1.

No statistically significant differences were found in the number of narcotics required postoperatively between the experimental and control groups, smokers and non-smokers, or patients receiving and not receiving IPPB therapy. Morphine sulfate 10 mg. and demerol 75 mg. with vistaril 50 mg. were the usual medications ordered for the relief of postoperative pain. The mean number of medications received for both groups was 8 with a range of 2 to 15 for the experimentals and 3 to 12 for the controls.

The average length of hospitalization for the experimental group was 7.36 days with a range from 5 to 13 days, while that for the control group was 6.27 days with a range from 5 to 7 days. One patient in the experimental group was found to have an ovarian cyst on surgical examination and, therefore, her discharge was delayed to complete laboratory tests. This difference between the groups was not statistically significant. No significant differences were found in the total sample between smokers and non-smokers or patients receiving IPPB therapy and not receiving IPPB.

Summary of Results

Preoperative baseline measurements of all dependent variables were within normal limits and did not differ significantly between the experimental and control groups. The groups were considered equal in those extraneous variables which have been shown to have some effect on pulmonary function. Because no statistically significant differences at the .05 level for a two-tailed test were found between the groups when the raw data for each postoperative day was analyzed all null hypotheses were accepted. The additional analysis of change scores from day to day did demonstrate a slightly greater postoperative improvement in ventilatory capacity for the experimental group. This difference was reflected in the following findings:

1. The difference between the groups in the change in $FEV_1/FVC\%$ from Preoperative to Postoperative Day 3 approached significance ($p < .10$) with the experimental group demonstrating the higher measurements.
2. From Preoperative to Postoperative Day 1 the controls had a greater decrease in $MMF_{25-75\%}/FVC$ ($p < .10$) than the experimentals.
3. From Preoperative to Postoperative Day 3 the control group had a statistically significant ($p < .01$) greater decrease in $MMF_{25-75\%}/FVC$ than the experimental group.
4. Analysis of all variables simultaneously demonstrated a statistically significant higher ranking for the experimental group on Postoperative Day 2.

The results of the analysis of those variables not included in the hypotheses, temperature elevation, narcotics required, and length of hospitalization, demonstrated no statistically significant differences between the experimental and control groups. With the exception of the known relationships between variables which measure the same physiological phenomenon or are partially determined by the same physiological characteristics, rank correlations of the dependent variables on Postoperative Day 1 and 2 yielded no significant relationships between selected variables for this sample of patients. Smoking history and IPPB therapy did not have a significant effect on the postoperative ventilatory capacities of those patients used for this study.

CHAPTER VI

DISCUSSION

This chapter is presented in three sections. In the first section the physiological findings of the study are presented and inferences derived from these findings are discussed.

In the second section the results of the study are examined in relation to established theory and previous studies.

In the final section implications for nursing practice and recommendations for further study of the problem area are suggested.

Discussion of Findings

Since no statistically significant differences in postoperative ventilatory capacity were found between the experimental and control groups when the data were analyzed for each postoperative day, all null hypotheses were accepted. The two groups were considered to be equivalent in those intervening variables which may affect ventilatory capacity and the analysis demonstrated that smoking history and IPPB therapy had no significant effect on the dependent variables.

Postoperatively, all patients in this study had a marked decrease in lung volume. The decrease on Postoperative Day 1 to 45% predicted for the experimental group and 37% predicted for the control group was similar to that found in previous studies (Anscombe, 1957; Pecora, 1969; Latimer et al., 1971; Lindeman and Van Aernam, 1971). Although the difference did not reach significance, the experimentals had a slightly greater increase in FVC% predicted over postoperative time. Dependent on lung volume, the FEV_1% predicted decreased in the same manner as the FVC% predicted and there were no significant differences between the groups in this measure.

Although no statistically significant differences were found in the scores on each postoperative day, examination of the less sensitive measure of flow in the airways, $FEV_1/FVC\%$, suggests that the experimental group did slightly better in this measurement, possibly by increasing their effort. On Postoperative Day 1 the experimental mean $FEV_1/FVC\%$ increased by 3% from the preoperative measurement. In contrast, the control group decreased by 2%. By Postoperative Day 3 the experimental group had increased to 86% and was 2% higher than the preoperative value, while the control group's $FEV_1/FVC\%$ of 85% remained lower than the preoperative value. This greater improvement for the experimental group was reflected in the change scores from Preoperative to Day 3 which approached significance ($p < .10$), with the control group having a greater decrease in $FEV_1/FVC\%$.

The suggestion of greater obstruction in the control group became more apparent when the more sensitive measure of flow, the $MMF/FVC_{25-75\%}$, was analyzed. From Preoperative to Postoperative Day 1 the experimental mean increased by 0.12, while the control group mean decreased by 0.14, a difference in change scores which approached significance ($p < .10$). After a decrease on Postoperative Day 2 for both groups, on Day 3 the experimental mean $MMF/FVC_{25-75\%}$ increased to .07 above the preoperative value. In contrast, the control group mean continued to be lower than the preoperative measurement by 0.21. This difference between the groups in the change from Preoperative to Day 3 was statistically significant at the .01 level with a greater decrease in the $MMF/FVC_{25-75\%}$ for the controls. The finding of a lower mean $MMF/FVC_{25-75\%}$ in the control group, in the presence of a mean $FEV_1/FVC\%$ within normal range, suggests obstruction limited to the smaller airways, i.e., 2 millimeters or less in diameter (Hogg, Macklem, and Thurlbeck, 1960; Macklem and Mead, 1967; Woolcock, Vincent, and Macklem, 1969; Levine et al., 1970; Macklem, Thurlbeck, and Fraser, 1971). This isolated reduction in $MMF_{25-75\%}/FVC$ has been shown to correlate with patients who had histologically proven small airways obstruction and physiologic abnormalities limited to frequency dependence of compliance (Gelb et al., 1973; Gelb and Zamel, 1973a).

All of the patients in the sample developed a decreased Pa_{O2} and an increased $A\text{-}aDO_2$ on air on Postoperative Day 2, which continued on Postoperative Day 3. These findings are consistent with the findings of previous studies (Nunn and Payne, 1962; Palmer and Gardiner, 1964; Hamilton et al., 1964; Marshall et al., 1969). No statistically significant differences in oxygen exchange were found between the groups, however, the experimental group did have a slightly greater increase in Pa_{O2} from Day 2 to Day 3.

The postoperative hypoxemia was not accompanied by an increase in Pa_{CO2}. The hypocapnia found in the majority of preoperative measurements continued postoperatively. The hypocapnia was assumed to be due to patient hyperventilation resulting from "needle anxiety" or the patients' attempts to compensate for a decreased functional residual capacity in the supine position (Ward et al., 1966c). Again, the finding of postoperative hypoxemia without an increase in Pa_{CO2} has been described in numerous studies (Bjork and Hilty, 1954; Gordh, Linderholm and Norlander, 1958; Nunn and Payne, 1962). Since the Pa_{CO2} did not increase for any sample patients, the hypoxemia found in this study is not due to hypoventilation. Because diffusion abnormalities are almost never severe enough to prevent equilibration between gas in the alveoli and capillary blood at rest (Finley, Swenson, and Comroe, 1962), the hypoxemia is a result of either venous-to-arterial shunting or maldistribution. These abnormalities in ventilation are assumed to be partly related to premature airway closure secondary to recumbency and a decrease in tidal volume, respiratory rate, and lung compliance (LeBlanc, Ruff, and Milic-Emili, 1970; Burger and Macklem, 1968). Proof of the presence of venous-to-arterial shunting is seen on the first postoperative day when the mean $\dot{Q}s/\dot{Q}_T\%$ increased to 10.6% for the experimentals and 11.2% for the controls. Although the amount of $\dot{Q}s/\dot{Q}_T\%$ for both groups was increased, this amount of venous-to-arterial shunting is not as great as expected with the high mean $A\text{-}aDO_2$ for both groups (Day 2: E = 47.32 mm.Hg, C = 49.31 mm.Hg; Day 3: E = 38.48 mm.Hg, C = 39.91 mm.Hg). Unfortunately, the $\dot{Q}s/\dot{Q}_T\%$ was not measured on Day 2 and 3, therefore, the exact amount of venous-to-arterial shunting cannot be distinguished from maldistribution. If the $\dot{Q}s/\dot{Q}_T\%$ was similar to that found on Day 1, the mean venous-to-arterial shunt does not appear great enough to account for the total $A\text{-}aDO_2$. Therefore, it must be assumed that a large part of the hypoxemia was due to mismatching of ventilation and perfusion or maldistribution. Many investigators, as well as this investigator, have found that an increased $A\text{-}aDO_2$ is primarily due to abnormalities in the ventilation-perfusion ratio (Farhi and Rahn, 1955; Briscoe, 1959; Lenfant, 1963; Mellemgard, 1966). In contrast, the studies presented in the theoretical framework reported that maldistribution contributed little to postoperative hypoxemia (Gordh, Linderholm and Norlander, 1958; Hamilton et al., 1964; Diament and Palmer, 1966; Pecora, 1969).

While it might be expected that the control group with the lower $MMF_{25-75\%}/FVC$ and small airways involvement would have a statistically significant greater $A\text{-}aDO_2$, it has been shown that small airways disease may occur with a borderline or normal $A\text{-}aDO_2$, probably as a result of collateral ventilation (Ingram and Schilder, 1966; Levine et al., 1970; McFadden and Linden, 1972; Gelb and Zamel, 1973b).

The experimental group had a slightly greater improvement in $A\text{-}aDO_2$ from Day 2 to Day 3 and a slightly smaller increase in $\dot{Q}s/\dot{Q}_T\%$ from Preoperative to Day 1.

Therefore, the teaching program may have had some effect on the amount of venous-to-arterial shunting or maldistribution in the postoperative period. The teaching program did have some effect on the patients regaining lung volume in the postoperative period and on the flow rates, especially $MMF/FVC_{25-75\%}$. Patients in the experimental group had less incidence of small airways obstruction postoperatively. The differences in lung volume and flow rate are supported by the statistically significant difference between the groups found on Day 2 when the dependent variables were analyzed simultaneously. The experimental group ranked significantly higher on Day 2 when all variables were considered. A number of variables were used simultaneously in this test, therefore, there is no way to determine absolutely which variables had the decisive effect or which combination of variables was responsible for the significant finding. If the following can be accepted: 1) Pa_{CO2} and pH do not vary and, therefore, have no effect; 2) the $A\text{-}aDO_2$ and Pa_{O2} measure the same phenomena, therefore, cancel each other; then, the remaining variables, $\dot{Q}s/\dot{Q}_T\%$, FVC% predicted, $FEV_1\%$ predicted, $FEV_1/FVC\%$, and $MMF/FVC_{25-75\%}$ are most likely the ones that increased the score of the experimental group. Since 4 of these 5 variables indicate improved ventilatory capacity when their values are higher, this analysis gives further evidence that the experimental teaching program had a positive effect on the mechanical function of the lungs.

Questions Related to the Findings

If periodic hyperinflations prevent a fall in lung volume and compliance, and decrease the amount of venous-to-arterial shunting in the laboratory situation (Bendixen et al., 1964; Hedley-Whyte et al., 1965) it is necessary to question why the teaching program, which included information about and patient practice in deep breathing, did not significantly affect postoperative ventilatory capacity. Examination of the theoretical bases of this study and the environment and methodology used may give insight into the reasons for the lack of significant differences between the groups. Three questions might be asked of the teaching program and its effects: 1) Did adequate learning take place preoperatively?, 2) Did the patients perform the exercises postoperatively?, and 3) If the patients did perform the exercises, were the maneuvers performed frequently enough to improve postoperative ventilatory function? It is possible that adequate learning may not have occurred. Modeling and reinforcement were utlized within the teaching strategy. The principle that the investigator be seen as expert in her speciality, in order to be an influential model and gain the attention of the patient was supported by patient comments such as, "You are a great nurse," "One doesn't meet nurses like you." However, patients seemed to value the investigator's response to their immediate felt needs more than her assistance with deep breathing and coughing. The physician remained "the person in charge of my care," and patients were cautious to follow his instructions. Comments such as, "My doctor didn't mention that" or "Are you sure my doctor wants me to do that?" seemed to question the activities of the nurse investigator. Because the postoperative measurements were conducted on the ward, questions arose from the staff and other patients as to the nature of the equipment and procedures. This atmosphere may have influenced the patients' evaluation of the investigator as a competent model. Bandura proposes that "Exposure of a person to a complex set of stimuli is no guarantee that he will attend to the whole range of stimuli, that he will necessarily select and learn the relevant cues and disregard the irrelevant ones, or that he will even perceive the cues accurately" (1962, p. 261). The principles that learning can increase with overt practice, graduated modeling, verbal instruction and positive reinforcement were used in the teaching program. It is the opinion of the investigator that the period for practice and positive reinforcement was inadequate to affect a change in behavior, i.e., learning, especially when the behavior entailed subjecting oneself to increased pain. There was not enough time for the behavior to become automatic or to acquire secondary reinforcement properties which would operate in the absence of direct reinforcement when the investigator was not present. The thirty minute preoperative session was possibly too short to develop a pattern of positive reinforcement that could be anticipated and would, therefore, increase the probability of performance. Certain motor skills are not learned merely by exposure, but require varying amounts of overt practice (Bandura, 1962). The mere prescription of behavioral rules is relatively ineffective in changing behavior. The power of verbal influence is largely determined by the anticipated or accompanying response consequences (Bandura, 1969). Although positive reinforcement was given by the investigator, the primary consequence accompanying the requested behavior of coughing and deep breathing for these patients was an increase in painful stimuli from their surgical incision. This negative effect which resulted from performing the exercises may have obliterated the expected positive reward of approval by the investigator. There are three major areas in which the application of modeling and reinforcement theory in the present study differed from many of Bandura's (1969) investigations: 1) an older age sample; 2) a shorter time period of modeling and reinforcement; and 3) the presence of painful stimuli while performing the desired behavior. It is the opinion of the investigator that these three factors may have decreased the effect of modeling and reinforcement on the postoperative behavior of these patients.

Did the patients perform the exercises frequently enough when the investigator was not present? It was assumed that patients' intrinsic motivation would be heightened by their need to re-establish a healthy state. Davis cautions that members of the health professions, who are only involved with the health values of society, may underestimate the concurrent attractiveness of other social values. Laymen may not be unaware of or indifferent to medical teaching, but they may be unable to integrate this information or value system with all else that engages them at the time (1963, p. 171). Closely allied to the assumption of the surgical patient's need to regain a healthy state is the principle that active participation by the learner is beneficial to learning and can aid in a more rapid return to physiological balance. The need for increased involvement of the patient in planning and decision-making had been advocated. However, Lederer (1965) suggests that after the patient has accepted diagnostic and initial therapeutic procedures he moves into a stage of "accepted illness" in which he views himself as ill and abandons pretenses of health. In the immediate postoperative period principles of active participation may be antagonistic to the environment surrounding the patient and his psycho-physiological state. In the stage of accepted illness the patient is in a setting which demands that the individual place himself in the hands of others. The acute condition demands an unconditional acceptance of the patient role and the dependency it entails (Wolff, 1964). At the same time, he may have a need for emotional dependency. Fink (1967) in his theoretical model of a crisis event describes this acute period as the shock phase. During this phase persons have emotions of anxiety and helplessness, and are unable to plan adequately to cope with the situation. "The patient's physical weakness, like that of a child, requires the strength of other persons to meet his needs. His regression into a self-centered, subjective world demands that healthier persons apply their more mature and objective judgment to his affairs . . ." (Lederer, 1965,

p. 161). This return to child-like behavior and great need for dependency is supported by Janis (1958) in his study of surgical patients. This dependency was reflected in the sample by their numerous requests for the investigator to help with their basic needs, and to listen to their feelings and experiences. It appeared that the basic needs of elimination, relief from pain and ambulation outweighed any fear or possibility of lung complications. They wanted to have things done for them rather than to assume the responsibility for activities themselves. The acutely ill patient moves to a stage of adaptation when there is an increase in satisfying experiences and he begins to be interested in helping himself. This was not demonstrated during the first three days postoperatively, despite the fact that the sample was instructed to perform certain behaviors by themselves. Based upon the findings of this study, the patient's ability for active participation and decision-making during the first 72 hours postoperatively seems questionable.

An absence of lung complications may not have been a priority goal of the patients. In Davis's study of polio patients (1963) only the passage of time and exacerbation of symptoms convinced the patients and their family of the physician's diagnosis. Without experiencing the symptoms of a complication of the lungs the experimental patients may not have been able to accept the importance of behaviors which would decrease possible complications. Without secondary reinforcement and the presence of a goal system, the patient may not have performed deep breathing when the investigator was not available. Also, it has been found that subjects may observe all the elements of a modeled behavior, but they may fail to reproduce the pattern due to physical limitations (Bandura, 1969). The thirty minutes of deep breathing and coughing on Day 1 and Day 2 in the investigator's presence would not be adequate. When asked if they were able to do the deep breathing and coughing without the investigator, most experimental patients replied, "I just did the blow bottles a little while ago," "I try but it hurts alot," "When I think about it, " etc. It appeared that the patients were not convinced that the maneuvers were necessary in addition to the inhalation therapy treatments which required very little patient effort. Strauss believes that patients continually evaluate medical regimens for efficiency and legitimacy. He describes certain conditions which must be met before a patient will adhere to a recommended regimen. The following conditions might be applicable to the present study: (1) initial or continuing trust in the person prescribing the regimen; (2) some one else doesn't supersede the person offering the regimen in legitimating; (3) evidence that the regimen works; (4) the non-appearance of distressing side effects (1973, p. 10). The patients in this study may not have developed trust in the investigator nor been given enough evidence that the exercises could decrease complications. In addition, after surgery the breathing exercises and coughing frequently increased the pain the patients were experiencing. Strauss also suggests that the amount of energy or effort needed to accomplish the procedure and the presence of symptoms are important in determining whether a patient will adhere to a regimen (1973, p. 14). Could the sample patients find sufficient energy to perform the exercises? Did the patients need some view of deterioration or symptoms to prompt them to adhere to a discomforting regimen? It may also be that during this period of acute stress and child-like behavior self-reinforcement processes are operating only at the basic level of meeting bodily needs, not at the level of improving one's state of health. Using Maslow's (1962) hierachy of human needs, Fink (1967) suggests that safety needs, e.g., physical health, protection from harm, and food, must be satisfied before an individual is motivated toward the growth needs of independence, achievement, or pursuit of knowledge. It was apparent to this investigator that this sample of patients studied in the immediate postoperative period were dominated by their safety needs. Future-oriented teaching related to growth needs requiring active participation of the patient seemed to be inappropriate in this phase of crisis for these patients.

The methodology and environment used for this study may have produced effects which confounded the results of the investigation. The procedures used to measure the variables of gas exchange required invasive techniques and were painful for some patients. It seemed to the investigator that several patients were more concerned with experiencing pain during postoperative measurements than with practicing and performing deep breathing and coughing. During the exploratory period of each teaching session patients frequently verbalized their fear of future arterial punctures and breathing 100 per cent oxygen. The reactive effect of testing may decrease the patients' sensitivity or responsiveness to the independent variable (Campbell and Stanley, 1963). It is possible that in this study the patients' pre-occupation with the procedures used to measure the dependent variables decreased attention, concentration and subsequent learning. It is also important to note the frequent vasoconstriction of the radial or brachial artery during the drawing of an arterial blood sample. There is the possibility that this vasospasm was also present in the pulmonary capillary bed and contributed to the incidence of ventilation-perfusion abnormalities.

The following characteristics of the institutional setting and methodology used for the present study are presented in contrast to those of previous investigators who found their teaching program to have a significant effect on a variety of pulmonary function measures. In the hospital used for this study, care given to upper abdominal surgical patients compared favorably with the postoperative care suggested for the prevention of postoperative complications (Bendixen et al., 1965; Secor, 1969). All sample patients received the following therapies: 1) information about the necessity for postoperative coughing during a preoperative visit with the physician in charge of their care; 2) inhalation therapy with assisted deep breathing and coughing, in the recovery room, every two hours for approximately 20 hours after surgery; 3) inhalation therapy on the ward every four hours; 4) ambulation in the recovery room, and; 5) assisted coughing and inhalation therapy every hour if a temperature elevation was evident. Other investigators who have reported significant results (Thoren, 1954; Healy, 1968; Lindeman and Van Aernam, 1971) have not described a comparable standard of pulmonary care for all patients. Thus, it seems to this investigator that their teaching programs were conducted in clinical settings where there was less attention to pulmonary function for the control patients. This research study was conducted by the investigator alone and the teaching program was necessarily limited to one preoperative and two postoperative 30 minute sessions. It is the opinion of the investigator that the use of numerous staff would increase the frequency of patient exposure to and practice in deep breathing and coughing over time, if only by increasing the nursing staff's awareness of the importance of lung function and measures necessary to prevent postoperative complications. Thoren (1954) utilized specially trained physiotherapists; and, in addition, all of the nursing staff assisted the patients with the respiratory exercises, which included postural drainage, several times a day. Thoren suggests that an essential part of the treatment "...is the constant repetition of the exercises for the patient under the supervision of the doctor and nurses in charge of the ward" (p. 202). Healy (1968) involved the staff nurses, anesthesiologists, physician in charge, and auxiliary personnel in her teaching program which included a follow-up plan with attention not only to exercises, but also family, analgesia, and ambulation. Lindeman and Van Aernam (1971) reported an earlier discharge and significantly greater improvement for the experimental group in postoperative FVC% predicted, FEV_1% predicted, and $MEFR_{200-1200}$. It is exciting that a preoperative teaching program has been found to affect the postoperative mechanical status of the lungs, however, the validity of the results of the study of these investigators is jeopardized by the possible effect of the variable of history. During the four month interval between the admission of the control and the experimental group, the medical, anesthesia, and nursing staffs participated in defining an effective postoperative "stir-up" regime, formulating a teaching plan, developing aids for teaching patients and staff members, and retraining of the nursing personnel. This investigator questions the effect this intensive educational program for all staff had on the level of postoperative care given to the experimental group which, in contrast with the control group, was treated after the retraining of the nursing personnel. It seems probable that the increased skill and awareness on the part of the nursing staff would increase the level of pulmonary care which, by itself without the teaching program, would improve the postoperative ventilatory capacity of the experimental patients.

Thoren (1954) and Lindeman and Van Aernam (1971) subjected their data to statistical analysis. It is assumed that these authors utilized a one-tailed test as the criterion for significance since the described hypotheses did not indicate the proposed direction of change. In contrast, a two-tailed test was used in the present study to determine any possible detrimental effects of the teaching program. The results of this study which approached significance at the .10 level would have been significant at the .05 level established for the study if a one-tailed test had been used.

Implications for Nursing Practice

If patients are not capable of planning, learning, or actively participating in their care during the period of acute illness, it is necessary to develop alternative nursing goals designed with consideration for the dependent needs and the motivational forces which are dominate during the phase of acute crisis. If teaching strategies are to be utilized, consideration might be given to the possibility of beginning teaching programs earlier in the preoperative period. If the patient is not admitted to the hospital for a lengthy preoperative period alternative systems of education should be explored. Methods might be developed which provide for teaching patients either in the home or during outpatient visits to the clinic or physician's office. The health team should not expect the patient to perform deep breathing and coughing without assistance while he is acutely ill and experiencing postoperative pain, unless the expected behavior has developed secondary reinforcement properties and become automatic. A longer period of modeling, reinforcement, and practice is required for the behavior to become a patient goal. The amount of time available in this study was inadequate. The results of this study indicate that in the initial postoperative period, when the patient is psychologically and physically dependent on the health team, he needs to be encouraged and helped to deep breath and cough frequently. The patients cannot be expected to have the motivation or physical capability to perform maneuvers by themselves as often as necessary. An important part of the postoperative care of surgical patients should be constant repetition and assistance with deep breathing and coughing exercises. The teaching program did decrease the incidence of small airways obstruction. Therefore, an effective teaching program appropriately carried out prior to the crisis period could further improve ventilatory capacity postoperatively in a facility where the patients' dependent needs are supported and constant assistance in coughing and deep breathing is given.

Patients recovering from surgery may be judged "less critical" than other patients, which creates some failure in the organization of treatment for these patients (Strauss, 1973). During this study the importance of assisting the patients to cope with their basic needs during the initial postoperative period was reinforced. Patients demonstrated a need for dependency which must be recognized and accepted. If a staffing pattern does not allow time for the professional nurse to meet the basic needs of postoperative patients, other less skilled health team members should be educated in the importance of anticipating requests for pain relief, ambulation, fluids, etc. The energy that patients devote needlessly to worrying about the fulfillment of their needs could be decreased by early anticipation of these needs by the staff. This patient energy could then be transferred to constructive efforts toward regaining a healthful state.

The results of this study indicate that nursing actions necessary to improve patients' lung function after surgery must be performed frequently and without interruption throughout all hours in the postoperative period. The required interventions such as, satisfying the patient's safety or basic needs, teaching with repetitive modeling and positive reinforcement over an extended period of time, helping the patient to effectively utilize inhalation therapy treatments, and assisting with deep breathing, coughing and position change must be performed diligently following a planned schedule of frequent assessment, intervention and evaluation. The importance of constant assessment and intervention in this acute crisis period creates the demand for all staff members to be knowledgeable in the theoretical principles and effective nursing interventions related to postoperative pulmonary atelectasis. It is evident that one designated respiratory nurse specialist cannot perform patient teaching and preventive actions frequently enough to significantly decrease the incidence of postoperative atelectasis for all patients undergoing surgery in a large acute care facility. It is the investigator's opinion that the specialist's primary objective must be the education of the staff.

Although procedures for decreasing the incidence of postoperative pulmonary complications are recognized and frequently discussed in the literature available to nurses, greater emphasis should be placed on the prevention and treatment of physiological changes which occur before frank atelectasis is evidenced by changes in physical examination, X-ray, and temperature. Although the patients in the experimental group of this study received the usual prescribed treatment for prevention of postoperative complications and the preoperative experimental teaching program, more than half of the total sample developed a postoperative temperature elevation, which may indicate pulmonary atelectasis. During the period of study this investigator questioned a sample of professional nurses in an intensive care unit about their understanding of atelectasis of the lung. The majority of this sample of nurses believed that atelectasis is confined to the later stages of lobular collapse or airway obstruction. It is important that instruction programs in pulmonary care include physiological content related to the more subtle changes predisposing to atelectasis; constant tidal ventilation, decreased respiratory rate, decreased lung compliance with subsequent venous-to-arterial shunting and hypoxemia. The nurse knowledgeable in the etiological mechanisms which promote early atelectasis will be prepared to prevent this complication through early observation, assessment and treatment.

One must also question the effect of the increased use of invasive techniques by the nurse upon the nurse-patient relationship. Do procedures that are sometimes painful impede the establishment of a nurse-patient relationship which has been built previously on comfort and support? Arterial blood oxygen and carbon dioxide partial pressures and pH are important diagnostic measurements in the care of surgical patients. Because of the evidence that postoperative atelectasis occurs before physical signs or X-ray changes are present, more frequent analysis of blood gases during the early postoperative period seem indicated. Professional nurses are being trained to assume this task (Petty, Bigelow and Levine, 1966; Sackner, Avery and Sokolowski, 1971). They must question whether this skill will increase their ability to assess and intervene during an acute emergency, or if this procedure is just another skill delegated to nurses to relieve overtaxed house staff (Sackner, Avery, and Sokolowski, 1971). McIntyre further suggests that while these technical skills may improve nursing assessment and judgment, they may alter the caring function (1971, p. 3).

The findings in this study emphasize the need for testing various models of patient teaching in the acute care setting. If the patient's attention and capabilities for learning are decreased during this stressful period, the nurse must develop and test new teaching strategies which allow for the psychophysiological state and environment in which the patient finds himself. Nurses should become more knowledgeable in the basic problem of patient regimens and the properties of a regimen that may or may not increase adherence to the regimen in a specific social setting.

Suggested Problems for Further Study of the Effect of Teaching Strategies on Postoperative Ventilatory Capacity

Research related to the teaching program utilized in this study might include the following changes in sample selection, independent variable, and dependent variables:

I. Sample Characteristics

A. No IPPB and blow bottle treatments

B. No smoking history

C. Other incisional sites (e.g., chest and lower abdominal)

II. Teaching Program

A. Additional preoperative teaching sessions, to increase the time available for modeling of the required behaviors and positive reinforcement of the patient

B. Additional postoperative practice the evening of surgery and during each shift, to increase the frequency of modeling cues, patient practice, and positive reinforcement

C. An evaluation of patient learning with a testing tool after the preoperative sessions

D. Inclusion of regular staff personnel to conduct the teaching sessions and postoperative practice

E. An assistant to conduct measurements of the dependent variables

F. Additional audiovisual aids and written information for patient use postoperatively

III. Comparisons of Teaching Programs

A. This program with groups of patients

B. Another teaching strategy (e.g., Lindeman and Van Aernam, 1971)

IV. Additional Criterion Measures

A. Venous-to-arterial shunting measured on the evening of surgery and Postoperative Days 2 and 3

B. Alveolar-arterial difference on air the evening of surgery and

Postoperative Day 1

C. Maximal-expiratory flow volume curve

D. Lung compliance

E. Functional residual capacity (FRC)

F. Patient evaluation of the teaching program

A variety of established programs concerned with preoperative teaching have been developed and are available to the nursing profession. An important advance in this problem area would be a synthesis of all available teaching programs into one standardized program. This could then be tested at various time intervals in relation to surgery and in a variety of settings with patients undergoing different surgical procedures.

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APPENDIX A

Experimental Teaching Program

Initial Introduction and Permission Request

Hi Mr. or Mrs.__________________. My name is Ginger Carrieri, I am a nurse. I am interested in ways of giving better care to patients, like yourself, who are going to have an operation. I am working in the pulmonary function laboratory and conducting a study of different methods of care for surgical patients, you have been selected to participate in this study. If you give your permission you will meet with me once before the operation and two times after surgery. During these meetings, which will be about twenty minutes in length, we will discuss different aspects of your care during and after surgery. You can decide whether you would like to take part in the study. If you say you will we will be taking a blood sample and doing a lung function test before surgery and once a day for three days after your operation. The blood samples are just about the same as the ones you may have had on the ward or will have before surgery. The lung function test only consists of breathing into a machine which tells the amount of air in your lungs.

(This explanation differed slightly with each patient as his questions and interest demanded).

I would really appreciate your being in the study and hope you will agree to participate. (If the patient would participate he was given the patient consent form to sign). I want you to know that I will be meeting with some of the other patients and if at all possible it would be better for the study if you didn't discuss with other patients or visitors the content of our conversations.

Topics of Conversation During Interactions with Control Group

I. Preoperative

Previous Surgery

Symptoms before this admission

Family

Environment

Occupation

II. Postoperative Day 1

Patient Well-Being

Friends who have visited patient

Questions about time spent in recovery room

Ambulation

Intake and fluids

III. Postoperative Day 2

Patient Well-Being

Ambulation

Friends who have visited patient

Intake and fluids

Gratitude for taking part in the study

Teaching Program for Experimental Subjects

I. Preoperative Nurse-Patient Interaction

A. Exploratory Period

1. Nurse explored with patient areas of fear, concern, or questions about the perioperative experience.

   How are you feeling?

   Do you have any questions about your operation that I might answer for you?

   Is there any information that you might like or that I could give you, anything that is bothering you?

2. Nurse and patient discussed information patient requested.

3. Areas which were referred to in the discussion if questioned by the patient.

   a. Preparation for surgery including premedication

   b. Postoperative experience

      (1) recovery room and personnel

      (2) equipment that may be used (i.e., nasogastric tube, urinary catheter, intravenous fluids, suctioning, etc.)

      (3) pain experience and medication

      (4) ambulation schedule

B. Discussion of the Patient as a Participator in his Case. Many patients assume that they have nothing to do with their recovery from an operation and that all they can do to help themselves is to follow the orders of the doctors and nurses. This is not true. There are certain activities that you as a patient can do for yourself after your operation that may help to speed your recovery and prevent complications. I think you will agree that it is better if you know what is expected of you or what you can do to help. With this knowledge you will be able to take some part in making your recovery smoother, less painful, and quicker.

C. Description of the Pulmonary System

1. Assessment of Patient's Present Knowledge

After your operation there is one area of your care in which you can really help to speed your recovery and prevent possible complications. That is the functioning of your lungs. I don't know how much you know about your lungs and the important part they play in your recovery after surgery. Can you tell me what you think your lungs look like and the importance they might have after your surgery?

Patient Explanation

Positive Reinforcement of Patient

2. Description of the Pulmonary System

(Using the patient's explanation or the following explanation, a description of the lungs was given only to the extent that the patient was offered reasons for the importance of performing breathing and coughing maneuvers after surgery.) You might think of your lungs as two large balloons or compartments of air which take in oxygen when you breathe in and remove carbon dioxide when you breathe out. These two large balloons or compartments of air are connected by tubes through which the air passes in and out. Although the lungs are usually thought of as two large compartments, it is more realistic to think of them in another way. Your lungs are really made up of millions of tiny spaces that are joined together to make the two large compartments. It might help to think of your lungs as two sponges. Your lungs have small spaces within one large compartment like a sponge. The lungs are different from the sponge in that they soak up air instead of water and are connected by tubes. After an operation these little spaces and tubes have a tendency to decrease in size and fill up with secretions such as mucus. A decrease in the size of the spaces and accumulation of secretions can lead to infection and other complications. This frequently happens after surgery because people often breathe less deeply. In normal breathing people usually sigh or take a deep breath every few minutes. After surgery, when you might have some pain, you tend to breathe less deeply or breathe at an even level instead of frequently sighing or breathing deeply. When this happens these little spaces of air do not expand as often as they should because air is not forced into them with a deep breath. Then mucus gets trapped and accumulates in the little spaces and tubes which blocks the amount of air that can get in and out of your body. One of the best ways to prevent collapse of these little air spaces and the accumulation of secretions is to take deep breaths and cough at frequent intervals after your surgery.

D. Preferred Method of Diaphragmatic Deep Breathing

After your operation there are some types of breathing that are more efficient than others. Certain types of breathing increase the volume of air that you take into your lungs and decrease the likelihood that secretions will accumulate. The most important thing for you to remember after your operation until you go home is to take deep breaths frequently, about every 10 minutes or even more frequently if possible. The best type of deep breath is like a "yawn" or a "sigh." You probably haven't been aware of it, but when you yawn or sigh you really inhale very deeply and hold your breath for about five seconds. I will demonstrate a yawn and you can see how it is a slow very deep breath that is held for a few seconds and then a slow expiration.

Nurse Models Yawn

Do you see what I mean?

Patient Response

Like a yawn the deep breath should be the deepest inhalation of air that you can take. You should breathe in through your nose and breathe out through your mouth slowly and deliberately. Also while you are breathing in you should try to balloon out your abdomen and then when you breathe out contract your abdomen. Using your abdomen helps to move your diaphragm up and down as much as possible. Let me tell you that again. You breathe in through your nose as deep as you can, ballooning out your abdomen, then you hold your breath for 5 seconds, then breathe out through your mouth slowly, contracting your abdomen. I will show you first.

Nurse Models Correct Diaphragmatic Deep Breath

Now, lets see if you can do that.

Patient Demonstrates Diaphragmatic Deep Breath
(in the position he is at the time)

Positive Reinforcement of Patient

Nurse corrects patient if the breathing is not correct.

Let's try that once more so you get some practice.

Patient Demonstrates Diaphragmatic Deep Breath
(in the position he is at the time)

Positive Reinforcement of Patient

E. Preferred Method of Coughing

This type of deep breathing should frequently be followed by a cough. Coughing helps to open the small spaces and clear the mucus from the spaces and tubes. A cough should follow several deep breaths. After you have taken several deep breaths like we practiced you take a deep breath in as you did before ballooning your abdomen and instead of holding it for five seconds and exhaling slowly you make a fast, hard expiration. The cough should be deep, not shallow or hacking. A shallow cough will not expand the spaces or clear the mucus and will only give you a sore throat. I will show you and then you can do it, okay?

Nurse Models Correct Cough

Now you try that.

Patient Demonstrates Correct Cough

Positive Reinforcement of Patient

F. Description of Panting Before Cough

If, after surgery, your incision hurts so much that it is impossible to cough after taking a deep breath then it might be easier for you to take a few short breaths, like "panting" and then after the last pant take a deep breath and then cough. I'll show you first and then you can do it.

Nurse Models Panting With Cough

Now you try it.

Patient Demonstrates Panting With Cough

Positive Reinforcement of Patient

G. Splinting of Incision

The deep breathing and coughing that you have been doing now is quite easy and you have been doing it well. After your operation, however, you will have your incision and some pain from that incision. This makes it more difficult to do what you have been doing. Although it will be more painful after surgery this is the time it is so important for you to do the breathing and coughing. There are certain things you can do to decrease the pain you may have while deep breathing and coughing after surgery. One thing you can do is hold your incision tightly while you cough or deep breathe. Your incision will be approximately here.

Nurse Points To Place Of Incision On Herself

To decrease the discomfort while deep breathing and coughing you should place your hand or arm over the area and apply pressure to this area while you are deep breathing and coughing. I will show you first.

Nurse Models Deep Breathing with Pressure at Incision Site

It is important to remember that no matter how hard you press on your incision you are not going to harm it.

Let's have you try it now.

Patient Demonstrates Deep Breathing with Pressure at Incision Site

Positive Reinforcement of Patient

The nurses may help you to splint your incision, but if they are not available then you should do it on your own. A visitor could also help, by either holding their arms around you tightly at the incision site or also applying pressure as you are doing. Although it is probably hard for you to imagine now, it will help decrease the pain when coughing or deep breathing.

H. Optimum Position For Relaxation and Effective Breathing Exercises

There is another way to decrease the discomfort and also increase the effectiveness of your deep breathing and cough. That is to assume a position that helps to relax the muscles of your abdomen and helps your diaphragm to move up and down as far as possible which gives better expansion of your lungs. In this position you can relax better and use the correct muscles for breathing. To assume this position you should lie in bed with your head well forward, your shoulders down, with your neck relaxed and your arms along your body. Your knees should be flexed. This position will make it easier for you to deep breathe and cough by helping you to relax your abdomen and to move your diaphragm for better expansion. Let's try that position now with you in the bed lying on your back with your head forward, shoulders down, your arms along your body and your knees flexed.

Patient Assumes Position with Help of Nurse

Positive Reinforcement of Patient

I. Breathing with Emphasis on Lower Lobe Expansion and Diaphragmatic Control

While you are in that position let's try the breathing again. This time I want you to concentrate on expanding the lower part of your chest. The reason that it is important to concentrate on expanding the lower part of your chest is that secretions tend to collect in the little spaces and tubes in the lower parts of the lungs. What I want you to do is to take a very deep breath as you did before through your nose hold this for five seconds and then slowly exhale through your mouth while contracting your abdomen. This time I will place my hands on your abdomen like this.

Nurse Places Her Hands At Her Costophrenic AngLe

The resistance of my hands will help you use your diaphragam and balloon out your abdomen. Okay, let's try it.

Nurse Places Hands on Patient's Costophrenic Angle

Patient Demonstrates Deep Breathing

Positive Reinforcement of Patient

Another way to see if you are expanding the lower part of your lungs is to push against my hands when they are at the sides of your chest. Again you will breathe the same way as you will after surgery on your own. Breathe in through your nose ballooning out your abdomen against my hands, hold the breath for five seconds and then contract your abdomen while slowly breathing out through your mouth. Let's try that.

Nurse Places Hands On Lower Sides of Chest

Patient Demonstrates Deep Breathing

Positive Reinforcement of Patient

J. Practice of Deep Breathing and Coughing in Supine Position With Pressure On Incision Site

Now for some practice let's try the breathing again in this position as you will be doing after surgery. Place your hand over your incision site and apply pressure. Now breathe in through your nose while ballooning out your abdomen and hold the breath for five seconds. Then breathe slowly out contracting your abdomen.

Patient Demonstrates Breathing In Supine Position With Pressure at Incision Site

Positive Reinforcement of Patient

Always remember that you should breathe slowly and deliberately because fast, jerky breathing will be more painful and will not remove secretions. Now let's try the coughing after the breathing. You will again apply pressure at the incision site and then take a deep breath through your nose ballooning out your abdomen and then instead of holding the breath for five seconds you will give a forceful cough from the bottom of your lungs.

Patient Demonstrates Cough In Supine Position With
Pressure At Incision Site

Positive Reinforcement of Patient

K. Changes in Position

You can also assume this relaxed position and do the breathing and coughing on either side. It is important that you change your position frequently after surgery. These changes in position help to maintain good circulation of your blood and distribute the air to the small spaces in your lungs so that they will be opened up frequently and secretions won't collect. It is important that you turn yourself frequently and there is a way that you can turn that will help you to do it without too much discomfort. If you are on your back, you bend one knee, then lift your arm that is opposite of the way you want to turn and roll on to your side pushing with the leg that is flexed. If the side rails are up you can use those to help pull yourself over. Let's try that now. Turn to your right side.

Patient Turns with Nurse's Assistance

Positive Reinforcement of Patient

While you are on your side let's have you do the breathing once and then the coughing. Can you breathe now like we said.

Patient Demonstrates Deep Breathing on Right Side

Positive Reinforcement of Patient

Now, try the coughing.

Patient Demonstrates Coughing on Right Side

Positive Reinforcement of Patient

Although we won't practice it now this can also be done on the other side, so if you are on either side you can still do the coughing and deep breathing. To turn back, flex the knee of your upper leg, place your hand on the side of the bed and push yourself back. Now turn back.

Patient Demonstrates Turning

Positive Reinforcement of Patient

L. Patient Questions

We have covered so many things in this meeting, can I answer any questions you might have about the breathing, coughing or anything else?

M. Summary

As I said in the beginning of the meeting, you can really help yourself to get well faster and leave the hospital sooner if you will remember to do the breathing and coughing we have practiced. The most important thing to remember is to take a deep breath as often as you can, every ten minutes would be a good time to try for. Taking deep breaths as we have done slowly, through your nose, ballooning out your abdomen and holding your breath for five seconds will keep your lungs expanded and secretions from accumulating. If you can't do them exactly as we have discussed try to remember that a yawn or a big sigh will also help your lungs to function more efficiently. If you try to get into the position we have practiced and always apply pressure to your incision while breathing and coughing you will be more relaxed and it will be less painful.

N. Patient Questions

Do you have anymore question I could answer for you?

II. First Postoperative Nurse-Patient Interaction

A. Exploratory Period

1. Nurse explored with patient areas of concern, fears, ability to perform deep breathing and coughing, questions patients had.

How are you feeling?

Have you been able to do the breathing and coughing we practiced before surgery?

Can I do anything for you before we practice some of the exercises?

B. Position and Deep Breathing with Pressure to Incision Site

1. Let's go over the breathing and coughing exercises you learned before surgery. Can you take the position that we said would help you to relax and breathe deeply?

Patient Assumes Position For Deep Breathing

Positive Reinforcement of the Patient

"That's good you remembered from before surgery".

2. Now, can you take a deep breath like we practiced?

Patient Demonstrates Deep Breathing with
Pressure To Incision Site

(Nurse observed for application of pressure to incision site, breathing in through nose, ballooning of abdomen, holding breath for five seconds, breathing out through mouth and contracting abdomen.)

Positive Reinforcement of Patient Of Those Aspects
Remembered

"Good, you remembered....."

Remember the last time we also discussed the importance of.......

I will show you again and then you can do it.

Nurse Models Correct Deep Breathing with
Incision Splinting

Now you try again.

Patient Demonstrates Deep Breathing with Incision Splinting

C. Practice of Cough and Panting with Incision Splinting

Let's try the coughing now. Can you cough holding your incision.

Patient Demonstrates Cough with Incision Splinting

(Nurse observed for deep breath before, deep breath with cough that was forceful from lower chest, holding of incision).

Positive Reinforcement of Patient Of Those Aspects
Remembered

(If patient could not do the breathing and coughing without panting the patient was asked to try the cough with panting).

Try the cough with the panting we practiced.

Patient Demonstrates Panting and Cough with Incision Splinting

Positive Reinforcement of Patient

D. Breathing with Emphasis on Lower Lobe Expansion and Diaphragmatic Control

Now, I will place my hands on your abdomen like we did before your operation to see how you are expanding the lower lobes of your lungs.

Nurse places hands on patient's costophrenic angle.

Patient Demonstrates Deep Diaphragmatic Breathing

Positive Reinforcement of Patient

If you are aware of expanding every part of your lungs you will breathe more slowly and efficiently. Breathing slowly and deliberately will be less painful and accomplish more.

E. Changes in Position with Practice of Deep Breathing and Cough

Have you been able to turn from side to side?

Have you done your coughing on the side too?

Let's try the turning now with the deep breathing and coughing.

Try turning to your right side.

Patient Demonstrates Turning To Left Side

Positive Reinforcement of Patient

(Nurse corrected patient on aspects he did not perform correctly).

While you are on your side let's have you do the breathing and coughing.

Can you take a deep breath like we said.

Patient Demonstrates Breathing on Left Side

Positive Reinforcement of Patient

Now, try the coughing.

Patient Demonstrates Coughing on Left Side

Positive Reinforcement of Patient

(Nurse corrected any aspects that were not correct).

Always remember to balloon out your abdomen and contract it when you take a deep breath. Also remember the importance of holding your breath for five seconds.

Now turn back to your back.

F. Patient Questions

Do you have any questions that I can answer about what we did or anything else?

G. Summary

Remember that the more you do the deep breathing, coughing and turning the more you will expand your lungs and prevent collapse of the little spaces and accumulation of secretions. Try to take a deep breath at least every ten minutes with a cough following every twenty minutes. You might think that there isn't any reason as your throat and lungs feel clear to you, but as we said the little spaces collapse and accumulate with fluid and you wouldn't know that. If the cough really hurts be sure to put pressure on your incision. Is there anything else I can answer or do for you so it will be easier for you to do the breathing and coughing?

III. Second Postoperative Nurse-Patient Interaction

A. Exploratory Period

1. Nurse explored with patient areas of concern, fears, ability to perform deep breathing and coughing, questions patient may have.

   How are you feeling?

   Anything that has bothered you since yesterday?

   Have you been able to do the breathing and coughing?

   Can I do anything for you before we do the exercises?

2. Nurse Assessment of Patient Status on the Health Continuum

   Nurse assessed patient as to his ability to ambulate, turn, range of motion etc. and gears her teaching to the level of the learner.

B. Position and Deep Breathing with Pressure to Incision Site

1. Okay, let's go over the breathing and coughing again as we did yesterday. Can you take the position that we said helps you to relax and get good expansion of your lungs?

   Patient Assumes Position For Deep Breathing

   Positive Reinforcement of Patient

   Have you been able to get in to this position when I'm not here?

2. Now, try taking a deep breath as we have practiced.

   Patient Demonstrates Deep Breathing with Pressure To Incision Site

   (Nurse observed for correct application of pressure to incision, correct breathing).

Positive Reinforcement of Patient of Those Aspects Remembered

"Good, you remembered . . ."

Remember the last time we also discussed the importance of . . . . . .

C. Practice of Cough and Panting with Cough with Incision Splinting

Let's try the coughing again. Cough holding your incision.

Patient Demonstrates Cough With Incision Splinting

(Nurse observes for correct cough and splinting).

Positive Reinforcement of Patient

(If patient could not do the breathing and coughing without panting the patient was asked to try the cough with panting).

Try the cough with the panting.

Patient Demonstrates Panting and Cough with Incision Splinting

Positive Reinforcement of Patient

D. Breathing with Emphasis on Lower Lobe Expansion and Diaphragmatic Control

Let's try expanding the lower lobes of your lungs again. I will place my hands on your abdomen as before.

Nurse Places Hands on Patient's Costophrenic Angle

Patient Demonstrates Deep Diaphragmatic Breathing

Positive Reinforcement of Patient

Try to remember when you do your breathing alone to concentrate on expanding every part of your chest.

E. Changes in Position with Practice of Deep Breathing and Cough

Let's try the turning now with the deep breathing and coughing.

(This section was exactly as the section E in the first postoperative nurse-patient interaction. If the patient ambulated frequently then he was asked to repeat one deep breath and one cough, instead of turning and coughing.)

F. Patient Questions

Do you have any questions about the breathing and coughing or anything else?

G. Summary

The most important thing for you to remember, as I have said before, is that you do these things on your own when I am not here. Other nurses can help you or a visitor. Be sure to take your deep breaths and hold for five seconds whenever possible. These should be followed by a cough at least every fifteen minutes. This is the last time I will be helping you with the exercises. But as you know, it is important for you to continue to do the breathing and coughing on your own like you've been doing. It's been really nice knowing you and thanks so much for being in the study.

APPENDIX B

Patient Consent Form And Information Guide

PATIENT CONSENT FORM

I am willing to participate in a research project concerned with the care of surgical patients. It is my understanding that my participation in this study necessitates meeting with a nurse five times during my hospitalization, four additional blood samples, and four lung function tests. The lung function test consists of taking a deep breath and forcefully breathing into a machine which determines the volume of air in my lungs. Although I have signed this consent form I may withdraw from this study at any time without prejudice to further treatment during my hospitalization.

Signed

Witness

Date

Patient Information Guide

E ________

Date ____________________ C ________

Name ____ SS No.# ____________________

Age ________ Sex ________ Wgt. ________ Hgt. ________ Hbg. ____________

M S W D ? No.# Children ______ Ethnic Origin __________ Occupation ____________

Completed Educ. ____________________ Smoking History ____________________

History of Cardio-Pulmonary Disease, Describe: ______________________________

____

History of Psychiatric Illness, Describe: ____________________________________

____

Present Medications ____

____

Previous Hospitalizations, Diagnosis and Time ________________________________

____

Preoperative Days in Hospital ____________________ Dates of Teaching ____________________

OPERATIVE PERIOD

Date of Operation ____________________ Preop Medication ____________________

____

Type of Operation ______________________________ Duration ____________________

Anesthesia Agents ____

Route of Anesthesia ______________________________ Surgeon ____________________

POSTOPERATIVE PERIOD

Time in Recovery ______________________________ ICU ____________________

Medications:

Sedatives:

Date	Time	Type	Date	Time	Type

Narcotics:

Postoperative Day of Ambulation

Chest X-Ray Findings Preop:

Postop:

Postop Pulmonary Interventions, i.e., IPPB, Rebreathing, etc.

Describe, Date and Time:

Postoperative Complications, Describe:

Length of Hospitalization after Surgery

Date of Discharge

Additional Comments

Ventilatory Measurements

Preoperative Date__________ Time__________

FVC	HIGH SCORE	PREDICTED	% PREDICTED
__________	__________	__________	__________
__________			
__________			
FEV_1			
__________	__________	__________	__________
__________			
__________			
FEV_1/FVC %			
__________	__________	__________	__________
__________			
__________			
$MMEF_{25-75\%}$			
__________	__________	__________	__________
__________			
__________	$MMF_{25-75\%}$/FVC = __________		

Postoperative #1 Date__________ Time__________

FVC	HIGH SCORE	PREDICTED	% PREDICTED
__________	__________	__________	__________
__________			
__________			

FEV_1 HIGH SCORE PREDICTED % PREDICTED

______ ______ ______ ______

______

______

$FEV_1/FVC\%$

______ ______ ______ ______

______

______

$MMF_{25-75\%}$

______ ______ ______ ______

______

______ $MMF_{25-75\%}/FVC$ = ______

Postoperative #2 Date ______ Time ______

FVC

______ ______ ______ ______

______

______

FEV_1

______ ______ ______ ______

______

______

$FEV_1/FVC\%$

______ ______ ______ ______

______

______

$MMF_{25-75\%}$	HIGH SCORE	PREDICTED	% PREDICTED
______	______	______	______
______			
______	$MMF_{25-75\%}/FVC$ = ______		

Postoperative #3

FVC			
______	______	______	______
______			
______			
FEV_1			
______	______	______	______
______			
______			
$FEV_1/FVC\%$			
______	______	______	______
______			
______			
$MMF_{25-75\%}$			
______	______	______	______
______			
______	$MMF_{25-75\%}/FVC$ = ______		

Arterial Blood Gas Partial Pressures

Preoperative: Room Air 100% O_2

Date	Time	Pa_{O_2}	$A\text{-}aDO_2$	Pa_{CO_2}	pH	Pa_{O_2}	Pa_{CO_2}	pH	%Shunt

(HBG =) (Temp. =)

Postoperative #2 Room Air

Date	Time	Pa_{O_2}	$A\text{-}aDO_2$	Pa_{CO_2}	pH

(HBG =) (Temp. =)

Postoperative #3 Room Air

Date	Time	Pa_{O_2}	$A\text{-}aDO_2$	Pa_{CO_2}	pH

(HBG =) (Temp. =)

Calculations of $A\text{-}aDO_2$ and $\dot{Q}s/\dot{Q}_T\%$:

APPENDIX C
LABORATORY PROCEDURES

I. Calculation of Percentage of Venous-to-Arterial Shunt:

The percentage of venous-to-arterial shunt ($\dot{Q}s/\dot{Q}_T\%$) was derived and calculated using the following derivations and precedures. The standard shunt formula is derived from the following:

The amount of O_2 in arterial blood = the amount of O_2 in blood that has traveled the pulmonary capillaries + the amount of O_2 in shunted blood. Since the amount of $O_2 = C_{O2} \times \dot{Q}$, where C = concentration (ml. O_2 / 100 ml. blood), and $\dot{Q}$ = blood flow then:

$$Ca_{O2}\,\dot{Q}_T = Cc_{O2}\dot{Q}c + C_{\bar{v}O2}\,\dot{Q}s$$

Where: $\dot{Q}_T$ = total blood flow

$\dot{Q}_c$ = blood flow through the capillaries

$\dot{Q}s$ = blood flow of mixed venoua blood through the shunt

a = arterial blood

$\bar{v}$ = mixed venous blood

c = blood at the end of the pulmonary capillaries

Since: $\dot{Q}_T = \dot{Q}c + \dot{Q}s$

$\dot{Q}c = \dot{Q}_T - \dot{Q}s$

Therefore the above equation becomes:

$$Ca_{O2}\dot{Q}_T = Cc_{O2}\,(\dot{Q}_T - \dot{Q}s) + C_{\bar{v}O2}\,\dot{Q}s$$

This can be rearranged to the following standard shunt equation:

$$\frac{\dot{Q}_s}{\dot{Q}_T} = \frac{Ca_{O2} - Cc_{O2}}{C\bar{v}_{O2} - Cc_{O2}} \quad \text{or} \quad \frac{Cc_{O2} - Ca_{O2}}{Cc_{O2} - C\bar{v}_{O2}}$$

(Comroe, 1965, p. 153)

To simplify the calculation of the percentage of venous-to-arterial shunt ($\dot{Q}s/\dot{Q}_T\%$) the investigator used the nomogram published by S. T. Chiang (1968) which was prepared according to the following equation:

$$\frac{\dot{Q}_s}{\dot{Q}_T} = \frac{P_{AO2} - Pa_{O2}}{(P_{AO2} - Pa_{O2}) + 1,670}$$

The following is a description of the derivation of that formula (Chiang, 1968, p. 565). It is assumed that the A-V difference for oxygen ($Ca_{O2} - C_{\bar{v}O2}$) is 5 vol. %. As described above in the procedure used for the determination of the A-aDO_2 it can be stated that:

$$P_{AO2} = (P_B - P_{H_2O})\, F_{IO_2} - P_{ACO2}$$

Since $P_{ACO_2} = Pa_{CO2}$ and during the administration of 100 per cent oxygen, after nitrogen washout, the $F_{IO2} = 1$ the formula can be written:

$$P_{AO2}\ (P_B - P_{H_2O}) - Pa_{CO2}$$

When a patient breathes 100 per cent oxygen there is such a high P_{AO2} that there is no alveolar to capillary gradient, i.e., $P_{AO2} = Pc_{O2}$. The pulmonary end-capillary and peripheral arterial blood are fully saturated the difference in their oxygen content (C_{O2}) is due solely to the oxygen in physical solution. Since the solubility coefficient for oxygen in whole blood is 0.0031 vol % per mm. Hg P_{O2} then:

$$Cc_{O2} - Ca_{O2} = (P_{AO2} - Pa_{O2}) \times 0.003$$

or

$$Cc_{O2} = Ca_{O2} + (P_{AO2} - Pa_{O2}) \times 0.003$$

Chiang substituted these formulae in the standard shunt formula to obtain:

$$\frac{\dot{Q}_s}{\dot{Q}_T} = \frac{(P_{AO2} - Pa_{O2}) \times 0.003}{(P_{AO2} - Pa_{O2}) \times 0.003 + (Ca_{O2} - C_{\bar{v}}\, O2)}$$

With the assumption that the A-V difference equals 5 vol. %.

$$\frac{\dot{Q}_s}{\dot{Q}_T} = \frac{(P_{AO2} - Pa_{O2}) \times 0.003}{(P_{AO2} - Pa_{O2}) \times 0.003 + 5}$$

The numerator and denominator were divided by 0.003 to become:

$$\frac{\dot{Q}s}{\dot{Q}_T} = \frac{P_{AO2} - Pa_{O2}}{(P_{AO2} - Pa_{O2}) + 1,670}$$

This formula was used by Chiang to derive the nomogram which provided the percentage of venous-to-arterial shunting if the alveolar-arterial difference was known.

II. Analysis of Blood Samples:

One cc. of the arterial blood was analyzed for hemoglobin using the IL Model 182 CO-Oximeter which had been flushed with IL Zeroing Solution. The IL 113 S-1 model of Blood Gas and Micro pH Analyzer distributed by the Instrumentation Laboratory Inc. was used for measuring the Pa_{O2}, Pa_{CO2}, and pH on air and 100 per cent oxygen. The P_{O2} and P_{CO2} were sloped by the pulmonary technician at 8 a.m., 12 noon, and 4 p.m. and balanced by the investigator before each blood sample was analyzed. The pH was sloped and balanced by the investigator before the analysis. The following is a short description of the procedures used by the investigator before and during the analysis of the arterial blood samples to slope and balance the pH, balance the P_{O2} and P_{CO2} electrodes, and analyze the samples.

A. pH Slope Standardization

The capillary of the glass electrode was flushed with isotonic saline and filled with a 6.84 Radiometer certified buffer. The pH Balance Control was then set to read 6.84. After flushing the system the same procedure was accomplished with a 7.384 buffer.

B. P_{O2} and P_{CO2} Balance

Initially the P_{O2} and P_{CO2} for the day were determined by multiplying the dry gas pressure by the decimal equivalent of the oxygen composition of room air and the carbon dioxide composition of the calibrated gas mixtures to obtain the P_{O2} and P_{CO2} for the day. For example:

$$(\underset{P_B}{753} - \underset{P_{H_2O}}{47})\ \underset{\substack{CO_2\\ \text{fraction}}}{.0512} = 36.1 \text{ mm.Hg } P_{CO2}$$

$$(\underset{P_B}{753} - \underset{P_{H_2O}}{47})\ \underset{\substack{O_2\\ \text{fraction}}}{.2093} = 148 \text{ mm.Hg } P_{O2}$$

The IL 113 was then balanced for O_2 by slowly bubbling room air for 5-10 seconds through the measurement chamber and balancing for the P_{O2} of the day. This procedure was repeated with 5% CO_2.

C. High Oxygen Balance

The steps described above were for high oxygen blood samples with the exception that a high O_2 gas mixture was used for the determination of the P_{O2} of the day and then for the balancing of the 800 mm.Hg oxygen scale.

D. Analysis of the Blood Sample

The measuring chamber of the unit was flushed with isotonic saline after which the blood sample was slowly injected into the chamber. A small amount of the blood was drawn into the pH capillary and this reading was recorded from the pH scale. The mode selector was then switched to the O_2 scale and then to the CO_2 scale for recording these measurements.

The measures of hemogloblin, Pa_{O2} on air or 100 per cent oxygen, Pa_{CO2}, and pH were corrected for temperature, if necessary, and recorded on the Patient Information Guide.

APPENDIX D
STATISTICAL ANALYSES

TABLE 12

Rank Sums of Dependent Variables For
Statistical Comparison of Smokers and Non-Smokers Between Groups

Variable	Preoperative				Postoperative 1				Postoperative 2				Postoperative 3			
	S[a]		N[b]		S		N		S		N		S		N	
	N	R.S.	N	R.S.	N	R.S.	N	R.S.	N	R.S.	N	R.S.	N	R.S.	N	R.S.
FVC % pred.	11	141.5	11	111.5	13	153.5	9	99.5	11	105.5	8	84.5	12	137.0	7	53.0
FEV_1 % pred.	13	139.0	9	114.0	13	142.5	9	110.5	11	106.5	8	83.5	12	134.0	7	56.0
FEV_1/FVC %	13	150.5	9	102.5	13	129.0	9	124.0	11	98.5	8	91.5	12	111.0	7	79.0
MMF/FVC $\left(\frac{L/sec.}{L}\right)$ 25-75%	13	151.0	9	102.0	13	135.0	9	118.0	11	104.0	8	86.0	12	122.0	7	68.0
$\dot{Q}s/\dot{Q}_T$%	12	113.0	8	97.0	12	109.5	8	100.5								
Pa_{O2} (mm.Hg)	13	147.5	9	105.5					10	79.5	7	73.5	11	115.5	7	55.5
$A\text{-}aDO_2$ (mm.Hg)	13	144.5	9	108.5					10	105.0	7	48.0	11	83.5	7	87.5
Pa_{CO2} (mm.Hg)	13	148.0	9	105.5					10	91.5	7	61.5	11	122.0	7	49.0
pH	13	132.0	9	121.0					10	75.0	7	78.0	11	85.0	7	86.0

Note.---Critical lower-tail values at .05 level for: N of 11 and N of 11 = 96; N of 13 and N of 9 = 73; N of 11 and N of 8 = 55; N of 12 and N of 7 = 461 N of 12 and N of 8 = 58; N of 10 and N of 7 = 42; N of 11 and N of 7 = 44.

[a]S = Smoker

[b]N = Non-Smoker

[c]R.S. = Rank Sum; Wilcoxen Rank Sum Test with .05 level of significance for a two-tailed test

TABLE 13

Rank Sums of Dependent Variables For
Statistical Comparison of Smokers and Non-Smokers Within Groups

Variable	G	Preoperative S[a] N	Preoperative S[a] R.S.[c]	Preoperative N[b] N	Preoperative N[b] R.S.	Postoperative 1 S N	Postoperative 1 S R.S.	Postoperative 1 N N	Postoperative 1 N R.S.	Postoperative 2 S N	Postoperative 2 S R.S.	Postoperative 2 N N	Postoperative 2 N R.S.	Postoperative 3 S N	Postoperative 3 S R.S.	Postoperative 3 N N	Postoperative 3 N R.S.
FVC % pred.	E	7	46.0	4	20.0	7	46.0	4	20.0	6	31.0	4	24.0	7	39.0	3	16.0
	C	6	35.0	5	31.0	6	43.0	5	23.0	5	24.5	4	20.5	5	31.0	4	14.0
FEV_1/FVC %	E	7	44.0	4	22.0	7	31.5	4	34.5	6	24.0	4	31.0	7	37.0	3	18.0
	C	6	35.5	5	30.5	6	35.5	5	30.5	5	23.5	4	21.5	5	23.0	4	22.0
MMF/FVC $\frac{(L/sec)}{L}$ 25-75%	E	7	45.0	4	21.0	7	32.5	4	33.5	6	28.5	4	26.5	7	42.5	3	12.5
	C	6	35.0	5	31.0	6	36.5	5	29.5	5	25.0	4	20.0	5	27.0	4	18.0
$\dot{Q}s/\dot{Q}_T$%	E	7	38.5	5	16.5					7	36.5	3	18.5				
	C	5	26.0	5	29.0					5	23.0	5	32.0				
Pa_{O2} (mm.Hg)	E	7	38.5	4	27.5					6	26.5	3	18.5	7	41.0	3	14.0
	C	6	38.0	5	28.0					4	16.0	4	20.0	4	21.0	4	15.0
$A\text{-}aDO_2$ (mm.Hg)	E	7	42.5	4	23.5					6	33.0	3	12.0	7	34.0	3	21.0
	C	6	33.0	5	34.0					4	23.5	4	12.5	5	21.5	4	23.5
Pa_{CO2} (mm.Hg)	E	7	46.0	4	20.0					6	30.5	3	14.5	7	45.0	3	10.0
	C	6	32.5	5	33.5					4	18.0	4	18.0	4	22.0	4	14.0
pH	E	7	39.5	4	26.5					6	31.5	3	13.5	7	33.0	3	22.0
	C	6	28.5	5	37.5					4	10.0*	4	26.0	4	13.5	4	22.5

(continued on next page)

Rank Sums of Dependent Variables For
Statistical Comparison of Smokers and Non-Smokers Within Groups

Note.---FEV_1 % predicted was not analyzed in this examination

Critical lower-tail values at .05 level for: N of 7 and N of 6 = 27; N of 7 and N of 5 = 20; N of 7 and N of 4 = 13; N of 7 and N of 3 = 7; N of 6 and N of 5 = 18; N of 6 and N of 4 = 12; N of 6 and N of 3 = 7; N of 5 and N of 5 = 17; N of 5 and N of 4 = 11; N of 4 and N of 4 = 10.

[a]S = Smoker

[b]N = Non-Smoker

[c]R. S. = Rank Sum; Wilcoxen Rank Sum Test with .05 level of significance for a two-tailed test.

*$p < .05$

TABLE 14

Rank Sums of Dependent Variable Change Scores For Statistical Comparison of Smokers and Non-Smokers Between Groups

	Pre to Day 1				Pre to Day 2				Pre to Day 3			
	S[a]		N[b]		S		N		S		N	
Variable	N	R.S.[c]	N	R.S.	N	R.S.	N	R.S.	N	R.S.	N	R.S.
FVC % pred.	13	137.0	9	116.0	11	105.5	8	84.5	12	103.5	7	86.5
FEV_1% pred.	13	144.5	9	108.5	11	106.0	8	84.0	12	104.5	7	85.5
FEV_1/FVC %	13	133.5	9	119.5	11	111.0	8	79.0	12	108.5	7	81.5
MMF/FVC $\frac{(L/sec)}{L}$ 25-75%	13	132.5	9	120.5	11	101.0	8	89.0	12	118.0	7	72.0
$\dot{Q}s/\dot{Q}_T$%	12	125.5	8	84.5								
Pa_{O2} (mm.Hg)					10	101.0	7	52.0	11	114.5	7	56.5
A-aDO_2 (mm.Hg)					10	120.0	7	33.0*	11	100.0	7	71.0
Pa_{CO2} (mm.Hg)					10	79.0	7	74.0	11	110.0	7	61.0
pH					10	98.5	7	54.5	11	112.0	7	59.0

Note.---Critical lower-tail values at .05 level for: N of 13 and N of 9 = 73; N of 12 and N of 8 = 58; N of 12 and N of 7 = 46; N of 11 and N of 8 = 55; N of 10 and N of 7 = 42.

[a] S = Smoker
[b] N = Non-Smoker
[c] R.S. = Rank Sum: Wilcoxen Rank Sum Test with .05 level of significance for a two-tailed test
*p $<$ .01

TABLE 15

Rank Sums of Dependent Variable Change Scores For
Statistical Comparison of Smokers and Non-Smokers Between Groups

	Post Day 1 to Day 2				Post Day 1 to Day 3				Post Day 2 to Day 3			
	S[a]		N[b]		S		N		S		N	
Variable	N	R.S.[c]	N	R.S.	N	R.S.	N	R.S.	N	R.S.	N	R.S.
FVC % pred.	11	110.0	8	80.0	12	131.0	7	59.0				
FEV_1 % pred.	11	119.5	8	70.5	12	138.0	7	52.0				
FEV_1/FVC %	11	126.5	8	63.5	12	136.5	7	53.5				
MMF/FVC $\frac{(L/sec)}{L}$ 25-75%	11	114.5	8	75.5	12	134.0	7	56.0				
Pa_{O2} (mm. Hg)									9	84.5	6	35.5
A-aDO_2 (mm. Hg)									9	53.5	6	66.5
Pa_{CO2} (mm. Hg)									9	78.0	6	42.0
pH									9	70.0	6	50.0

Note.---Critical lower-tail values at .05 level for: N of 11 and N of 8 = 55; N of 12 and N of 7 = 46; N of 9 and N of 6 = 31

[a] S = Smoker

[b] N = Non-Smoker

[c] R.S. = Rank Sum: Wilcoxen Rank Sum Test with .05 level of significance for a two-tailed test

TABLE 16

Rank Sums of Dependent Variables For
Statistical Comparison of IPPB Therapy and No IPPB Therapy Between Groups

	Preoperative				Postoperative 1				Postoperative 2				Postoperative 3			
	I[a]		N[b]		I		N		I		N		I		N	
Variable	N	R.S.[c]	N	R.S.	N	R.S.	N	R.S.	N	R.S.	N	R.S.	N	R.S.	N	R.S.
FVC % pred.	17	189.5	5	63.5	17	201.5	5	51.5	15	155.5	4	34.5	14	150.0	5	40.0
FEV_1% pred.	17	188.5	5	64.5	17	192.0	5	61.0	15	149.5	4	40.5	14	148.0	5	42.0
FEV_1/FVC %	17	202.0	5	51.0	17	177.5	5	75.5	15	137.0	4	53.0	14	128.5	5	61.5
MMF/FVC $\frac{(L/sec)}{L}$ 25-75%	17	205.0	5	48.0	17	174.0	5	79.0	15	144.0	4	45.5	14	131.0	5	59.0
$\dot{Q}s/\dot{Q}_T$%	15	174.0	5	36.0	15	171.5	5	39.5								
Pa_{O2} (mm.Hg)	17	191.5	5	61.5					13	115.5	4	37.5	14	120.5	4	50.5
A-aDO_2 (mm.Hg)	17	207.0	5	46.0					13	11.0	4	42.0	14	144.0	4	27.0
Pa_{CO2} (mm.Hg)	17	190.0	5	63.0					13	121.0	4	32.0	14	129.0	4	42.0
pH	17	207.5	5	45.5					13	117.5	4	35.5	14	147.0	4	24.0

Note.---Critical lower-tail values at .05 level for: N of 17 and N of 5 = 32; N of 15 and N of 5 = 29; N of 15 and N of 4 = 20; N of 14 and N of 5 = 28; N of 14 and N or 4 = 19; N of 13 and N of 4 = 18.

[a] I = IPPB Therapy

[b] N = No IPPB Therapy

[c] R.S. = Rank Sum; Wilcoxen Rank Sum Test with .05 level of significance for a two-tailed test

TABLE 17

Rank Sums of Dependent Variable Change Scores
Statistical Comparison of IPPB Therapy and No IPPB Therapy Between Groups

	Post Day 1 to Day 2				Post Day 1 to Day 3				Post Day 2 to Day 3			
	I[a]		N[b]		I		N		I		N	
Variable	N	R.S.[c]	N	R.S.	N	R.S.	N	R.S.	N	R.S.	N	R.S.
FVC % pred.	15	147.0	4	43.0	14	139.5	5	50.5				
FEV_1 % pred.	15	146.0	4	44.0	14	144.0	5	46.0				
FEV_1/FVC %	15	150.0	4	40.0	14	151.0	5	39.0				
MMF/FVC $\frac{(L/sec.)}{L}$ 25-75%	15	161.5	4	28.5	14	152.0	5	38.0				
Pa_{O2} (mm.Hg)									11	72.5	4	47.5
$A\text{-}aDO_2$ (mm.Hg)									11	103.0	4	17.0*
Pa_{CO2} (mm.Hg)									11	85.5	4	34.5
pH									11	91.0	4	29.0

Note.---Critical lower-tail values at .05 level for: N of 15 and N of 4 = 20; N of 14 and N of 5 = 28; N of 11 and N of 4 = 16

[a]I = IPPB Therapy

[b]N = No IPPB Therapy

[c]R.S. = Rank Sum; Wilcoxen Rank Sum Test with .05 level of significance for a two-tailed test

*$p < .10$

TABLE 18

Rank Sums of Dependent Variable Change Scores For Statistical Comparison of IPPB Therapy and No IPPB Therapy Between Groups

	Pre to Day 1				Pre to Day 2				Pre to Day 3			
	I[a]		N[b]		I		N		I		N	
Variable	N	R.S.[c]	N	R.S.	N	R.S.	N	R.S.	N	R.S.	N	R.S.
FVC % pred.	17	182.0	5	71.0	15	135.0	4	55.0	14	120.5	5	69.5
FEV_1 % pred.	17	196.0	5	57.0	15	151.0	4	39.0	14	130.0	5	60.0
FEV_1/FVC %	17	178.0	5	75.0	15	133.5	4	56.5	14	133.5	5	56.5
MMF/FVC $\frac{(L/sec.)}{L}$ 25-75%	17	181.5	5	71.5	15	133.0	4	57.0	14	152.5	5	37.5
$\dot{Q}s/\dot{Q}_T$%	15	155.0	5	55.0								
Pa_{O2} (mm.Hg)					13	118.0	4	35.0	14	125.5	4	45.5
$A\text{-}aDO_2$ (mm.Hg)					13	113.0	4	40.0	14	140.0	4	31.0
Pa_{CO2} (mm.Hg)					13	120.5	4	32.5	14	140.0	4	31.0
pH					13	121.0	4	32.0	14	132.5	4	38.5

Note.---Critical lower-tail values at .05 level for: N of 17 and N of 5 = 32; N of 15 and N of 5 = 29; N of 15 and N of 4= 20; N of 14 and N of 5 = 28; N of 14 and N of 4 = 19; N of 13 and N of 4 = 18.

[a]I = IPPB Therapy

[b]N = no IPPB Therapy

[c]R.S. = Rank Sum; Wilcoxen Rank Sum Test with .05 level of significance for a two-tailed test

TABLE 19

Rank Sums of Dependent Variables For
Statistical Comparison of IPPB Therapy and No IPPB Therapy Within Groups

Variable	Group	Preoperative				Postoperative 1				Postoperative 2				Postoperative 3			
		I[a]		N[b]		I		N		I		N		I		N	
		N	R.S.[c]	N	R.S.	N	R.S.	N	R.S.	N	R.S.	N	R.S.	N	R.S.	N	R.S.
FVC % pred.	E	8	49.0	3	17.0	8	53.0	3	14.0	7	42.0	3	13.0	7	45.0	3	10.0
	C	9	51.0	2	15.0	9	53.0	2	13.0	d	d	d	d	7	35.0	2	10.0
FEV_1/FVC %	E	8	49.0	3	17.0	8	44.0	3	22.0	7	36.0	3	19.0	7	30.5	3	24.5
	C	9	55.0	2	11.0	9	58.0	2	8.0	d	d	d	d	7	36.0	2	9.0
MMF/FVC (L/sec / L) 25-75%	E	8	50.0	3	16.0	8	44.0	3	22.0	7	40.0	3	15.0	7	33.0	3	22.0
	C	9	55.0	2	11.0	9	47.0	2	19.0	d	d	d	d	7	33.5	3	11.5
$\dot{Q}s/\dot{Q}_T$%	E	7	45.0	3	10.0	7	46.0	3	9.0								
	C	8	46.0	2	9.0	8	45.0	2	10.0								
Pa_{O2} (mm.Hg)	E	8	46.5	3	18.5					7	40.0	3	15.0	7	35.5	3	19.5
	C	9	53.5	2	12.5					d	d	d	d	d	d	d	d
$A\text{-}aDO_2$ (mm.Hg)	E	8	49.5	3	16.5					6	28.0	3	17.0	7	38.0	3	17.0
	C	9	58.0	2	8.0					d	d	d	d	d	d	d	d
Pa_{CO2} (mm.Hg)	E	8	47.5	3	18.5					6	31.0	3	14.0	7	36.0	3	19.0
	C	9	53.0	2	13.0					d	d	d	d	d	d	d	d
pH	E	8	49.5	3	16.5					6	28.5	3	16.5	7	45.0	3	10.0
	C	9	59.0	2	7.0					d	d	d	d	d	d	d	d

Note.---Critical lower-tail values at .05 level for: N of 9 and N of 2 = 3; N of 8 and N of 3 = 8; N of 8 and N of 2 = 3; N of 7 and N of 3 = 7; N of 7 and N of 2 = 3; N of 6 and N of 3 = 7

FEV_1% predicted was not analyzed in this examination

[a] I = IPPB Therapy

[b] N = No IPPB Therapy

[c] R.S. = Rank Sum: Wilcoxen Rank Sum Test with .05 level of significance for two-tailed test

[d] The control group contained an insufficient sample of 1 patient

COPY 1