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Dimensions and predictors of pain in critically ill thoracoabdominal surgical patients

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DIMENSIONS AND PREDICTORS OF PAIN IN CRITICALLY ILL THORACOABDOMINAL SURGICAL PATIENTS

by

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Dedication

This work is dedicated with love to my husband, Rich, whose moral, emotional and physical support and absolute, unfailing confidence in me guided me through my doctoral studies.

It is dedicated to my children, Lisa, Tim and Darin, who have grown into beautiful, responsible adults during the years their mother was "learning science." My children are truly the major accomplishments of my life.

Finally, this work is respectfully dedicated to the critically ill patients who agreed to participate in my research. These men and women recounted their individual pain experiences with me so that future patients might experience less pain and suffering. I am immensely grateful to each of them.

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DIMENSIONS AND PREDICTORS OF PAIN IN CRITICALLY ILL THORACOABDOMINAL SURGICAL PATIENTS

Kathleen Ann Puntillo

Abstract

Pain is a significant stressor for critically ill patients. Yet the nature of their pain remains poorly understood. To address this problem, dimensions of post-surgical and procedural pain in critical care patients were studied. Also investigated were predictors of pain and relationships of pain to morbidity factors.

The sample consisted of 74 cardiovascular surgical patients. Tonic post-surgical pain was measured over three immediate postoperative days. Procedural pain from chest tube removal and endotracheal suctioning was also measured. Dimensions of pain examined were its intensity and extent as well as its sensory (e.g. throbbing or sharp) and affective qualities. Pain measures included the McGill Pain Questionnaire-Short Form and pain intensity scales. Predictors included personality adjustment measured by the California Q-Set, age, gender, and amount of analgesics. Morbidity factors were also determined through chart review.

Results indicated that patient tonic pain intensity was moderate but did not diminish over three days. Patient pain was quite localized. Patients used few sensory and affective pain descriptors, indicating that physical sensations and emotional tension associated with pain caused little distress. Vascular surgery patients reported significantly more pain than cardiac surgery patients, and

chest tube pain was significantly more intense than endotracheal suctioning or tonic pain. The more pain intensity associated with chest tube removal, the less pain relief obtained from analgesics.

Overall, patients received very little analgesics. However, analgesic amount was a primary and significant pain predictor. Gender was a significant predictor of degree of sensory pain, suggesting that women may be more bothered by physical sensations of pain than men. Personality factors did not predict any pain dimension.

The longer a patient needed to be intubated, the less s/he was bothered by physical sensations of pain, suggesting that severity of illness might influence pain perception. Patients with higher pain intensity were significantly more likely to have atelectasis. However, other morbidity factors, such as length of critical care stay and psychological disturbances, were not associated with patient pain.

Research results demonstrated that pain can be assessed comprehensively with critically ill patients even when they are intubated. Findings suggest the need to develop and test more effective interventions for critical care patient pain relief.

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Table of Contents

Tables

Figure

Appendices

Chapter 1

The Study Problem

Introduction

Pain is an unpleasant and unusually complex perceptual experience that is often associated with negative emotions and tissue damage. Critically ill patients, those who have or are at high risk for life-threatening problems (American Association of Critical-Care Nurses, 1986), frequently suffer pain that is inadequately controlled. Because of their compromised conditions, they are particularly vulnerable to pain's deleterious consequences (Berre, 1984; Bouckoms, 1988; McCaffery, 1984; Phillips & Cousins, 1986).

Critical care patients have identified pain to be a major problem. In fact, patient accounts of the pain experienced when in critical care units are often vivid and startling (Cook, 1981; Donald, 1976; Eisendrath, Matthay, Dunkel, Zimmerman & Layzer, 1983; Puntillo, 1990). Critical care nurses who care for these patients as well as nurse researchers recognize the need for knowledge regarding pain assessment and management (Funk, 1989; Harrison & Cotanch, 1987; Lewandowski & Kositsky, 1983; Puntillo, 1988; Radwin, 1987). Yet, pain research involving critically ill patients is scant.

Based on research to date, the frequency and intensity of pain in critical care patients appear to be high. Suhayda and Kim (1984) estimated through chart audits that pain and discomfort were problems for 66% of 50 medical-

surgical Intensive Care Unit (ICU) patients. Through another chart audit, 42% of 158 critical care and medical-surgical patients were found to have the nursing diagnosis of, "alteration in comfort" (Kim et al., 1984). Puntillo (1990) found that over 70% of her sample of predominantly surgical patients (N=24) recalled pain as a problem during their stay in ICU. Furthermore, 67% stated that pain intensity was moderate to severe. Certainly, this level of intensity can be construed as significant for those experiencing it.

Many critically ill patients undergo either thoracic or abdominal surgeries. The intensity of thoracoabdominal surgical pain is often reported to be moderate to severe (Benedetti, Bonica & Belluci, 1984; Bonica, 1990; Bonica, 1981; Pflug & Bonica, 1977; Rawal, Sjostrand & Dahlstrom, 1981), with the incidence of severe/very severe pain being 50% (Bonica, 1981). Both the severity of critical care patients' underlying conditions and their frequent inability to communicate their pain are significant challenges to the provision of adequate pain relief (Bouckoms, 1988).

There exists minimal pain research involving critical care patients. Recently, however, the effect of relaxation on post-operative cardiac surgery pain was explored (Miller & Perry, 1990). Subjects (N=15) who were encouraged in the use of a relaxation technique taught before surgery reported significantly less pain per a visual descriptor scale ($p=.03$) than controls (N=14) who did not use the relaxation

technique. One dimension of pain, its intensity, was measured in this study.

Puntillo (1990) documented the recalled pain experiences of 24 medical-surgical ICU patients. This group of patients described various sources of their pain, difficulties they had in communicating their pain, and nonpharmacologic methods that helped relieve their pain. Results from the study clearly indicated that pain, its communication and treatment were significant problems for many of these ICU patients. Yet, this was a retrospective study, since patients were interviewed after ICU transfer.

Analgesia studies have, on rare occasions, included patients in critical care settings (Dittman, Steenblock, Krnazlin & Wolff, 1982; El-Baz & Goldin, 1987; Rawal, Sjostrand, Christoffersson, Dahlstrom, Arvil & Rydman, 1984; Rawal & Tandon, 1985; Worthley, 1985; Yeager, Glass, Neff & Brinck-Johnsen, 1987). However, in only a few of these analgesia studies has pain intensity been directly quantified (El-Baz & Goldin, 1987; Rawal et al, 1984), and none have investigated the multiple dimensions of pain.

In short, a comprehensive, prospective study of the pain experienced by thoracoabdominal surgery patients while they are in critical care units has not been undertaken. As a result, little is known about the multiple dimensions of this phenomenon. No scientific foundation exists for assessing critical care pain, nor for prescribing and determining the adequacy of treatment interventions. The

purpose of this study, therefore, was to develop knowledge regarding the dimensions, correlates and predictors of pain in critically ill thoracoabdominal surgical patients.

Significance of the Problem

It is essential that health professionals maintain or restore stability in critically ill patients (American Association of Critical-Care Nurses, 1986). Acute post-operative pain has no useful function (Bonica, 1981). Inadequately controlled pain can lead to significant psychological and physiological consequences for critically ill patients.

Psychological Consequences of Pain

Pain is a significant psychological stressor. In narrative literature, pain in critical care patients has been associated with sensory overload (Baker, 1984), psychological discomfort (Nadelson, 1976; Noble, 1979) and even delerium (McKegney, 1966; Nadelson, 1976), all of which are psychological stressors. In turn, stress has been identified as a progenitor of Intensive Care Unit psychosis (McKegney, 1966).

Pain and its accompanying anxiety are thought to make a patient less able to tolerate such ICU environmental stressors as noise (Hansell, 1984). In fact, a significant correlation was found between noise levels and amount of pain medications given to patients (albeit an indirect measure of pain) in a recovery room with an environment similar to a critical care unit (Minckley, 1968).

Pain has been implicated through research as a leading cause of critical care patient stress. In fact, many investigators of ICU environmental stressors have identified pain as a major patient stressor. For example, patients who have been asked to recall their ICU stays identified pain as their greatest worry when in ICU and a leading cause of insufficient sleep (Jones, Hoggart, Withey, Donaghue & Ellis, 1979). Surgical Intensive Care Unit (SICU) patients ranked being in pain as their first (of 22) (Wilson, 1987) or second (of 40) (Ballard, 1981) greatest ICU environmental stressor. In yet another ICU stress study, both medical and surgical ICU patients and their nurses ranked being in pain as the third (patients) or first (nurses) greatest critical care patient stressor (Cochran & Ganong, 1989).

Male cardiac surgical patients have also identified pain as a major ICU stressor, ranking pain fourth on a list of 43 possible items (Nastasy, 1985). A relationship between pain and two other highly ranked stressors in this cardiac surgical patient sample -- inability to communicate while intubated (number one stressor) and loss of control (number three stressor)-- can also be postulated. That is, a person unable to communicate pain may feel helpless, may not receive pain-relieving interventions in a timely fashion and, thus, may suffer from more pain.

Pain has been reported to be the worst memory of another cardiac surgical patient population's postperative period (Paiement, Boulanger, Jones & Roy, 1979).

Specifically, pain from chest tubes, pain from chest or leg incisions and neck pain from Swan Ganz catheters were listed by 44 of 100 patients as the worst things to bear during this perioperative period. These patients specifically reported that chest tube pain occurred during deep breathing, during "milking" of the tubes or during tube removal. Few other studies have investigated the pain caused by various procedures performed regularly in ICU (Byran-Brown, 1986).

Other interventions within a critical care unit are often a source of pain and stress for patients. Coronary Care Unit (CCU) patients who had received intraaortic balloon pump (IABP) therapy reported that admission to CCU and pain and discomfort from treatments and unexplained procedures were their greatest stressors (Patacky, Garvin & Schwirian, 1985). Cardiac surgical patients have described excruciating pain associated with endotracheal (ET) suctioning and chest tube removal (Puntillo, 1990), but this procedural pain was not quantified.

Although only one of the above studies was directed exclusively to the problems of pain in the critically ill (Puntillo, 1990), some definite conclusions can be drawn from critical care stress studies. Patients, when given the choice of prioritizing the many potential ICU problems and stressors, identify pain as a major problem. The findings are clear: pain is substantial; pain interrupts sleep; and pain creates enormous psychological stress.

Physiological Consequences of Pain

There is clinical and empirical evidence for the relationship between pain and substantial pathophysiological consequences. In fact, the subjective experience of pain has long been known to be closely associated with complications in post-operative patients (Bonica, 1953; Crile & Lower, 1915). Physiological disturbances that result from surgeries on thoracic or abdominal viscera may be particularly profound due to the degree, seriousness (Bonica, 1953), and persistence of these disturbances (Rybro, Schurizek, Peterson & Wernberg, 1982). In patients with chest injuries, pain can lead to poor cough, shallow breathing and subsequent decrease in lung compliance (Lloyd, Smith & O'Connor, 1965).

When pain interferes with these mechanics of respiration, the potential for respiratory complications occurring is heightened. The most common and most significant side effects of thoracoabdominal surgical procedures are due to inefficient ventilation (Benedetti, Bonica and Belluci, 1984; Bonica, 1981). In fact, an ineffective respiratory pattern and effort due to pain in upper abdominal surgical patients has led to decreases in arterial oxygen and carbon dioxide; decreases in vital capacity (VC) and peak expiratory flow rate (PEFR); and increases in arterial-alveolar oxygen difference (A-aDO2) (Pflug, Murphy, Bulter & Tucker, 1974).

Post-operative vital capacity has been reported to be significantly worse in upper abdominal surgical patients who were treated with "as needed" (prn) intramuscular papaveretum and who reported more pain than in a comparative sized group treated with epidural fentanyl (Welchew & Thornton, 1982). Critical care coronary artery bypass graft patients who needed more morphine to control their post-operative pain had increased incidences of respiratory insufficiency, re-intubation and mechanical ventilation (El-Baz & Goldin, 1987).

Low lung volumes and respiratory effort can precede development of atelectasis (James, Kollberg, Iwen & Gellatly, 1981), impaired respiratory tract clearance and consequently impaired oxygenation. The incidence of pneumonia in thoracic surgical patients has been reported to be as high as 40% (Garabaldi, Britt, Coleman, Reading & Pace, 1981). Atelectasis and pneumonia can, in turn, lead to respiratory failure.

Obese upper abdominal gastroplasty patients who had less pain relief and who required more analgesics to achieve adequate pain relief had greater post-operative respiratory morbidity. That is, they developed more atelectasis and lung parenchymal infiltrations, had higher fevers and coughs, and had more purulent sputum than did patients requiring less analgesics and reporting more excellent analgesia (Rawal et al., 1984). Patients in these two groups had similar pre-operative levels of disease severity,

as evidenced by comparable arterial blood gas, peak expiratory flow rate, forced vital capacity and forced expiratory volume respiratory data. Likewise, surgical anesthesia, incisions and surgeons did not differ between groups. Thus, the differences between groups in post-operative analgesic needs and respiratory complications could well have been due less to morbidity factors than to analgesic needs for pain relief.

Hasenbos et al. (1985A; 1985B) also found a higher incidence of atelectasis, a greater need for bronchoscopies and more elevated pC02 levels in their group of thoracic surgical patients whose pain was harder to relieve. Pre-operative severity of illness was actually less in the group requiring more analgesics (administered IM) to relieve pain than those requiring less analgesics (administered epidurally). Thus, morbidity in the form of post-operative respiratory complications seemed to evolve from inadequate management of pain. These studies clearly point to the need for earlier intervention to prevent such intense pain and the need for other pain treatments besides medication.

Thus, inadequately treated post-operative pain is likely to elicit adverse respiratory responses (Craig, 1981; O'Gara, 1988), causing potential life-threatening complications in critically ill patients. In some patients, these complications may progress to death (Bonica, 1981).

Cardiovascular complications generally associated with pain result from increased activation of the sympathetic

nervous system (SNS). SNS responses can significantly alter cardiovascular parameters. Myocardial oxygen consumption is increased due to increased heart rate and contractility from the inotropic effects of SNS activation. Afterload, increased as a result of peripheral vasoconstriction, also increases the workload of the heart. At the same time, blood flow to myocardial tissue may be impaired (Bouckoms, 1988; O'Gara, 1988) due to coronary artery vasoconstriction from SNS activation. Compromised critical care patients may be particularly prone to the deleterious effects of these altered cardiovascular responses if increased myocardial oxygen demand exceeds restricted supply.

Severe pain can lead to profound reflex physiological stress responses (Kehlet, 1986; Wilmore, Long, Mason & Pruitt, 1976). Endocrine and metabolic responses such as increased cortisol, catecholamines, antidiuretic hormone synthesis; glycolysis and hyperglycemia; increased protein catabolism; decreased plasma insulin; and increased lipolysis may all be related to the extent of tissue injury. Endocrine-metabolic response to thoracoabdominal surgical procedures is substantial (Kehlet, 1986). However, it has been extremely difficult to isolate metabolic responses due to pain from those due to the surgical procedure or trauma itself (Kehlet, 1986).

Nevertheless, one advantage of pain control in surgical patients may be reduced substrate mobilization and attenuation of the stress response (Bryan-Brown, 1986).

Opiate administration, while alleviating pain, may also decrease adverse post-operative endocrine-metabolic responses (Kehlet, 1982). In fact, plasma beta-endorphins and cortisol levels were lower in an experimental group of CABG patients treated with epidural morphine and who reported excellent analgesia than in a control group who had received intravenous morphine(El-Baz & Goldin, 1987).

As with data regarding psychological consequences of pain, evidence also confirms that its physiological consequences may be significant. Alteration of respiratory, cardiovascular and endocrine-metabolic function can result in life-threatening complications in vulnerable, critically ill patients. More comprehensive research on the dimensions, predictors and outcomes of pain in critically ill thoracoabdominal surgery patients is essential.

Chapter 2

Conceptual Framework

Pain is a multidimensional experience (Melzack & Casey, 1968; Melzack & Wall, 1983). Physiological theory provides an understanding of how pain is generated, transmitted and integrated into a perceptual experience. Explanations derived from physiological theory create a foundation for recognizing the multiple dimensions of pain, a necessary prerequisite to the description and quantification of these dimensions (Clark, Janal, & Carroll, 1989). In turn, this foundation is supported by knowledge of psychological processes as well as biosocial, treatment and illness-related factors that are intricately woven into a person's pain experience.

Physiological Theories of Pain

The pain of patients with thoracoabdominal injuries is the perceptual culmination of noxious afferent information derived from segmental (spinal cord), suprasegmental (thalamic and brainstem) and cortical levels of the central nervous system (CNS) (Benedetti, Bonica & Bellucci, 1984). There are three potential peripheral sources of noxious impulses leading to pain in patients with thoracoabdominal injuries: cutaneous, deep somatic and visceral tissues. For example, during a thoracotomy procedure for a lung resection, noxious impulses originate from the cutaneous surgical skin incision and from deep somatic structures such as resected thoracic muscles, parietal pleura and lung

parenchyma. Likewise, an abdominal procedure will generate similar cutaneous and somatic impulses as well as visceral impulses due to retraction and pressure applied to abdominal organs.

Cutaneous, deep somatic and visceral pain differ somewhat from one another. Cutaneous afferent noxious impulses are transmitted primarily through myelinated A-delta fibers and also through unmyelinated C fibers (Meyer, Campbell & Raja, 1985; Perl, 1984). Human intraneuronal microstimulation studies have revealed that the pain believed to be transmitted through A-delta fibers is reported as sharp and fast in nature. In contrast, C fibers are believed to be associated with pain that is described as diffuse, dull and delayed (Torebjork, 1985).

Deep somatic pain originating from fascia, tendons, joints, ligaments and muscles (Bonica, 1953; Fields, 1987) is frequently more difficult to localize. In addition, it is associated with Autonomic Nervous System (ANS) responses such as vasoconstriction, nausea, vomiting and sweating, and may be accompanied by muscle spasms (Inman & Saunders, 1944). Patients with thoracoabdominal injuries may frequently experience this deep somatic pain as well as visceral pain (Benedetti et al, 1984).

Noxious fibers that are visceral in origin account for a very small percentage of primary afferent fibers (Cervero, 1988) and are ten times more likely to be of the C fiber type than A-deltas (Cervero, 1985). Thus, the difficulty in

localizing and describing visceral pain may be due in part to the small number and specific type of visceral fibers. Many visceral fibers travel to the spinal cord with SNS fibers, entering the spinal cord at levels thoracic 2-3 and lumbar 2-3 (Cervero, 1988). Some types of deep somatic and visceral pain have similar qualitative characteristics, in part because they converge on the same secondary neurons in the spinal cord. As a result, they are associated with the phenomenon of referred pain (Fields, 1987). That is, the individual may localize pain to the somatic structure innervated by the converged neuron rather than the visceral structure that may, in fact, be the source of pain.

Before pain is perceived, suprasegmental connections and transmission of nociceptive information from the spinal cord to higher centers must, under normal circumstances, occur. Synapsing between primary cutaneous, deep somatic and visceral fibers and ascending tracts occurs in dorsal horn spinal cord laminae (Price, Hayashi, Dubner & Ruda, 1979; Willis, 1985). Ascending tracts carry noxious information to many areas of the brain, which helps to account for the multiple sensory, motivational-emotional and cognitive dimensions of a pain experience.

The actual perception of pain is believed to be a cortical process. The importance of the cortex to pain is immense. It is widely acknowledged that, functionally, the cortex plays a major role in perception and evaluation of

pain (Melzack & Casey, 1968) and in influencing the psychic trauma and fear that may accompany pain (Bonica, 1953).

The particular sites of cortical involvement have yet to be clearly identified, primarily due to the difficulty of experimentation (Andersson & Rydenhag, 1985). However, there is some evidence to suggest the involvement of many cortical areas in pain perception since introduction of a painful stimulus has led to widespread cortical bloodflow (Lassen, Ingvar & Skinhoj, 1978). In contrast, elimination of pain perception by extensive cortical lesions has been inconsistent (Andersson & Rydenhag, 1985).

Monkey experiments have led to the localization of some cortical neurons that respond to noxious stimuli (Kenshalo & Isensee, 1983). These tested neurons were in somatosensory cortical areas 3B and 1, within and posterior to the central sulcus. One group of these neurons had discrete, well localized contralateral peripheral receptive fields and may, therefore, be associated with the sensory-discriminative aspects of pain. Another group of monkey neurons had widespread peripheral fields. These fields may participate in general cortical arousal activities, motor adjustments and perhaps the motivational-affective nature of pain (Kenshalo & Isensee, 1983).

Consciousness is a necessary prerequisite to the perception of pain. Consciousness is a level of awareness where thought-processing and feeling can occur (Vander Sherman & Luciano, 1985); it is comprised of arousal and

awareness (Mitchell, 1988). A noxious sensation becomes pain when that sensation reaches conscious levels (Fields, 1987). Before this time, considerable central processing and modifying of the sensation occur all along the neural axis (Livingston, 1978). In fact, a balancing of pain transmission and pain inhibition occurs.

A critical care patient with altered levels of consciousness may respond reflexively to a noxious stimulus yet not perceive pain. Nociception is the stimulation of neural pathways by noxious stimuli. The reflex response to nociception can be at the spinal cord level only as evidenced, for example, by the withdrawal of a leg due to a pinprick stimulus. In contrast to nociception, pain requires perceptual activity. Numerous factors can alter a critical care patient's level of consciousness and, therefore, influence pain perception. These factors may include neurologic conditions, such as metabolic encephalopathy or cerebral ischemia, or the effects of numerous pharmacological agents, such as anesthetics, analgesics, hypnotics or sedatives.

Reflex motor and SNS activities that accompany pain are due to segmental, suprasegmental and cortical integration of noxious input. Specifically, reflex motor activity is due to direct or indirect (through interneurons) synapsing of fibers onto lower motor neurons whose cell bodies are in lamina VIII of the anterior dorsal horn of the spinal cord (Kandel & Schwartz, 1984). This reflex activity may result

in contraction of skeletal muscles, especially those in the abdominal wall, and may lead to abdominal wall rigidity (Ganong, 1987). As a result, reflex skeletal muscle spasms of oblique abdominal muscles can affect diaphragmatic excursion. Subsequent ineffectiveness of diaphragm and intercostal muscles can result in hypoventilation, as evidenced by elevated levels of $paCO_2$, or hyperventilation (i.e., decreased pCO_2) if respiratory rate and pattern is rapid and shallow. Additionally, pain and spasms cause the individual to voluntarily avoid coughing, deep breathing or moving, maneuvers that help prevent respiratory complications (Bonica & Benedetti, 1980). The voluntary nature of these avoidance activities results from suprasegmental and cortical input to the spinal cord.

Sympathetic Nervous System responses to pain can be explained by activity of segmental reflex arcs that are also under suprasegmental and cortical influence. That is, visceral afferents synapse with interneurons to preganglionic cell bodies of the SNS and/or Parasympathetic Nervous System (PNS) that are located in the intermediolateral gray matter in lamina VII (Ganong, 1985). The suprasegmental input to these preganglionic cell bodies is through a series of descending pathways from hypothalamus, medulla and other higher cortical centers (Noback & Demarest, 1981).

Responses to thoracoabdominal surgery can be influenced by higher center output such as control over motor

activities as well as feelings of fear or anxiety. The total pain experience, including its physiological consequences, is due to integration of these physiological and psychological responses.

The Multiple Dimensions of Pain

The preceding discussion of anatomy and physiology of pain transmission and perception provides a foundation supportive of the multiple dimensions of pain. Pain, in fact, has sensory-discriminative, motivational-affective, and cognitive dimensions (Melzack & Casey, 1968). Attention to all of these dimensions tells us more about the individual's pain experience and, theoretically, can generate more appropriate treatment plans.

Sensory-discriminative dimensions of pain encompass the magnitude of pain as well as its spacial and temporal properties. The magnitude of pain is its severity or intensity. The sensation of pain is its spacial, thermal and pressure characteristics. Spacial properties of pain also include its body location. Sensory-discriminative dimensions of pain are the most well understood and most often assessed dimensions due to our advanced knowledge of neuroanatomical and physiological pain mechanisms (Melzack & Casey, 1968; Price & Dubner, 1977). For example, the variability of the felt pain sensation -- sharp, well-localized versus dull or diffuse-- demonstrated by experimental stimulation is thought to be due to different

fiber types, A-delta and C fibers, respectively (Torebjork, 1985).

Motivational-affective dimensions of pain include the unpleasant emotions and aversive drives associated with pain perception (Melzack & Casey, 1968). When pain is perceived, the individual's "feeling-tone threshold" is lowered as a result of nociceptive input to limbic brain areas (Cazzullo & Gallo, 1987, p. 257), and negative emotions are felt. Aversive drives initiate motor responses that are evidenced physiologically and behaviorally. These multiple responses are due to physiological recruitment of numerous brain sites.

Cognitive dimensions of pain serve as central control processes (Melzack & Casey, 1968) and require cortical integration. Cognition can greatly influence pain perception. Cognition is the generation of a representation of an event, thinking about it and remembering it (Levine & Shefner, 1981). The experience and meaning of sensory stimuli such as pain are catalogued and built upon as such experiences occur over time. That is, a stimulus from the environment, like pain, is identified, localized, classified and stored through cognitive processes. This stored information, which includes past experiences and expectations, influences sensory neuronal circuits and shapes current perceptions (Livingston, 1978). Cognition encompasses feedback from all neurological levels and uses the cortical processes of memory and mental operations

(Scott, Oberst & Dropkin, 1980). Although neurophysiological mechanisms of complex cognitive processes have yet to be delineated (Boss, 1988), cognitive processes of evaluation and meaning derivation can influence and control sensory-discriminative and motivational-affective dimensions of pain. Cognitive appraisal of pain and emotional responses are, in fact, tightly linked (Price, 1988). Cognitive dimensions of pain are activated when patients evaluate and make judgments about the meaning of pain or the effectiveness of pain relief measures.

In sum, all three dimensions of pain-- sensory-discriminative, motivational-affective and cognitive-- interact with one another to contribute perceptual and cognitive information and motor behavioral responses associated with a pain experience (Melzack & Casey, 1968). To fully understand and ultimately treat a critical care patient's pain experience requires attention to all of pain's dimensions.

Mediators of Pain

Many factors may influence the pain experience of critically ill patients. These include individual demographic and personality characteristics as well as factors related to the particular illness or treatment of an individual. Each of these mediators, depicted in Figure 1, is discussed.

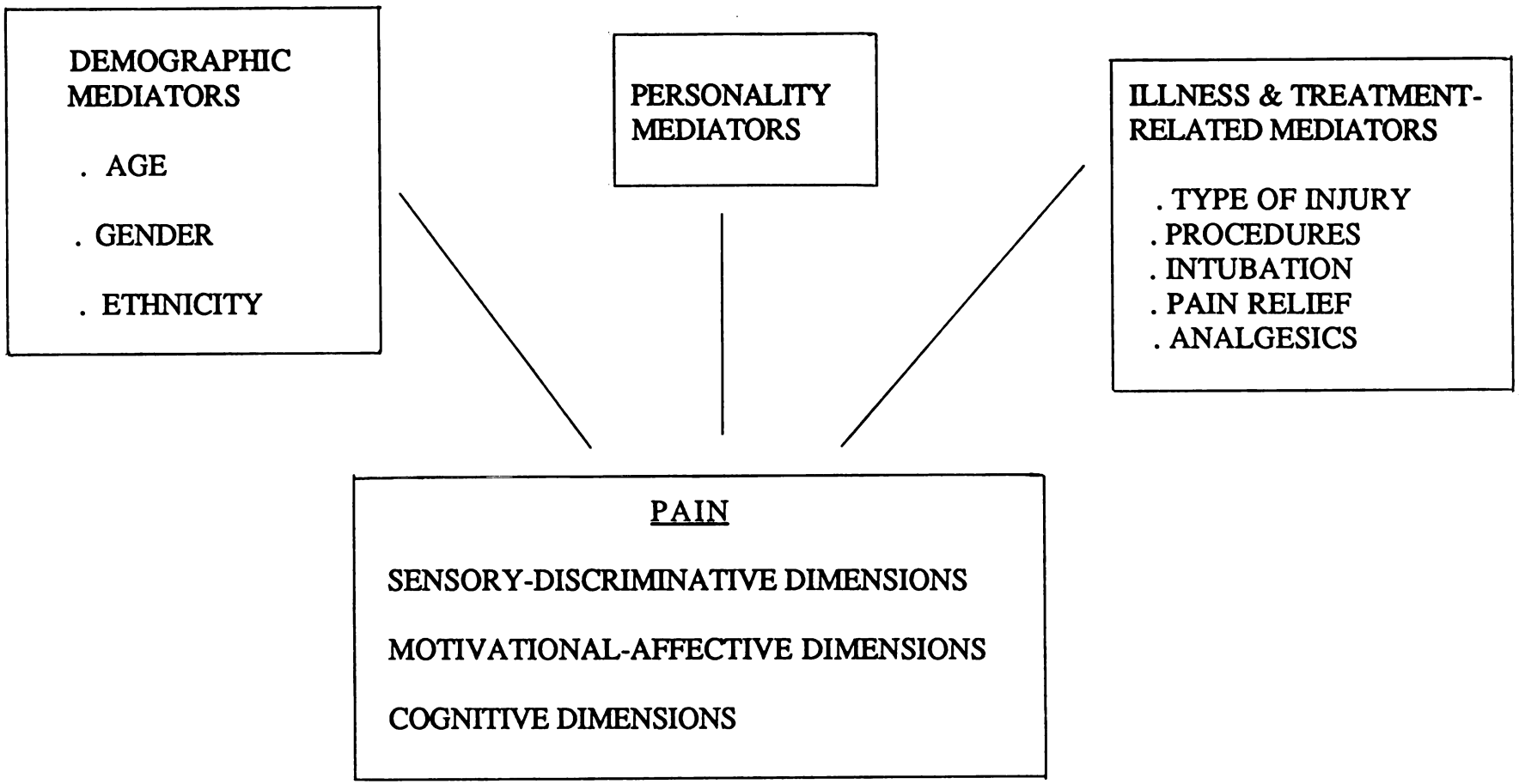

FIGURE 1: MEDIATORS OF THE PAIN EXPERIENCE IN CRITICALLY ILL THORACOABDOMINAL SURGERY PATIENTS

Demographic Mediators

Certain biosocial demographic characteristics such as age, gender and ethnicity may influence a patient's pain experience. Findings about the effects of age on pain have, for the most part, been equivocal (Harkins, Kwentus & Price, 1984). For example, Procacci, Bozza, Buzzelli, & Della Corte (1975) and Sherman & Robillard (1960) found that threshold for radiant heat pain increased progressively with advancing age in both genders and that women had lower pain thresholds than men in all age groups. Procacci et al. (1975) suggested that the increased threshold is due to increased dispersion of thermal energy via the blood supply as a result of decreased skin thickness as well as to an increase in cutaneous nociceptor threshold. Schludermann & Zubek (1962) also saw an increased pain threshold in men as they aged. There was a significant decline in pain sensitivity after the age of 60. However, the researchers found that these changes in pain thresholds depended on body location tested as well as the socioeconomic status of subjects. That is, upper body parts became less pain sensitive than lower body parts. Additionally, college-educated professional men were less sensitive to pain than the unskilled and skilled laborers in the study.

Contrary to the above findings, Harkins & Chapman (1976; 1977) found no difference in pain thresholds between younger (M = 23 years) and older (M = 71.4 years) men (1976) or younger (M = 22 years) or older (M = 70 years) women.

However, both older men and women had more difficulty discriminating between varying degrees of mild pain and were, therefore, less inclined to report mild levels of pain. Thus, reporting bias was a confounding variable. Although these researchers did not comment on threshold differences between men and women in their two studies, there was a difference. In both age groups, women had lower pain thresholds than men.

In post-operative analgesia studies of predominantly surgical patients, there was a positive relationship between age and pain relief from analgesics (Belville, Forrest, Miller & Brown, 1971). That is, there was progressively more pain relief from medications reported in each of the age categories over the age of 40.

It has been difficult to generalize about the relationship between gender and pain (Weisenberg, 1977). In one experimental study of pain tolerance, men were able to tolerate pain better than women (Notermans & Tophoff, 1975). Tolerance was ascertained by asking subjects to hold an electric current stimulus on their finger as long as possible. However, age-tolerance results differed when the painful experimental stimulus was that of deep somatic pressure pain; that is, painful pressure applied to the achilles heel (Woodrow, Friedman, Sieglaub & Collen, 1972). Tolerance to this pressure pain consistently decreased in both genders as their ages increased. The decreases due to

age were more steep in males, and tolerance levels were consistently greater in males than females across all ages.

Nevertheless, findings about the effects of age and gender on pain are inconclusive. While it appears men are less sensitive to pain than women and the elderly are less sensitive to pain than younger people, research results are not definitive. Variability of results can be due to differences in type and location of pain stimuli, differences in control of and/or attention to confounding variables and differences in reporting criteria (Harkins, Kwentus & Price, 1984). The influence of age and gender on pain in critical care patients is unknown.

Ethnicity and culture also may affect a pain experience. A now classical study by Zborowski (1952) shed some light on cultural differences in reactions and attitudes to pain. Men hospitalized with clinical pain at Veteran's Administration facilities were categorized into four ethnocultural groups: (1) "Old Americans"; those from Anglo-Saxon ancestory whose families had been in the United States for generations; (2) Irish; (3) Italian Americans; and, (4) Jewish Americans. Zborowski found Old Americans reacted with matter-of-factness to the pain; Irish were stoic; Italian-Americans were very vocal and demonstrative but satisfied when pain was relieved; and Jewish Americans were also vocal and demonstrative but less assuaged by pain relief measures. That is, Jewish Americans continued to worry about their future in relation to problems with pain.

Sternbach & Tursky (1965) examined women's reactions to experimental pain and found that the point where subjects were unwilling to accept higher pain stimuli levels (a measure of tolerance) differed among ethnic groups. Yankee women (i.e., Protestants of British descent who had been in America for generations) showed the highest tolerance, followed by Jewish women, Irish women and Italian women. While the research paradigm differed between Zborowski and Sternbach & Tursky, there were similarities between older American and Irish groups in how they experienced pain. However, Jewish women tolerated more experimental pain than Italian women (Sternbach & Tursky, 1965), while Jewish men were less satisfied by pain relief measures than were Italian men (Zborowski, 1952).

Woodrow and colleagues (1972) found that tolerance to experimentally-induced achilles heel pressure pain significantly differed according to ethnicity. That is, Whites had the highest pain tolerance; Blacks second; and Orientals were third. However, racial representation in this study was skewed, a factor that could have influenced results. Eighty-three percent of the study population were White, 13% were Black, and only 4% of the 41,119 subjects were Oriental.

Contrary to the findings from the above three studies on ethnic differences in pain (Sternbach & Tursky, 1965; Woodrow et al., 1972; Zborowski 1952), no differences were seen among ethnic groups in report of episiotomy pain

sensation and attitudes towards pain (Flannery, Sos & McGovern, 1981). That is, Black, Italian, Jewish, Irish and "Old American" women had similar responses to episiotomy pain. These findings conflict with the earlier reported Sternbach and Tursky (1965) results. However, Flannery et al. (1981) studied clinical pain sensation and attitudes while Sternbach & Tursky (1965) studied experimentally-induced pain tolerance. It is well known that experimental and clinical pain can differ considerably. Experimental pain deals primarily with the reporting of pain threshold and tolerance while a clinical pain experience also includes the pain environment as well as emotional reactions and attitudes towards pain (Beecher, 1952).

Differences in study findings relating age, gender and ethnoculture to pain could be due to differences in study samples, in clinical versus experimental pain and in other methodological factors. What remains, however, is the distinct possibility that these biosocial characteristics may influence a thoracoabdominal surgical patient's critical care pain experience.

Personality Characteristics as Mediators of Pain

Personality characteristics, including the psychological state of the person experiencing pain, may be important pain mediators. In fact, cognitive pain dimensions are modified by personality characteristics and emotions that are a fundamental part of a pain experience (Cazzullo & Gala, 1987). Anxiety is the most common emotion

generated by onset of acute pain. It has been defined as, "an active organization of defense mechanisms, a reaction to an internal or external danger, and a threat to the integrity of the personality, consisting of mind and body" (Cazzullo & Gala, 1987, p. 262). Whether anxiety associated with pain is due to disruption of attention due to noxious sensory input or to an intrinsic reflexive limbic or autonomic nervous system response is not clear (Chapman, 1986). Irrespective of its etiology, numerous studies suggest that anxiety may influence a pain experience.

For instance, anxiety is believed to be a correlate of the pain associated with surgery. Positive correlations between post-operative pain and anxiety have been well documented (Chapman & Cox, 1977; Hinshaw, Gerber, Atwood & Allen, 1983; Levesque, Grenier, Kerouac & Riedy, 1984; Martinez-Urrutia, 1975; Scott, Clum & Peoples, 1983; Wolfer & Davis, 1970). Bruegel (1971), however, found no relationship between pre-operative trait anxiety and post-operative pain perception and analgesia usage.

In addition to anxiety, the association between other personality characteristics and pain has also been explored. For example, the relationship of experimental pain tolerance to extroversion (one's threshold for and tolerance of social stimuli), and neuroticism (one's degree of emotional and perceptual reactivity to stimuli) have been established (Lynn & Eysenck, 1961). Specifically when college students had radiant heat applied to their foreheads, those with

higher extroversion scores tolerated the painful stimulus for a longer period of time than those with low extroversion scores. In contrast, neuroticism scores correlated negatively and significantly with pain tolerance. From this study it was asserted that pain tolerance was positively related to extroversion and negatively related to neuroticism.

Other studies relating personality characteristics and pain tolerance are less conclusive. Otto & Dougher (1985), while confirming that men were more tolerant of pain than women, could not relate masculinity-femininity and social desirability to levels of experimental pressure pain tolerance. Additionally, no significant correlation could be found between ice water immersion pain tolerance and multiple personality measures such as self-esteem, self-confidence, self-control, personality adjustment, achievement, dominance and endurance (Lukin & Ray, 1982).

The relationship between personality characteristics, including the presence of anxiety, one's degree of extroversion, and emotional/perceptual reactivity and pain needs further exploration. None of these factors has yet been studied as they relate to the pain of critically ill patients.

Illness and Treatment-Related Mediators of Pain

Pain from Care Procedures

Critically ill patients are subjected to numerous diagnostic and treatment-related procedures performed in the

critical care setting. Pain resulting from these procedures has not been well investigated (Bryan-Brown, 1986). Yet, patients have identified pain from chest tubes, Swan-Ganz catheters (Paiement et al., 1979) and procedures in general (Patacky et al., 1985) to be causes of stress. Other critical care patients described the pain they felt when they underwent endotracheal suctioning and chest tube removal (Puntillo, 1990). However, there have not been detailed investigations of procedural pain in surgical critical care patients.

Burn patients, however, represent a group of patients that are frequently subjected to painful debridement and dressing change procedures. Therefore, some information about procedural pain can be gained from prior burn pain research. In a survey of 93 burn units, health care professionals reported that they believed patient pain from debridement was usually at a moderate level of intensity after pre-medication (Perry & Heidrich, 1982). Those professionals with less experience ranked patient pain higher than did those who had worked with burn patients longer. Patients in this survey did not rate their pain.

In a second study, both burn patients and their nurses rated the pain patients experienced during burn wound care (Van der Does, 1989). Mean ratings for overall and worst wound care pain were 3.22 and 4.04 respectively (patients) and 3.79 and 5.04 respectively (nurses). The pain rating scale was a 0-10 visual analogue scale.

Correlations between patients' and nurses' ratings were statistically significant but moderate. The author explained that the low intensity ratings may have been due to inclusion of patients undergoing wound care procedures late in their hospital stays when wounds were almost healed and during the first few days when patients report little pain. Intubated patients were intentionally excluded from this study, so their procedural pain experience in unknown.

Many critically ill thoracoabdominal surgical patients are intubated and require ET suctioning and have chest tubes removed after surgery. The dimensions of pain associated with these procedures and the relationship of this procedural pain to the patient's tonic surgical pain have not been investigated.

Analgesics

Although analgesia is defined as, "absence of pain on noxious stimulation" (International Association for the Study of Pain, 1979, p. 250), analgesics usually refer to drugs used to manage pain (American Pain Society, 1987). Analgesics are the most widely used pain treatment modality in critical care units. However, the type, amount and mode of analgesia can vary widely. Therefore, it is difficult to determine the effects of analgesics on pain.

Frequently in surgical patient pain studies, the amount of analgesics used is a measure of pain; sometimes it is the only pain measure (Cooperman, Hall, Mkialacki, Hardy & Sadar, 1977; Lange, Dahn & Jacobs, 1988). Unfortunately,

correlation of pain report with amount of analgesia administration is sometimes omitted from discussions of post-operative pain research, even if both are measured (Locsin, 1981; Madden, Singer, Peck & Nayman, 1978; Menzel & Martinson, 1977). However, Cohen (1980) found that 82% of 109 abdominal surgical patients received less narcotic analgesics than ordered. In fact, over one third of the patients reporting the greatest degree of pain distress received less analgesics than they could have received. From this study, there appeared to be a negative correlation between pain and amount of analgesics received. On the other hand, there were significant positive correlations between pain intensity and narcotic intake and between pain distress and narcotic intake in 42 abdominal surgical patients (Flaherty & Fitzpatrick, 1978).

The relationship between pain and analgesic administration in studies of patient-controlled analgesia (PCA) is also inconclusive. Three PCA studies serve as examples of the variable relationship between amount and mode of analgesia administration and level of analgesia. In the first, Kleiman, Lipman, Hare & MacDonald (1988) compared the effects of scheduled Intramuscular (IM) versus PCA-delivered morphine sulfate (MS) in patients undergoing major abdominal or orthopedic surgical procedures over a 48 hour post-operative period. Although patient reports of pain and total amount of analgesics used (approximately 10 mg every

four hours) were no different between groups, patients preferred PCA.

Bollish, Collins, Kirking & Bartlett (1985) used a crossover design to compare the effects of as needed (prn) IM versus PCA MS in 20 post-operative abdominal surgical patients. During the 24 hours that patients had PCA morphine, they reported significantly less pain. However, the amount of morphine they received did not differ significantly from the amount given during the 24 hours they were administered IM morphine. Therefore, differences in pain levels were not explained by the amount of analgesics used.

Hecker & Albert (1988) also compared the effects of PCA and IM morphine administration in cholecystectomy patients. Their PCA group used significantly less morphine and reported significantly less pain than did those who received morphine IM during the two day study period. To summarize the PCA study findings, no consistent relationship emerged between amount of analgesics administered and pain levels.

Two epidural analgesia studies have examined pain alleviation for critical care patients. In the first, levels of analgesia were studied in a group of grossly obese post-operative gastroplasty patients (Rawal et al., 1984). Fifteen patients received IM MS for post-operative pain while 15 others received epidural MS. Eighty-seven percent of the epidural MS group who had received a mean 9.3 mg MS reported excellent analgesia versus 73% of the IM group who

had received a mean of 66 mg of MS. There was also a lower incidence of pulmonary complications such as atelectasis and lung parenchymal infiltrations in the epidural MS group.

In the second study, 30 CABG patients were treated post-operatively with IV morphine while 30 others were treated with epidural morphine (El-Baz & Goldin, 1987). Morphine doses were signifiantly lower in the epidural group, while pain relief was better. There was, therefore, an inverse relationship between amount of analgesics and level of reported analgesia in both of these epidural analgesia studies. However, the difference in site of administration (systemic versus epidural space) is substantial since epidural narcotic analgesics are estimated to be up to ten times more potent than are systemic analgesics. What remains to be determined is the relationship between amount of analgesics administered and the perception of critical care patient pain when type of analgesic and site of delivery are kept constant.

Altered Communication Due to Endotracheal Intubation

Communication between patients and health professionals in critical care units can be particularly difficult, especially when the patient is intubated (Quettenton, 1987). A person's pain is subjective; thus, the pain's magnitude, location, qualities and meaning can only come from the individual experiencing it. Even when patients are able to verbalize, inadequate assessment can result from cursory questioning of patients about pain. In fact, general,

cursory questioning about a patient's pain was found to be an insufficient method of eliciting enough information about a patient's real pain situation (Marks & Sacher, 1973); rather, more detailed and focused questioning was required.

The advantage of being able to verbalize pain was demonstrated in a study that used simulated case presentations of people with painful disorders. Doctors, nurses and social workers attributed greater pain to those cases in which patients could verbalize their pain than those who were unable to do so (Baer, Davitz & Lieb, 1970). The researchers stressed the importance of verbal communication to pain assessment, advising, "If a patient is in pain he had better 'speak up'" (p. 391). Unfortunately, such advice is not helpful to many critically ill intubated patients who cannot, "speak up."

With intubation, the problem of communication is magnified. Patient perceptions of pain during mechanical ventilation have been explored in descriptive research studies. Gries & Fernsler (1988) interviewed nine ICU patients one to seven days after their extubation in order to identify stressors from intubation. All patients reported discomfort from ET tube placement and suctioning. Similarly, all patients reported difficulty in communicating with nurses; this was a major source of stress for them and a factor that could have significantly influenced their communication of pain.

Paiement et al. (1979) explored the intubation and other experiences of cardiac surgical patients. Only 58% of the 100 study patients remembered being intubated and only 8% remembered it as being uncomfortable. Thus, the lack of pain due to intubation was contrary to previous research reviewed. Nevertheless, intubation presents a significant barrier to the thoracoabdominal surgery patient's ability to communicate their pain to health professionals and may, indeed, significantly influence their pain experience.

Pain Relief

The cognitive dimensions of a pain experience are explored when patients are asked to judge or evaluate pain treatment effects. Exploring pain relief with patients may elicit information about the meaning of the pain to them (McGuire, 1981) and influence the pain experience. Pain relief serves as a mediator of pain since it is expected that the relationship between relief and pain is inverse (Wallenstein, 1984). Fishman et al. (1987) assessed pain intensity and pain relief obtained from most recent intervention-- usually analgesics-- in 50 hospitalized cancer patients. There were strong negative correlations between pain intensity and relief, as measured by a VAS pain intensity and a VAS pain relief scale.

Patients anticipate pain relief from treatment interventions (Melzack, 1975). Therefore, in order to adequately evaluate a person's total pain experience, assessment of pain relief needs consideration (Fishman et

al., 1987; Huskisson, 1974). Evaluating presence and sources of pain relief is essential to the appropriate clinical management of pain. Some interventions may, in fact, exacerbate pain (Donovan & Dillon, 1987). Therefore, without an evaluation of pain relief, severity of pain dimensions may increase.

Type of Injury

The type of injury may serve as a mediator of pain. Although there is evidence to suggest a poor correlation between perception of pain intensity and extent of wound or tissue damage (Beecher, 1956; Keats, 1956), the intensity of various types of surgical pain has been differentially graded. In fact, the site of operation has been shown to be an important factor determining post-operative pain severity (Parkhouse, Lambrichts & Simpson, 1961; Swerdlow, Starmer & Daw, 1964). For example, when the amount of narcotic and the number of and interval between doses have been used as pain intensity criteria, intrathoracic, upper abdominal and renal surgeries have been estimated to be very severe in intensity (Benedetti et al., 1984). Specifically, 72-75% of thoracic surgical patients and 63% of upper abdominal surgical patients required post-operative analgesia compared to 51% of lower abdominal and 27% of non-abdominal surgical patients (Loan & Dundee, 1967). Pain also appears to vary according to type of abdominal incision, such as whether an abdominal surgical incision is vertical, transverse or subcostal (Parkhouse et al., 1961). A subcostal incision

has been associated with less pain than a midline incision (Benedetti et al., 1984). However, in most surgical pain intensity studies, the quantification of pain severity has, for the most part, been indirect; analgesia administration versus direct patient reporting has served as the pain intensity criterion. The relationship of other pain dimensions-- extent, sensory and affective qualities-- has not been explored. Thus, our understanding about the relationship between type of surgical injury and pain is obscure.

Morbidity Status

As reviewed earlier, there have been numerous concerns expressed about the many potentially negative outcomes of pain in critically ill patients, including both psychological (McKegney, 1966; Nadelson, 1976; Noble, 1979) and physiological (Craig, 1981; El-Baz & Golden, 1987; Hasenbos, 1985A,B; O'Gara, 1988; Yeager et al., 1987) morbidity. However, psychological disturbance such as confusion, depression and hallucinations associated with critical care patient pain has not been well substantiated by research.

Physiological morbidity has been evidenced by patient development of pulmonary, cardiovascular and endocrine-metabolic complications. Primary pulmonary complications include atelectasis, pulmonary infections and hypoxemia (Stevens & Edwards, 1990).

Increased morbidity in critically ill patients can be due to the impact of endocrine-metabolic stress responses on physiological integrity. Increased energy is derived through the mobilization of glucose, protein and fat stores and then utilized (Kehlet, 1986). The requisite energy expenditure, as evidenced by increased oxygen consumption and carbon dioxide production, may diminish the body's ability to mobilize homeostatic responses and avert complications.

Increased energy expenditure-- and perhaps its resultant complications-- can be minimized in critically ill patients through use of analgesics. In fact, there was a significant decrease in total and resting energy expenditure in seven critically ill intubated medical-surgical patients after they had received morphine either by continuous infusion or by IV boluses (Swinamer, Phang, Jones, Grace & King, 1988). This decreased energy expenditure, as measured by decreased oxygen consumption and carbon dioxide production, did not require high doses of morphine and was independent of the patient's severity of illness. However, analgesics did not significantly affect the amount of energy expenditure during patient care activities such as nursing assessments, chest x-rays or dressing changes. Nevertheless, diminished physiological resources and increased energy needs may enhance patient vulnerability to development of complications and increase their morbidity. Morbidity status and its relationship to pain in critically

ill thoracoabdominal surgical patients warrants further study.

In summary, the framework of this study includes physiological theories of pain that help to account for the multidimensional nature of pain and its adverse consequences. It addresses care procedures that are also a source of pain for critical care patients. Furthermore, it provides a conceptual basis for variables that can mediate a critically ill thoracoabdominal surgery patient's pain experience. These variables include biosocial demographic, personality and treatment and illness-related mediators. Treatment and illness-related variables are analgesic administration, length of patient intubation, amount of pain relief obtained from analgesics, type of procedures experienced and the type of surgical injury incurred. The conceptual framework also provides a basis for relating pain to morbidity. From this conceptual framework, some assumptions can be made about the pain of these patients.

Assumptions

(1) Critically ill thoracoabdominal surgery patients have pain from surgery as well as from procedures performed, the dimensions of which are poorly understood.

(2) There are demographic, personality and treatment or illness-related variables that influence the perception of pain in critically ill thoracoabdominal surgery patients, but the exact relationship of such factors to the pain experience is unknown.

(3) The patient's morbidity status in the form of negative patient outcomes such as need for reintubation, infections, psychological disturbances and pulmonary complications may be related to the pain experienced by critically ill thoracoabdominal surgery patients.

Research Questions

The following research questions, derived from the conceptual framework, served to guide and focus the present study.

(1) What are the various dimensions of tonic and procedural pain experienced by thoracoabdominal surgery patients in critical care units?

a) What are the average values and ranges for degree of sensory pain, affective pain, overall intensity of pain and extent of pain experienced by these patients?

b) What are the relationships among sensory pain, affective pain, overall intensity of pain and extent of pain experienced by these patients?

c) Do the dimensions of pain differ for tonic versus procedural pain?

(2) To what degree are specific demographic, personality, and illness or treatment- related variables associated with the dimensions of pain experienced by thoracoabdominal surgery patients in critical care units?

a) To what extent do age, gender, ethnicity, personality disposition and amount of analgesics received contribute to the variance in magnitude of tonic pain as

indicated by degree of sensory pain, degree of affective pain, overall intensity of pain and extent of pain?

b) What is the correlation between length of intubation and degree of sensory, affective, intensity and extent of tonic pain?

c) What is the correlation between amount of pain relief reported and degree of sensory pain, degree of affective pain, overall intensity of pain and extent of pain?

d) Do the dimensions of pain differ between certain care procedures?

e) Do the dimensions of pain differ according to type of injury; that is, between thoracic and abdominal surgical procedures?

(3) What is the relationship of intensity, extent, sensory and affective dimensions of pain to morbidity status in thoracoabdominal surgical patients in critical care units?

Definition of Terms

Tonic pain was defined as the ongoing pain experienced as part of the surgical injury as described by the patient each day over a 3 day period while in a critical care unit.

Procedural pain was defined as the episodic pain that occurred with specific procedures as described by the patient immediately following chest tube removal and ET suctioning.

Dimensions of Pain were defined as the following:

a) **Degree of Sensory Pain** as determined by the score on the Pain Rating Index- Sensory scale (PRI-S) of the McGill Pain Questionnaire-Short Form (MPQ-SF). Degree of sensory pain for tonic pain was measured each day for three days. Degree of sensory pain for procedural pain was the measure of sensory pain after both an ET suctioning and a chest tube removal procedure.

b) **Degree of Affective Pain** as determined by the score on the Pain Rating Index-Affective scale (PRI-A) of the MPQ-SF. Degree of affective pain for tonic pain was measured each day for three days. Degree of affective pain for procedural pain was the measure of affective pain after both an ET suctioning and a chest tube removal procedure.

c) **Degree of Pain Intensity** as determined by a score on the 0-10 Numerical Rating Scale (NRS) and the score on the 0-10cm Visual Analogue Scale (VAS). Degree of pain intensity for tonic pain were the three NRS and VAS measures taken each day for three days. Degree of pain intensity for procedural pain was the NRS and VAS measures of pain intensity after both an ET suctioning and a chest tube removal procedure.

d) **Extent of Pain** as determined by a score for the number of body areas where pain is experienced as located by the patient on a Body Outline Drawing. Extent of pain for tonic pain was measured each day for three days. Extent of pain for procedural pain was the measure of pain extent

after both an ET suctioning and a chest tube removal procedure.

Demographic Data were the age, gender and ethnicity of patients in the study as provided from information on the patient's chart.

Personality adjustment was the overall score received by an individual on the California Q-Set instrument, reflecting an integrated assessment of personality characteristics such as anxiety, extroversion, introversion, resilience, and depression.

Illness and treatment-related variables were length of intubation, the amount of analgesics received and the amount of pain relief from analgesics reported by the patient.

a) Type of injury was designated as thoracic or abdominal surgical procedure as noted on the patient's chart.

b) Length of intubation was the number of hours the patient was intubated from time of admission to a critical care unit until extubation or to end of study time, if longer.

c) Care procedures were endotracheal tube suctioning and chest tube removal done by critical care staff and noted by investigator.

d) Amount of Analgesics was the total amount of opiates administered intravenously or by mouth during the study time, converted to mg. of morphine.

e) Amount of Pain Relief from Analgesics was determined by a score on a 0-10 Numerical Rating Scale- Pain Relief (NRS-PR), measured at each data collection period.

Morbidity status was calculated by totalling the number of days a patient was in a critical care unit (i.e., length of stay) and by determining the presence and total number of certain other post-operative complications. These complications included infections; re-intubation; pulmonary complications of atelectasis, pleural effusions and pneumonia; and psychological disturbances such as confusion, depression and hallucinations. These data were determined from information in the patient's chart.

Chapter 3

Methodology

Research Design and Setting

The study design was descriptive and correlational in that the aims were to describe the dimensions of pain and to establish relationships between these dimensions and other specified variables that may influence the pain experience.

The research settings were the following critical care units at the University of California, San Francisco: 7 & 9 Moffitt Intensive Care Unit, the Cardiovascular Special Care Unit and the Post-Anesthesia Care Unit.

Sample

Potential subjects were identified through review of operating schedules and through communication with critical care personnel concerning tentative and newly-admitted patients who met the following eligibility criteria:

(1) consenting adults 18 years of age or older undergoing thoracic and/or abdominal surgical procedures;

(2) admitted to a critical care unit after surgery;

(3) able to speak and understand English;

(4) no evidence of impaired level of consciousness after surgery, other than normal recovery from anesthesia;

(5) no evidence of chronic pre-hospital opiate use.

Permission to conduct this study was obtained from appropriate hospital research committees and the University Human Subjects Review board.

Each of the subjects was identified and screened for appropriateness to participate in the study either before surgery or within the first 48 hours of ICU admission. If the subject met inclusion criteria, had no known medical reasons for exclusion and was willing to participate in the study, informed consent was obtained. No informed consent was obtained within two hours after IV opiate administration.

Subject participation was voluntary, and subjects signed an informed consent agreement. It was emphasized to the patient that procedures would be followed to protect their confidentiality, and that they would only be identified by a number. They were told that participation in the study would not put them at any unusual risk, although answering the researcher's questions and completing the research instruments (while purposely made brief due to the nature of the patient population) may seem tedious or tiring. They were informed that it should take no longer than five minutes to answer the questions during each of five data collection periods. They would not be required to verbalize their answers unless they wish to, and they would be able to point to the one-word or one-number answers on the data collection forms if they were unable to put simple marks on the papers. They were advised that they could decline to answer any questions, stop the interview, or withdraw from the study at any point. They were also assured that participation in the study would not interfere

with their normal care and that, should they refuse to participate or withdraw at any time, there would be no ill effects to their health care. Confidentiality and anonymity would be assured through the use of coded data collection sheets.

A family member or close friend of the patient was also asked to participate in the study by completing a California Q-Set, to measure the personality of the patient. These individuals signed an informed consent specific to their part of the study.

A power analysis was done to determine the minimal sample size needed for multiple regression analysis with five variables since multiple regression was to be the most stringent statistical analysis to be done. The sample size, with an effect size of .13 (moderate), a power of .80 and an alpha = .05, was predicted to be 101 subjects. Since four variables and 61 subjects were finally used for multiple regression analyses, the effect size was .16 and power was .71 at alpha = .05.

A total of 108 patients who met inclusion criteria were approached for consent. Ninety-eight (92%) agreed to be in the study. During the course of the study period, 23 of the 98 subjects were dropped from the study. Three withdrew themselves from the study, two were transferred from the critical care unit early on the first post-operative day, and 18 were unable to participate because of their medical conditions. Of the 18 unable to participate,

six had physiological instability and 12 had post-operative alteration in cognitive processing as evidenced by confusion, stupor, disorientation or paranoia. One subject was dropped from analyses as he was the only subject who had not had either cardiac or vascular surgery; he had undergone an esophagogastrectomy. The final sample included 74 patients and 61 family members or friends.

Measures

Measures of Dependent Variables

The dependent variables, tonic pain and procedural pain, included four dimensions of pain: degree of pain intensity, extent of pain, degree of sensory pain, and degree of affective pain. Degree of pain intensity was measured by a horizontal 0-10 Numerical Rating Scale (NRS) and a horizontal 0-10 cm. visual analogue scale (VAS). Extent of pain was measured by the Body Outline Drawing (BOD). Degrees of sensory pain and affective pain were measured by the word descriptor list of McGill Pain Questionnaire-Short Form (MPQ-SF).

Measures of Pain Intensity

Two measures of pain intensity were employed. The first was a numerical rating scale. The numerical rating scale was a 10 cm horizontal line with the numbers 0-10 placed below it and the words "no pain" to the left of the line and "worst possible pain" to the right of the line. (See Appendix A). Patients were asked to rate the intensity of their pain using the range of numbers, from 0-

10. A major advantage of such a scale is its ease of use. Patients either circled, pointed to, verbalized a number or used their fingers (on rare occasions) to communicate the intensity of their pain.

The visual analogue scale (VAS) was the second measure of pain intensity. It was a straight, 10 cm. horizontal line with the words "no pain" to the left of the line and "worst possible pain" to the right of the line (See Appendix A). Subjects were asked to make a vertical mark along the line at the point that best depicted the perceived intensity of their pain. Since there are an infinite number of points along a line, the VAS is a very sensitive method of measuring pain (Huskisson, 1974).

The validity of the VAS as a pain measurement tool has been a subject of extensive research. Correlation coefficients between the VAS and verbal rating scales (VRS), numerical rating scales (NRS), and simple descriptive scales ranged from .59 to .91 and have all been statistically significant (Ohnhaus & Adler, 1975; Reading, 1980; Woodforde & Merskey, 1972). Construct validity of the VAS has been established through factor analysis (Jensen, Karoly & Braver, 1986). VAS reliability was assessed when the instrument was used to measure labor pain (Revill, Robinson, Rosen & Hogg, 1976). Pethidine administration to patients in labor had no significant influence on memory or on the visual motor abilities needed to score the VAS even though this drug affects pupil size. This latter point is an

important consideration for critical care patients who receive similar types of medications.

Strong and significant correlations have been reported from previous studies between NRSs and VASs (Downie et al., 1978; Jensen et al., 1986; Kremer et al., 1981; and Reading, 1980). The sensitivity of the NRS is believed to be less than the VAS since numbers are placed along the length of the line. Research shows that most response marks will be placed near the numbers, expecially the numbers five or ten (Huskisson, 1983).

If the population is elderly or if there are problems with abstract abilities or multisystem disease (Kremer et al., 1981), such as is seen in some critical care patients, the NRS may serve as a more valid and feasible instrument than a VAS. When used in pain research in non-critical care patients, the "failure rate" associated with the use of a VAS has been reported to be from 7% to 11% (Huskisson, 1974; Kremer, Atkinson & Ignelzi, 1981). Thus, the two pain intensity scales were used in order to investigate their correlation coefficients and feasibility of use in this specific population of critical care patients.

As shown in Table 1, there were strong and significant correlations between VAS and NRS measures of intensity across all pain assessment times (r = .84 -.94; p<001) in this study. Patients were willing/able to complete 28 more measures using the NRS over the five data collection periods than using the VAS (253 NRS versus 225 VAS). In other

Table 1

Correlations of Visual Analogue Scale (VAS) & Numerical Rating Scale (NRS) Intensity Measures at Five Data Collection Times

Dimension	NRS T1	NRS T2	NRS T3	NRS ET	NRS CT
VAS T1	.94 (N=64)				
VAS T2		.84 (N=62)			
VAS T3			.86 (N=29)		
VAS ET				.85 (N=38)	
VAS CT					.87 (N=31)

Note. T= Tonic Pain; ET= endotracheal tube suctioning; CT= chest tube removal. All correlations significant at p=000.

words, although there was high convergent validity between the NRS and VAS, there was an 11% VAS failure rate. Although just one measure of pain intensity could have been selected for future analyses because of the strong correlations, both were used. This was done to determine the effect of the 11% VAS failure rate on analytical findings.

Measure of Pain Extent

A body outline drawing (BOD) was used to quantify the extent of pain (See Appendix B). With the BOD, the patient was asked to place marks in areas on the drawing that coincided with the areas where pain was felt. It was believed that the BOD would be a relatively easy source of knowledge about pain experienced by critical care patients with verbalization difficulties. Quantification of pain was done by a procedure developed by Margolis, Tait & Krause (1986). A template with boundaries drawn on it that separate the body into 45 areas was used. The template was placed over a patient's completed pain drawing, and a numerical value was then derived from the total number of body areas chosen by the patient. A patient's possible score could range from 0 to 45 for extent of the body experiencing pain. Inter-rater reliability of scored drawings submitted by 101 chronic low back pain patients and scored by instructed secretaries was reported to be .997 by Margolis et al (1986). The body outline drawing's

psychometric properties-- its reliability and validity-- had not been well established.

Measures of Sensory and Affective Pain

The word descriptor list of the McGill Pain Questionnaire- Short Form (MPQ-SF) (Melzack, 1987) was used to measure the sensory and affective pain (See Appendix C). It was developed from the original McGill Pain Questionnaire (Melzack, 1975), a longer form (MPQ-LF). Sensation categories of the MPQ-SF consist of temporal, spacial, thermal and pressure information about a patient's pain. Affective words on the instrument relate to tension or Autonomic Nervous System (ANS) responses such as gastro-intestinal upset (i.e., sickening). In the construction of the MPQ-SF, the instrument developers chose 11 sensory and four affective words from the long form MPQ (MPQ-LF). Words were chosen based upon their having been selected at least 33% of the time in prior studies of diverse pain conditions. Intensity of each of the 15 words is graded on a 4-point word descriptor scale ranging from "none" to "severe" pain. The words are given a numerical rating of 0-3. Two scores from the MPQ-SF were calculated for this study: Pain Rating Index- Sensory (PRI-S) and Pain Rating Index- Affective (PRI-A). The range of scores on the PRI-S are from 0-33, and the range of scores on the PRI-A are from 0-12. In prior research, the entire MPQ-SF usually took 2-5 minutes to administer. In this study, administration took approximately five-ten minutes.

Reliability and validity of the MPQ-LF have been successfully tested over the 16 years since its introduction (Chapman et al., 1985; Dubuisson & Melzack, 1976; Perry, Heller & Levine, 1988; Tursky, Jamner & Friedman, 1982). The MPQ-SF has been tested in diverse samples of patients with both acute and chronic pain (Melzack, 1987), including post-surgical patients, and has been found to correlate significantly with the LF-MPQ. It also demonstrated sensitivity to the effects of analgesics, one indicator of its reliability. To the knowledge of the investigator, the MPQ-SF has not been used previously in a critical care patient study. Alpha reliability coefficients for the MPQ-SF, computed for these study data at the five data collection times, were uniformly high with ranges from .75 to .87.

Measures of Mediating Variables

Demographic Variables

Demographic variables of age, gender and ethnicity were obtained by chart review.

Personality Adjustment

Personality adjustment was measured by the California Q-Set, which was completed by a patient's family member or close personal friend. This individual was asked to complete the California Q-Set with the investigator sometime during the patient's postoperative recovery before hospital discharge. No Q-Sets were done pre-operatively to avoid the

possibility of patient/family member discussion of the test with the patient before the patient had surgery.

The California Q-Set is an instrument that objectifies the personality evaluation of an individual. It is a modified ranking procedure where a judge (someone who knows the subject) describes a particular individual by ranking each of 100 behaviors on a continuum of psychological salience. The 100 items are sorted according to nine categories ranging from "most salient or descriptive" to "least salient or descriptive" of the individual. A score from 9 to 1 is then given each item depending on the category it has been assigned.

Specific criterion items within the Q-Set have been validated to describe the optimally adjusted personality. The final Q Set score for each individual patient was the correlation between the individual's score and the mean of previously published scores ascertained from a panel of nine clinical psychologist experts (Block, 1961). This was the score used as a personality measure in this study. For this study, these correlation scores between subjects and experts ranged from $\underline{r}$ = -.27 to .72, indicating that a wide sample variance was obtained.

Administration of the Q-Set in prior research took approximately 20-30 minutes to complete when sorters were trained and experienced in the sorting procedure (Block, 1961). However, in this study the Q Set took patients'

family members and friends approximately 45 minutes to complete.

Concurrent and convergent validity of the Q-Set as well as its reliability over time have been described (Block & Block, 1980). Interrater reliabilities have been between .70 and .78 (Block, 1971). Average reliabilities between nurse and family member sortings have been found to be even higher (.94) (Weiss, 1989). Only one Q Set per subject was performed in this present study.

Amount of Analgesics

Amount of analgesics was the total amount of opiates administered intravenously and by mouth during the study period, converted to mg. of morphine, on a 24 hour basis. Many researchers have tallied request for or use of analgesics in post-operative pain studies (Bafford, 1977; Christoph, 1985; Cohen, 1980; Cooperman, Hall, Mikalacki, Hardy & Sadar, 1977; Egbert, Battit, Welch & Bartlett, 1964; Flaherty & Fitzpatrick, 1978; Levesque, Grenier, Kerouac & Reidy, 1984; Locsin, 1981; Madden, Singer, Peck & Nayman, 1978; Menzel & Martinson, 1977; Rawal, Sjostrand & Dahlstrom, 1981; Rawal & Tandon, 1985). They have used these tallies as measures-- albeit indirect ones-- of post-operative pain or analgesia. This analgesia information was obtained in the present study from the patient's chart.

Length of Intubation

Length of intubation was measured by the total number of hours-- measured to the nearest one-half hour-- that the

patient was intubated, from time of critical care unit admission to time of extubation or to end of study time for that patient if they were intubated for that entire period. This information was obtained from the patient's chart.

Pain Relief

Amount of pain relief from analgesics was determined by a score on a horizontal 0-10 Numerical Rating Scale- Pain Relief (NRS-PR) (See Appendix A). Patients were asked to use the scale to rate the relief they obtained from analgesics they had received. A numerical rating scale has been described previously in the discussion of pain intensity.

The use of word descriptor pain relief scales (that is, scales with words like, "none", "slight", "lots" and "complete" relief) and visual analogue pain relief scales have been recommended (Huskisson, 1974; Langley & Sheppeard, 1985). Correlations between these two types of pain relief measures have been high (r = .92) when both were used to measure analgesic effects in 35 cancer patients (Wallenstein, 1984). A 0-10 NRS-PR scale was used in this study to coincide with the 0-10 NRS of pain intensity and to avoid potential problems associated with the abstract nature of visual analogue scales (Kremer et al., 1981).

During data collection, however, concern arose about the validity of the 0-10 NRS-Pain Relief (NRS-PR) scale. Those patients who were unable/unwilling to complete this

scale 21% of the time. Those patients who were unable to complete the 0-10 scale, when asked how much pain relief they received from analgesics, gave other answers. These answers included: they had no pain; they were not getting any pain medications; or they didn't know if they had received any medications. All of these other responses were coded separately for future analytical purposes. In essence, many patients seemed to be confused and/or unclear about pain medication administration; that is, if or when they had received analgesics. For these reasons, the validity of the NRS-PR response was in question.

Care Procedures

Care procedures under study were endotracheal tube suctioning and chest tube removal. To differentiate pain across type of procedure, measures of procedural pain were taken immediately after one of each of the types of procedures occurred for the patient.

Type of Injury

Type of injury was designated as thoracic (from cardiac surgery) or abdominal (from vascular surgery). Cardiac patients had vertical thoracic incisions-- specifically sternotomies-- while vascular surgical patient had vertical upper and lower abdominal incisions.

Measures of Morbidity Status

Morbidity status was measured by the following: number of days in the critical care unit and the presence of the following complications: infections; re-intubation; pulmonary complications of atelectasis, pleural effusion, and pneumonia; and psychological disturbances such as confusion, depression and hallucinations. These were all determined from information in the patient's chart. A score was developed for the number of days in the unit as well as for the total number of complications experienced by a patient. In addition, the presence or absence of each specific complication was identified for each subject.

Procedure

The study period was three consecutive days during the first five days of critical care unit stay or until the patient was transferred to a non-critical care unit. Seventy-eight percent of the time the three-day study period began on post-operative day #1. Each day, beginning no sooner than 12 hours after the patient's critical care unit admission, data were collected on tonic pain and pain relief.

During tonic pain data collection periods, measures were taken of Pain Rating Index-Sensory (PRI-S) and Pain Rating Index-Affective (PRI-A) per MPQ-SF, pain intensity using the Numerical Rating Scale (NRS) and Visual Analogue Scale (VAS), pain extent using the Body Outline Drawing

(BOD) and amount of pain relief from analgesics using the Numerical Rating Scale- Pain Relief (NRS-PR). In addition, time and amount of last analgesic administration was noted. These data were not collected until at least two hours after the last opiate administration.

Before each time of tonic pain data collection, the patient's level of consciousness (LOC) was assessed through use of a Sedation Scale modified from Bennett et al (1982) (See Table 2). Data were collected if patient's LOC was 3 or less, indicating that the patient was not too sedated to answer the investigator's questions. When in doubt about the patient's level of sedation, the investigator consulted with the patient's assigned nurse to make the assessment. If the patient's nurse and/or the investigator thought that the patient was too sedated (i.e., in categories 4 or 5), the patient was not interviewed at that time.

The procedures of endotracheal tube suctioning and chest tube removal were used to study procedural pain. These are not regularly scheduled procedures. Therefore, the investigator was either in the critical care unit and knew when these procedures were to be done or was paged from another part of the university by the patient's nurse. In the latter instance, the investigator would then immediately go to the critical care unit for the purpose of data collection.

As with collection of tonic pain, before each time of procedural pain data collection, the participant's LOC was

assessed through use of the Sedation Scale. Data were collected if patient's LOC was 3 or less. In addition, time and amount of last analgesic administration was noted. Procedural pain data were collected regardless of length of time since last analgesia administration since timing of procedure and analgesic administration could not be controlled by the investigator.

Data were collected within minutes (on rare occasions up to 15 minutes) after ET suctioning and chest tube removal. During procedural pain data collection periods, measures were taken of Pain Rating Index-Sensory and Pain Rating Index-Affect using the MPQ-SF, pain intensity using the NRS and VAS and pain extent using the BOD. Amount of pain relief from analgesics was measured by the NRS-PR.

At each data collection time, the order of the measures was as follows. First, pain extent was measured per BOD. Second, one of the pain intensity measures was taken. The order of the VAS-intensity and NRS-intensity measures was alternated, according to an established protocol. That is, for tonic pain measures the NRS was administered first to patients with even-numbered identification numbers; the VAS was administered second. For procedural pain measures, the VAS was administered first to patients with even-numbered identification numbers; the NRS was administered second. After the first intensity measure, the MPQ-SF was administered. The investigator asked if each of the words--said out loud by the investigator-- matched the person's

Table 2

Sedation Scale

1. Wide awake
2. Drowsy
3. Dozing intermittently
4. Sleeping almost all the time
5. Awakens only when vigorously aroused

pain. If the answer was yes, the patient was asked to rate the intensity of that pain descriptor by verbalizing or pointing to one of the words, "mild", "moderate" or "severe". These three words were enlarged on a poster for easier visibility. After the MPQ-SF was administered, the patient was asked to rate pain intensity using the second intensity measure. Finally, the patient was asked to rate pain relief, using the 0-10 pain relief NRS. Since VAS, NRS and NRS-PR measures were on the same form, patients were blinded to their answers on each of the other intensity and relief scales when being asked to complete a particular instrument. This was done by having the investigator cover all but the one intensity measure being used with a piece of poster paper. Questions were asked in a consistent and specific way, depending upon whether tonic pain or procedural pain was being assessed. (See Appendix D for the interview script).

Table 3 depicts the specific numbers of tonic pain and procedural pain assessments done. Numbers of tonic pain assessments decreased over days two and three as patients were transferred from critical care units. Only procedural pain was measured in one study patient. Therefore, the total number of tonic pain assessments were 73. Endotracheal tube suctioning and chest tube pain assessments did not include the entire sample population of 74 because: (1) all patients were not intubated during the study time; (2) all patients did not have chest tubes; (3) since ET

Table 3

Data Points	Sample
Tonic Pain 1	N = 73*
Tonic Pain 2	N = 67
Tonic Pain 3	N = 33
Chest Tube Removal Pain	N = 35
Endotracheal Suctioning Pain	N = 45
TOTAL	253

Note. *N = 17 at Tonic Pain #1 because one of 74 subjects did not have tonic pain assessments.

suctioning and chest tube removal were not scheduled procedures, the investigator was not always present in the critical care units when the procedures were being performed. Sometime during the patient's postoperative recovery period, a patient's family member or close friend was asked to complete the Q-Set. The Q-Sets were completed in an available hospital room with a table. The investigator was present the entire time during the Q-Set procedure to answer any questions and guide the family member or friend. Finally, a chart review was done to collect relevant demographic, clinical progress and treatment-related data.

Four research assistants were used at various times during the study to obtain patient consent, do pain assessments and to administer the Q-Set. However, data were predominently collected by the principal investigator. Consistency of approach among investigators was assured through training and observation procedures. Research assistants observed the principal investigator during each of the data collection steps, and then the principal investigator observed the assistants in the performance of a Q-Set procedure and patient assessments, providing feedback and critique when necessary.

Data Analysis

Descriptive and inferential statistics were used to analyze research question #1. Means, standard deviations two procedural pain scores of the four pain dimensions.

Possible scores for the four pain dimensions were as follows: pain intensity per NRS was from 0-10; pain intensity per VAS was from 0-10; pain extent per BOD was 0-45; pain sensation and affect per MPQ-SF were from 0-33 and 0-12 respectively. Pearson product moment correlations were done to determine the correlations among the four dimensions of pain and to evaluate instrument performance. Four *t*-test analyses were done to identify differences between the two procedures in each of the four pain dimensions. Since a significant difference was found between the two procedures, repeated measures analyses of variance (ANOVA) were done to see if there were significant differences among tonic pain, ET pain and CT pain on all of the pain dimensions. Post-hoc Scheffe's were done when any ANOVA reached significance in order to determine more specifically where the difference in groups occurred.

Descriptive and inferential statistics were used to analyze research question #2. Frequency distributions of ethnic and gender categories were calculated. The first showed the population to be 90% Caucasian. Therefore, ethnicity was deleted as an independent variable in later multiple regression analyses. The two genders were adequately represented to consider gender as a valid multiple regression variable. Means, standard deviations and ranges were calculated for age, personality disposition scores and analgesics administered.

Univariate correlations were computed to determine relationships among the interval variables used for multiple regression analysis-- age, personality disposition and analgesics-- and evaluate presence of multi-collinearity. Five multiple regressions were then run on pain intensity (two), extent, sensation and affect dimensions. For each of the five multiple regressions, demographic variables of age and gender were entered at Step 1; the "optimally adjusted personality" measure derived from the California Q Set was entered at Step 2; and average amount of analgesics administered was entered at Step 3. Because demographic variables were significant predictors of sensory pain, two more four-step multiple regression analyses were run to determine whether it was age or gender-- the two demographic variables-- that was the significant predictor variable. Residual analyses for the multiple regressions included examination for curvilinearity, for heteroscedasticity and for outliers. These analyses indicated that the multiple regression models were adequate.

Means, standard deviations and ranges of intubation length and pain relief were calculated. Study period means for tonic pain intensity, extent, sensation and affect were calculated and used in the Pearson correlations to examine the relationship to length of intubation and pain as well as pain relief and pain. Mean pain dimension scores were used since length of intubation could span the study period. T-tests were also performed to analyze differences in pain

between the two care procedures and between the two types of injuries.

Descriptive and inferential statistics were used to analyze research question #3. Means and ranges were calculated for total number of complications. A frequency distribution was calculated for each of the morbidity factors. Univariate Pearson correlations were done to relate pain dimensions to length of critical care stay as well as to the number of morbidity factors. Chi-Square and Fisher exact tests were used to establish the relationship between presence of specific morbidity factors and pain. Since these were analyses of nominal data, categories of high and low pain were established. The high pain categories were scores above the means of pain intensity, extent, sensation and affect; low pain categories were made up of scores equal to or below the means of pain intensity, extent, sensation and affect.

Alpha levels of significance were set at $p=<.05$ for all analyses. Statistical analyses were conducted with the assistance of the CRUNCH computer software program.

Chapter 4

Findings

Findings and statistical analyses of data collected are presented in this chapter. Presented first is a description of sample characteristics.

Sample Characteristics

The final study sample consisted of 74 patients. Sixty-one of these patients had family members or friends who were willing to complete the California Q Set. Consent was obtained from 59 of these patients pre-operatively, while 15 patients gave consent when they were in the critical care unit. There were 57 males and 17 females, with a mean age of 64 years and age range of 34 to 83 years. Sixty of the patients had undergone cardiac surgical procedures, while 14 had abdominal vascular surgery. Biographical and surgical information are summarized in Table 4. The age differences for males and females were not significant.

Over 90% (N = 67) of the sample population were Caucasian. The number of Blacks, Hispanics and Asians were 4, 2, and 1 respectively. All patients were opioid naive prior to surgery, as determined by chart review.

Eighty-four percent of this study's patients were assessed pre-operatively by an anesthesiologist as having severe systemic disease, categories III and IV of the American Society of Anesthesiologists (ASA) preoperative physical status rating (Tinker & Roberts, 1986). Table 5 categorizes this sample population according to ASA

Table 4

Demographics of Sample Population

Variable	N	Mean	S.D.
Gender			
Male	57		
Female	17		
Age (Total)		64	10.98
Gender			
Male		64.8	
Female		61.6	
Surgery Type			
Cardiac	60		
Gender			
Male	44		
Female	16		
Vascular	14		
Gender			
Male	13		
Female	1		

Note. There were no significant differences in mean ages of males and females per t test.

Table 5

Pre Operative Physical Status Rating

ASA* Category		N%	Frequency
I	Healthy patient	0	0
II	Mild systemic disease--no functional limitation	12	16
III	Severe systemic disease--definite functional limitation	39	53
IV	Severe systemic disease that is a constant threat to life	23	31
V	Moribund patient unlikely to survive 24 hours with or without operation	0	0

Note. * American Society of Anesthesologists' (ASA) Physical Status Rating Categories

criteria. Twelve of the patients underwent surgery on an emergency basis, while the remainder had planned surgeries.

Mean length of stay in critical care units for these patients was five days (range 1-60 days). Ninety-two percent (N=68) of the patients were discharged from the hospital an average of 14 days after critical care unit admission (range 6-88 days). Four of the 74 study patients expired in the hospital after completion of the study, and two patients were transferred to rehabilitation hospitals on mechanical ventilators.

Findings Related to Research Question #1

The first research question asked:

(1) What are the various dimensions of tonic and procedural pain experienced by thoracoabdominal surgery patients in critical care units?

a) What are the average values and ranges for degree of sensory pain, affective pain, overall intensity of pain and extent of pain experienced by these patients?

b) What are the relationships among sensory pain, affective pain, overall intensity of pain and extent of pain experienced by these patients?

c) Do the dimensions of pain differ for tonic versus procedural pain?

Dimensions of Tonic and Procedural Pain

The first tonic pain measure was collected either on a subject's post-operative day one (78%), two (19%) or three (3%). Since 97% of tonic pain #1 data collections were done

on either day one or two, a t-test was done to determine if there was a difference in pain reports between those two days. There were no significant differences in the mean amount of pain reported on any of the dimensions of Tonic Pain #1 regardless if Tonic Pain #1 was measured on post-operative days 1 or 2. Therefore, tonic pain #1 was considered to be post-operative day #1 in all further analyses.

Means and standard deviations of the four dimensions of tonic pain and procedural pain (further categorized as either chest tube [CT] or endotracheal suctioning [ET] pain) are summarized in Table 6. Except for CT pain, pain intensity varied little from the mid-range of the two 0-10 intensity measures across data collection times, (NRS tonic pain grouped mean 5.2; VAS grouped mean 4.8). Given that a score of 45 was possible on the number of body parts affected by the pain, there was a low mean and little variance of pain extent, as measured by the BOD (tonic pain extent grouped mean 3.9; SD 1.89). Scores, too, were low on measures of the sensory (tonic pain grouped mean 7.4) and affective (tonic pain grouped mean 3.0) nature of pain.

Relationships Among Pain Dimensions

The relationships among the constructs of sensory pain, affective pain, overall intensity of pain and extent of pain experienced by these patients were analyzed. As stated earlier, there were strong and significant correlations between VAS and NRS measures of intensity across all pain

Table 6

Dimensions of Tonic and Procedural Pain

	Intensity				
Type of Pain	VAS	NRS	Extent	Sensation	Affect
Tonic Pain 1	N=64	N=73	N=72	N=69	N=69
	4.5[a]	5.2	3.9	7.3	3.0
	(2.9)[b]	(2.9)	(2.5)	(6.3)	2.7)
Tonic Pain 2	N=63	N=67	N=68	N=68	N=67
	4.9	5.2	3.9	7.3	2.9
	(2.9)	(2.7)	(2.0)	(4.9)	(2.7)
Tonic Pain 3	N=29	N=33	N=33	N=31	N=31
	4.5	5.0	4.0	5.9	3.0
	(2.8)	(2.7)	(2.3)	(4.7)	2.8)
ET Pain	N=38	N=45	N=45	N=44	N=44
	4.1	4.9	2.8	7.4	3.5
	(3.5)	(3.3)	(1.9)	(6.9)	(3.5)
CT Pain	N=31	N=35	N=35	N=34	N=34
	6.6	6.6	2.4	9.6	3.6
	(3.0)	(3.1)	(1.4)	(6.1)	(3.0)

Note. VAS = visual analogue scale. NRS = numerical rating scale. ET = endotracheal. CT = chest tube. Possible ranges for intensity per VAS and NRS = 0-10; range for extent = 0-45; range for sensation = 0-33; range for affect = 0-12.
[a] = Mean. [b] = Standard deviation.

assessment times (r = .84 -.94; p<001). With few exceptions, all measures of the four pain dimensions significantly correlated with each other over each of the data collection times. (See tables 7 through 11). These exceptions involved measures of pain **extent** derived from the Body Outline Diagram. The nonsignificant correlations are all summarized in Table 12.

Differences Between Tonic Pain and Procedural Pain

Finally, in order to answer the next question, "do dimensions of pain differ for **tonic pain** versus **procedural pain?**", the procedural pain category was further divided into CT and ET pain. This was done because there were significant differences found between the two procedures; therefore, they could not be combined into one variable with any validity. Paired t-tests showed that CT pain was greater than ET pain on all dimensions except **extent**; that is, for **intensity, sensory** and **affect.** Furthermore, this difference reached significance on pain intensity as measured by both VAS (p.=.003) and NRS (p.=.02). (See Tables 13 and 14 for VAS and NRS paired t tests).

Tonic pain from study day #1 was used in this analysis of tonic pain versus ET and CT pain for two reasons: (1) as reported earlier, there were no significant differences among the three tonic pain measures; therefore, tonic pain #1 could be considered as reflective of the patient's pain experience; (2) most often, CT removal and ET suctioning

Table 7

Correlations Between Pain Dimensions at Tonic Pain #1

Pain Dimensions	Intensity (NRS)	Intensity (VAS)	Extent	Sensory	Affect
Intensity (NRS)	+	.94	.39	.70	.75
Intensity (VAS)		+	.48	.67	.73
Extent			+	.32	.21^{NS}
Sensory				+	.63
Affect					+

Note. NRS = Numerical Rating Scale. VAS = Visual Analogue Scale. All correlations significant at $p<.01$ except correlation between extent and affect.

Table 8

Correlations Between Pain Dimensions at Tonic Pain #2

Pain Dimensions	Intensity (NRS)	Intensity (VAS)	Extent	Sensory	Affect
Intensity (NRS)	+	.84	.33	.61	.55
Intensity (VAS)		+	.27*	.60	.44
Extent			+	.24*	.10NS
Sensory				+	.65
Affect					+

Note. NRS = Numerical Rating Scale. VAS = Visual Analogue Scale. * $p<.05$; NS = not significant; All other correlations significant at $p<.01$

Table 9

Correlations Between Pain Dimensions at Tonic Pain #3

Pain Dimensions	Intensity (NRS)	Intensity (VAS)	Extent	Sensory	Affect
Intensity (NRS)	+	.86	.31NS	.63	.65
Intensity (VAS)		+	.32NS	.51	.43*
Extent			+	.27NS	.24NS
Sensory				+	.59
Affect					+

Note. NRS = Numerical Rating Scale. VAS = Visual Analogue Scale. *$p<.05$; NS = not significant; All other correlations significant at $p<.01$

Table 10

Correlations Between Pain Dimensions of Chest Tube Pain

Pain Dimensions	Intensity (NRS)	Intensity (VAS)	Extent	Sensory	Affect
Intensity (NRS)	+	.87	.43	.63	.54
Intensity (VAS)		+	.57	.67	.54
Extent			+	.48	.63
Sensory				+	.66
Affect					+

Note. NRS = Numerical Rating Scale. VAS = Visual Analogue Scale.
All Correlations significant at $p<.01$

Table 11

Correlations Between Pain Dimensions of Endotracheal Tube Pain

Pain Dimensions	Intensity (NRS)	Intensity (VAS)	Extent	Sensory	Affect
Intensity (NRS)	+	.85	.52	.69	.63
Intensity (VAS)		+	.54	.68	.59
Extent			+	.36*	.41
Sensory				+	.63
Affect					+

Note. NRS = Numerical Rating Scale. VAS = Visual Analogue Scale. *$p<.05$; All other correlations significant at $p<.01$

Table 12

Non Significant Correlations Among All Measures of Four Dimensions of Pain

	Affective			Sensory	VAS	NRS
	T1	T2	T3	T3	T3	T3
Extent T1	.21 (N=68)					
Extent T2		.10 (N=31)				
Extent T3			.24 (N=31)	.27 (N=31)	.32 (N=29)	.31 (N=33)

Note. VAS = visual analogue scale. NRS = numerical rating scale. T1= Tonic Pain 1. T2= Tonic Pain 2. T3= Tonic Pain 3. VAS= visual analogue scale. NRS= numerical rating scale. All other correlations between measures significant ($p<.05$).

Table 13

Comparison of Pain Intensity per Visual Analogue Scale Between Chest Tube (CT) Removal & Endotracheal Tube (ET) Suctioning (N=19)

	Mean	STD	t	p
CT	6.2	3.7		
			3.5	.003
ET	3.3	3.4		

df= 18

Table 14

Comparison of Pain Intensity per Numerical Rating Scale Between Chest Tube (CT) Removal & Endotracheal Tube (ET) Suctioning (N=25)

	Mean	STD	t	p
CT	6.2	3.5		
			2.4	.02
ET	4.3	3.2		

df= 24

data were collected on study day #1, so it provided the most concurrent comparison with procedural pain.

Repeated measures ANOVA determined that there were, indeed, significant differences among Tonic Pain (TP), CT and ET pain intensity per both VAS, $F(34,2) = 6.48$, $p.=.004$) and NRS. $F(48,2) = 3.53$, $p.=.04$) (See Tables 15 & 16). A post hoc Scheffe determined that CT pain intensity was significantly higher than either TP or ET pain. There was also a significant difference among TP, CT pain and ET pain in pain extent, $F(46,2) = 5.51$, ($p=.007$) (Table 17). A post hoc Scheffe analysis indicated that tonic pain involved significantly more of the body than did CT pain. That is, surgical pain was a more pervasive experience whereas CT pain was more localized.

Findings Related to Research Question #2

The second research question asked the following: to what degree are specific demographic, personality, and illness or treatment- related variables associated with the dimensions of pain experienced by thoracoabdominal surgery patients in critical care units?

a) To what extent do age, gender, ethnicity, personality disposition and amount of analgesics received contribute to the variance in magnitude of tonic pain as indicated by degree of sensory pain, degree of affective pain, overall intensity of pain and extent of pain?

Table 15

Repeated Measure ANOVA: Comparison of Tonic Pain, Endotracheal Suctioning Pain & Chest Tube Removal Pain Intensity per Visual Analogue Scale (N=17)

Source	df	SS	MSS	F	P
Between Subjects	16	387.0416			
Within Subjects	34	232.9600			
Between measures	2	67.1839	33.5920	6.484	.0043
Residual	32	165.7761	5.1805		

Table 16

Repeated Measure ANOVA: Comparison of Tonic Pain, Endotracheal Suctioning Pain & Chest Tube Removal Pain Intensity per Numerical Rating Scale (N=24)

Source	df	SS	MSS	F	P
Between Subjects	23	461.9132			
Within Subjects	48	294.8334			
Between measures	2	39.2153	19.6076	3.529	.0372
Residual	66	255.6181	5.5569		

Table 17

Repeated Measure ANOVA: Comparison of Tonic Pain, Endotracheal Suctioning Pain & Chest Tube Removal Pain Extent (N=23)

Source	df	SS	MSS	F	P
Between Subjects	22	99.6232			
Within Subjects	46	148.6667			
Between measures	2	29.7681	14.8841	5.508	.0073
Residual	44	118.8986	2.7022		

b) What is the correlation between length of intubation and degree of sensory, affective, intensity and extent of tonic pain?

c) What is the correlation between amount of pain relief reported and degree of sensory pain, degree of affective pain, overall intensity of pain and extent of pain?

d) Do the dimensions of pain differ between certain care procedures?

e) Do the dimensions of pain differ according to type of injury; that is, between thoracic and abdominal surgical procedures?

Predictors of Tonic Pain Variance

The first part of research question #2 concerned the extent to which age, gender, ethnicity, personality disposition and total amount of analgesics predicted a significant variance in degree of pain. Five separate hierarchical multiple regressions were run, using the mean of each pain dimension across all tonic assessments as the dependent variable. That is, the dependent variables for these five multiple regressions were mean pain intensity per VAS, mean pain intensity per NRS, mean pain extent, mean pain sensation and mean pain affect. Means were used because, as reported earlier, there were no significant differences among the days on any of the tonic pain dimensions. Sample sizes were too small to justify multiple

regression analyses of CT and ET pain dimensions (N = 36 & N = 45, respectively).

As mentioned earlier, patient ethnicity, one of the original demographic variables under consideration, was not included in the multiple regression analysis since 90% of the sample population was Caucasion. Simple correlations among the independent variables of age, personality disposition and the average amount of daily analgesics administered over the three days did not support the presence of multicollinearity. Therefore, these variables could be considered quite independent of each other. Only one of the independent variables-- average amount of analgesics administered-- had significant univariate correlations with the dependent variables (i.e. each of the pain dimensions).

Multiple regression analyses are summarized in Tables 18 through 22. For the dimension of pain intensity per NRS, the model explained 15% of the variance ($\underline{R}^2$ = .147) and reached the statistical requirement of less than $\underline{p}$=.05 (actual $\underline{p}$=.004). This same analysis using the VAS data showed similar findings, with a total contributed variance of 12% at a .016 level of significance. In both cases, the significance was accounted for primarily by the variable analgesics which was entered into the model after demographics and personality disposition. For the dimension of pain sensation, 27% of the variance ($\underline{R}^2$ = .269) was accounted for, which was statistically significant at

Table 18

Multiple Regression Analysis of Tonic Pain Intensity per Numerical Rating Scale (N=60)

Step	Variable	Model: R^2	Beta	Step: R^2 Change	F	Sig.
1.	Demographics	.005		.005	.176	.840
	Age		.06118			
	Gender		.04573			
2.	Personality Disposition	.005	-.00308	.000	.001	.981
3.	Analgesics	.147	.38164	.142	9.284	.004

Table 19

Multiple Regression Analysis of Tonic Pain Intensity per Visual Analogue Scale. (N=57)

Step	Variable	Model: R^2	Beta	Step: R^2 Change	F	Sig.
1.	Demographics	.020		.020	.600	.556
	Age		.12052			
	Gender		.08127			
2.	Personality Disposition	.021	.03096	.001	.056	.814
3.	Analgesics	.123	.32371	.102	6.174	.016

Table 20

Multiple Regression Analysis of Tonic Pain Extent (N=60)

Step	Variable	Model: R^2	Beta	Step: R^2 Change	F	Sig.
1.	Demographics	.012		.012	.368	.696
	Age		.09860			
	Gender		.05242			
2.	Personality Disposition	.026	-.12318	.015	.928	.340
3.	Analgesics	.117	.30607	.091	5.771	.020

Table 21

Multiple Regression Analysis of Tonic Pain Sensation (N=59)

Step	Variable	Model: R^2	Beta	Step: R^2 Change	F	Sig.
1.	Demographics	.091		.091	3.404	.040
	Age		-.19589			
	Gender		.21241			
2.	Personality Disposition	.093	-.04895	.002	.174	.678
3.	Analgesics	.269	.42492	.176	13.260	.001

Table 22

Multiple Regression Analysis of Tonic Pain Affect (N=59)

Step	Variable	Model: R^2	Beta	Step: R^2 Change	F	Sig.
1.	Demographics	.004		.004	.117	.891
	Age		.04278			
	Gender		-.03990			
2.	Personality Disposition	.005	-.03530	.001	.076	.784
3.	Analgesics	.128	.35467	.123	7.740	.007

p=.001. Two variables contributed to the majority of this significance, demographic characteristics and analgesics. It could not be determined whether age or gender accounted most for the significance seen for demographic characteristics, since beta calculations were similar for both, although in an opposite direction. That is, the beta weight for age was -.196, while the beta weight for gender was .212. Therefore, two more multiple regression analyses were done, with each demographic characteristic entered at separate steps. This made a total of four steps in each of these two multiple regression analyses. When gender was entered first, at step 1, it contributed to the significance of the model (p.=.001). (See Table 23). However, when age was entered first into the multiple regression model, it did not contribute to the significance of the model. (See Table 24). This suggests that gender was the demographic variable of significance. To help identify which gender may have reported more pain sensations, a t-test was done of the difference in pain sensation between genders. This showed that women reported more pain sensations than men, but the difference was nonsignificant.

Regression models for pain extent and pain affect were also significant, the significance being accounted for primarily by analgesics. There was 18% of the variance in pain extent (p=.02) and 13% of the variance in pain affect (p=.01) explained in the multiple regression models.

Table 23

Four-Step Multiple Regression Analysis of Tonic Pain Sensation:

Gender at Step One (N=59)

Step	Variable	Model: R^2	Beta	Step: R^2 Change	F	Sig.
1.	Gender	.052	.22886	.052	3.941	.052
2.	Age	.091	-.19589	.038	2.867	.096
3.	Personality Disposition	.093	-.04895	.002	.174	.678
4.	Analgesics	.269	.42492	.176	13.259	.001

Table 24

Four-Step Multiple Regression Analysis of Tonic Pain Sensation:

Age at Step One (N=59)

Step	Variable	Model: R^2	Beta	Step: R^2 Change	F	Sig.
1.	Age	.045	-.21372	.046	3.437	.069
2.	Gender	.091	.21241	.045	3.371	.072
3.	Personality Disposition	.093	-.04895	.002	.174	.678
4.	Analgesics	.269	.42492	.176	13.259	.001

Length of Intubation and Pain

One of the illness-related variables of interest investigated was altered communication and its influence on patient pain. That is, do intubated patients have more pain?

Sixty-three patients were intubated during some period of their critical care stay. Mean length of intubation was 23.5 hours (range 0-76 hours). As indicated earlier, Pearson product moment correlations were done to determine the relationship between length of ICU intubation and average tonic pain intensity, extent, sensation and affect. Only one correlation reached significance; there was a negative correlation between mean length of intubation and reported pain sensations ($r = -.25$; $p<.04$). That is, those who were intubated longer chose less sensory words to describe their pain than did those who were intubated for a shorter period of time. (See Table 25 for correlations between length of intubation and pain dimensions).

To add more specificity to the analysis of intubation, patients who were intubated versus non-intubated at the actual time of pain assessment were compared. Tonic pain #1 was used since, at this time, more patients were intubated ($N = 17$). Individual t-tests elicited no significant differences in any of the dimensions of pain due to communication status. Although patients who were not intubated and could talk described slightly more pain than

Table 25

Pearson Product Moment Correlations Between Length of Intubation and Mean Pain Intensity, Extent, Sensation and Affect

	Length of Intubation
Pain Intensity (NRS)	$r = -.06$
Pain Intensity (VAS)	$r = -.11$
Pain Extent	$r = -.004$
Pain Sensation	$r = -.25^{*}$
Pain Affect	$r = -.10$

Note. NRS = Numerical Rating Scale. VAS = Visual Analogue Scale. * Significant at $p<.04$

did those who were intubated and could not verbalize, this finding did not reach statistical significance.

Pain Relief and Pain

The next analysis under research question #2 addressed the relationship between pain experienced and pain relief received from analgesics. In general, patients in this study received very little post-operative analgesia. For example, 20% of the time, patients had not received any pain medication for greater than 12 hours before a particular data collection period. The average amount of morphine-equivalent analgesia given before ET and CT procedures was 2.5 mg. Patients had received this medication an average of 6.7 hours before ET suctioning and 2.9 hours before CT removal. Mean amounts of daily analgesic administration over the three post-operative study days were the following: Day 1- $\underline{M}$ = 14.4 mg; Day 2- $\underline{M}$ = 9.6 mg; Day 3- $\underline{M}$ = 6.4 mg.

When patients were asked what their overall pain relief from analgesics was (i.e., tonic pain relief), they reported a mean relief from 6.3 to 6.5 (on a scale of 0-10) across the three tonic pain measures. Reported mean pain relief from medications administered prior to ET suctioning or CT removal was lower (5.1 and 4.7, respectively).

It was expected that the correlations between amount of pain experienced and amount of pain relief obtained from analgesics received would be negative. That is, as a person's pain intensity, extent, sensation and affect increased, amount of pain relief they judged to be obtained

from analgesics would decrease. Most of the correlations (14/25) were negative, but none reached significance. Those correlations which were positive were very low ($r < .26$) and nonsignificant. However, a one-tailed correlation between pain intensity (per VAS) due to CT removal and amount of pain relief obtained from analgesics before this procedure did reach significance ($N = 26$; $r = -.33$; $p=.05$). This indicated that, the less the pain relief patients felt they had obtained from pain medications administered beforehand, the more the pain intensity associated with CT removal.

Differences Between Care Procedures

There were two types of chest tubes removed, either mediastinal or pleural. Removal of pleural tubes elicited significantly greater pain intensity (M NRS = 7.7) than did removal of mediastinal tubes (M NRS = 5.3; $p=.03$). However, as mentioned earlier under the results for Question #1, regardless of the type of chest tube, patients had considerably more pain when their chest tubes were removed than during ET suctioning.

Paired t-tests showed that CT pain was greater than ET pain on all dimensions except extent; that is, for **intensity, sensory** and **affect.** Furthermore, this difference reached significance on pain intensity as measured by both VAS ($p=.003$) and NRS ($p=.02$). (Refer back to Tables 13 and 14 on page 80 for VAS and NRS paired t-tests).

Differences Between Types of Injury

Next, differences in tonic pain due to thoracic incisions versus tonic pain due to abdominal incisions were explored. As mentioned earlier, cardiac surgical patients had thoracic incisions (sternotomies), while vascular surgical patients had abdominal incisions. Independent t tests showed that vascular patients had more pain on almost all tonic pain measures-- except TP #2 VAS pain intensity and pain extent-- across the three tonic pain assessments. This greater pain in vascular patients was significant on the TP #1 pain intensity per NRS ($p=.02$). (See Table 26). Vascular patients (N = 14) had a mean pain intensity of 6.8 compared to cardiac patients (N = 59) mean pain intensity of 4.8. Differences in thoracic (cardiac surgery) and abdominal (vascular surgery) patient procedural pain were not measured, since vascular patients did not have chest tubes and few of them (N = 3) underwent ET suctioning.

Findings Related to Research Question #3

Finally, Research Question #3 asked, "what is the relationship of the intensity, extent, sensory and affective dimensions of pain to morbidity status in thoracoabdominal surgical patients in critical care units?

Length of Critical Care Stay as an Indicator of Morbidity

When length of critical care stay was examined and correlated with mean pain intensity, extent, sensation and affect, product moment correlations were low and nonsignificant for any of the pain dimensions. (See Table

27). That is, the nature of pain experienced was not related to the amount of time a patient ended up spending in the critical care unit.

Total Number of Complications and Morbidity

The relationship of total number of complications to pain intensity, extent, sensation and affect was also examined. Mean number of complications was 1.4, with a range of 0-5 (the possible range). Pearson product moment correlations were small and non-significant between the number of complications patients had and their pain status. (See Table 28 for these results).

Individual Complications and Morbidity

Frequencies of the morbidity factors are presented in Table 29. Clearly, the most predominant morbidity factor of those studied was atelectasis, involving 67% of the sample. As shown in Tables 30-34, Chi square and Fisher's exact tests to evaluate the relationship of tonic pain intensity, extent, sensation and affect to specific morbidity factors showed only one significant relationship. Presence of atelectasis was significantly related to a patient's report of high pain intensity at tonic pain #1 per Chi-square $(1, N = 72) = 3.69$, $p=05$. Other relationships between morbidity factors and tonic pain #1 were nonsignificant.

Table 26

Comparison of Tonic Pain Intensity at Time 1 per Numerical Rating Scale Between Cardiac & Vascular Patients

	Mean	STD	t	p
Cardiac (N=59)	4.81	2.92		
			-2.58	.02
Vascular (N=14)	6.79	2.49		

Table 27

Pearson Product Moment Correlations Between Length of Critical Care Stay and the Average of Pain Dimensions Across All Tonic Assessments

Pain Dimension	Correlation
Average intensity (VAS) (N=68)	r = -.06
Average intensity (NRS) (N=72)	r = .03
Average pain extent (N=72)	r = -.08
Average pain sensation (N=71)	r = .03
Average pain affect (N=71)	r = -.02

Note. VAS = Visual Analogue Scale. NRS = Numerical Rating Scale. All correlations non-significant at $p<.05$

Table 28

Pearson Product Moment Correlations Between Morbidity Score And Mean Pain Intensity, Extent, Sensation and Affect Across All Tonic Assessments.

	Morbidity Score
Pain Intensity (NRS)	r = .13
Pain Intensity (VAS)	r = .01
Pain Extent	r = .03
Pain Sensation	r = .17
Pain Affect	r = .13

Note. NRS = numerical rating scale. VAS = visual analogue scale. All correlations nonsignificant at $p<.05$.

Table 29

Frequencies of Morbidity Factors Present in Sample of Critical Care Cardiac & Vascular Surgical Patients

Morbidity Factor	N	% of Subjects
Infection	4	5.48
Re-intubation	4	5.48
Atelectasis	49	67.12
Pneumonia	4	5.48
Psychological Disturbances	15	20.55
Pleural Effusions	29	39.73

Table 31

Relationships* Between Tonic Pain 1 Intensity (per Visual Analogue Scale) and Morbidity Factors

Morbidity Factor	Lower Pain(n)	Higher Pain(n)	Phi Coefficient	p Value
Infections	2	2	.02	1.00
Re-intubation	2	2	.02	1.00
Atelectasis	24	25	.17	.24
Pneumonia	1	3	.14	.32
Pleural effusions	13	16	.16	.26
Psychological disturbances	9	6	.05	.87

Note. Lower pain = mean tonic pain 1 intensity per VAS less or equal to 4.5. Higher pain = mean tonic pain 1 intensity greater than 4.5. * per Chi square or Fisher's exact test if comparisons of <five subjects.

Chapter 5

Discussion

Three research questions served to focus the investigation of pain in critically ill thoracoabdominal surgery patients. Answers to the first research question addressed the nature of tonic pain by comparing and contrasting values given to the four dimensions of pain by these patients. Similarities and differences between the two types of pain-- tonic and procedural pain-- were also analyzed. Patients were able to discriminate between the pain types on the various pain dimensions and found chest tube pain to be significantly more painful than either tonic pain or endotracheal suctioning pain.

In research question #2, certain factors were explored that correlated with and/or predicted pain in these patients. The amount of analgesics patients received predicted a significant amount of the pain variance across all pain dimensions-- intensity, extent, sensation and affect. In addition, patient gender was a significant predictor of pain sensation. Intubation status, a factor which affects communication abilities, had no significant effect on patients' pain except that patients who were intubated longer reported less sensory pain. Study patients received very little analgesics over their first three post-operative days, and reports of pain relief from analgesics did not correlate well with reports of pain amount. Finally, type of injury did affect the amount of pain

experienced by patients. That is, vascular patients had significantly more pain than cardiac surgical patients.

In research question #3, the relationship of certain morbidity factors to pain was examined in these critically ill patients. Only one of the morbidity factors under investigation was significantly related to patient pain intensity. That is, there was a greater incidence of atelectasis in patients having more pain. Correlations between pain and both length of critical care stay and total number of morbidity factors were nonsignificant.

Meaning of the Findings

Dimensions of Pain

Dimensions of pain intensity, extent, sensation and affect were studied. These critical care patients had a moderate degree (5 on a 0-10 scale) of tonic post-surgical pain intensity; this intensity did not change over the immediate three-day post-operative period. Nevertheless, the pain intensity instruments used discriminated among different degrees of pain intensity; that is, pain intensity scores were higher for chest tube removal pain than tonic and ET pain.

Patients localized their pain through use of the body outline diagram and identified specific body parts that the pain involved, an indicator of the sensory-discriminative properties of pain. Pain extent, however, was minimal, with mean scores from 2.4 to 4.0 (possible 0 - 45) across the five pain measurement times. It is difficult to compare

body pain extent scores with the findings of the instrument developers (Margolis et al., 1986). They measured pain extent in chronic back pain patients but did not present mean scores. This lack of normative data limits interpretation. However, Heye (1989) used a similar body outline diagram (BOD) to explore cardiac surgical patients' pain three to six days post-operatively, after patients were transferred from critical care units. Pain extent in her patients was somewhat higher; in her study, patients located pain to an average of 6 body parts on the BOD. This difference between Heye's and the present study findings may be due to Heye's slight modification of the BOD of Margolis et al. (1986); Heye used a total of 47 body parts versus 45 (personal communication). However, this slight difference in pain extent scores between Heye's and this present study may suggest that the pain of cardiac surgical pain patients becomes more diffuse over a longer period of post-operative time.

Patients in the present study also reported relatively low degrees of pain sensation ($\underline{M}$ = 7.4 of possible 0 - 33) and affect ($\underline{M}$ = 3.0 of possible 0 - 12), as measured by the McGill Pain Questionnaire-Short Form (MPQ-SF). This contrasts with higher mean sensation (11.7) and slightly higher affect (3.7) scores measured by the MPQ-SF on general care unit post-surgical patients (Melzack, 1987). Further analysis of these differences is limited since the specific type of surgical patients and the number of days post-

operative when pain measurements occurred were not reported by Melzack.

The sensory and affective pain dimensions of this patient population can be compared to other surgical patients who used the long form of the McGill Pain Questionnaire (MPQ-LF) by calculating and comparing percentages of possible scores. That is, using data from a meta-analysis of painful conditions assessed by the MPQ-LF, post-surgical sensory scores were 34% of the possible score; post-surgical affective scores were 16% of the possible MPQ-LF score (Wilkie, Savedra, Holzemer, Tesler & Paul, 1990).

Patients in this present study reported 22% of the possible MPQ-SF sensory score (M 7.4 out of possible 33), and 31% of the possible MPQ-SF affective score (M 3.7 out of total possible 12). Thus, while sensory scores were lower in this study, critical care patients scored substantially higher on the dimension of affective pain. This indicates a stronger emotional component to critical care patient pain. The emotional component may be procedure-related since affective scores were higher for ET and CT removal than for tonic pain. This suggests that the pain from procedures may have generated more fear and anxiety in patients than did the general pain from surgery. If so, the fear and anxiety may be due, in part, to patients' expectations about their pain course after surgery. That is, patients may expect to have post-operative pain and have prepared themselves for it. However, they may have no expectations about procedures

that are done to them in the critical care unit, and this may increase pain's affective responses.

Emotional responses to pain are affected not only by the noxious stimulus but also by many situational or contextual variables such as lack of information or lack of control (Chapman & Turner, 1986; McGrath, 1983). Johnson (1973) found that the distress associated with pain decreased when subjects were informed about the types of sensations they would be expected to feel during a painful event. Thus, the increased pain affect scores of patients in this present study may have been due, in part, to distress from the unknown.

Relationships Among Pain Dimensions

Almost all of the four pain dimensions were strongly correlated with one another. This strong relationship leads to the question: can pain dimensions be differentiated from one another? The answer appears to be "yes", at least in certain patient populations. Weaker correlations have been found among MPQ-LF subscales in chronic pain patients without known organic pathology than in arthritic patients with chronic pain (Perry, Heller & Levine, 1988). Thus, the Perry et al. findings support the belief that qualitative differences in a pain experience may be reflected by variability in pain dimensions. Patients in the present study were receiving opiates and-- at times-- anxiolytics during their post-operative course. While sedation assessments were done before any data collections, subtle

effects of sedatives may have influenced patients' abilities to discriminate among pain dimensions. Yet, with that in mind, the strong relationship among dimensions in these critical care study patients demonstrates consistency in the pain experience of patients with this particular type of post-operative pain in a critical care environment.

There were very strong and significant correlations between the two measures of pain intensity. This supports the validity of these two measures of pain intensity. However, fewer patients were able to complete a VAS. The NRS, which was completed more often by patients in this study, was more easily scored (that is, the length of the line does not need to be measured) and required less detailed instructions than the VAS.

The lowest correlations among pain dimensions occurred for pain extent. Most noticeable was that BOD measures did not correlate significantly with any of the other measures of pain dimensions at the third tonic pain assessment even though there were no significant changes in pain extent over time. Each of the subjects had used the BOD at least twice before this tonic pain #3 time and should have had instrument familiarity. However, the smaller sample size at tonic pain #3 ($N = 33$) may explain, to some degree, the lower correlations since there would be less power to elucidate more subtle effects.

The Nature of Tonic and Procedural Pain

Two types of pain were investigated in this study-- the background, or tonic, pain after surgery and the episodic pain that resulted from caregiver procedures. The study detailed the nature of tonic pain in critically ill surgical patients in a longitudinal manner. Prior to this, there were few time-intensity pain profiles following various operations (Bonica, 1981) and none involving critically ill patients. What was evidenced here is that tonic pain intensity changed very little over a three-day post-operative time period. A theoretical explanation of the relationship between analgesic coverage, patient activity levels and pain may help to explain this lack of change in pain intensity over time. That is, on post-operative day one, the residual effects of analgesics given during surgery may help to attenuate the barrage of nociceptive activity originating from organs, tissues and somatic structures involved in the operative procedure. On post-operative days two and three, when nociceptive stimulation from the surgical procedure itself would be expected to be decreasing somewhat, patient activity is often increasing. That is, patients are expected to participate in recuperative activities such as deep breathing, coughing and ambulating. There are, then, new stiumli originating from tension on surgical wounds and incisions. Pain-producing biochemical substances are released from involved tissues, and nociceptor thresholds are decreased (Benedetti, 1990;

Bonica, 1981). At this time, amounts of analgesics administered post-operatively may be sufficient to maintain a balance of pain and analgesia but insufficient to decrease the pain.

In this study, patients received very little and decreasing amounts of post-operative analgesics (14.4 mg MS, day 1; 9.6 mg, day 2; 6.4 mg, day 3). Thus, the balance of new causes for additional pain stimuli with decreased amounts of analgesia coverage may account for the maintenance of pain intensity at a moderate degree over the three post-operative days.

In light of this explanation for a possible lack of decrease in tonic pain over time, consideration needs to be given to clinicians' and patients' analgesic beliefs and goals. If post-operative pain serves no useful function (Bonica, 1981), then an analgesic goal related to post-operative pain would be the total absence of pain (Weis, Sriwatanakul, Weintraub & Lasagna, 1983). Yet complete analgesia without opioid side effects is difficult to attain (Benedetti, 1990).

The second type of pain investigated was episodic, procedural pain. Clearly, as evidenced from the findings, all procedural pain was not alike. The removal of chest tubes, particularly pleural tubes, generated significantly more pain intensity than did ET suctioning. In spite of the fact that patients involuntarily cough during ET suctioning, which creates pressure and tension on thoracoabdominal

incisions, patients did not find suctioning more painful than CT removal. A physiological explanation may account for the difference in pain between procedures. The lungs and respiratory tract have receptors that respond to irritants (Cervero, 1985). While a burning pain results from inhalation of irritant chemicals, the usual response to respiratory tract stimuli may be a sensation of dyspnea rather than pain. Parietal and costal pleura, on the other hand, do contain sensory nerve endings of intracostal nerves (Donat, 1987), as do thoracic muscles through which chest tubes are withdrawn. Pleuritic chest pain is made worse by deep breathing (Donat, 1987), a maneuver patients are asked to perform as the chest tube is removed. Thus, nociceptive nerve involvement is more extensive with chest tube removal than ET suctioning.

A second factor that may explain the difference between the ET suctioning and chest tube removal procedures may relate to the timing of the procedural assessments. More ET suctioning than chest tube removal assessments were done on post-operative day one. Since cardiac patients receive large peri-operative analgesic doses (Sebel & Bovill, 1987), residual operative analgesia may decrease the intensity of ET suctioning pain on day one. This analgesic "coverage" from residual surgical anesthesia would have diminished by day two, when a number of the chest tubes were removed.

In addition to a greater pain intensity, chest tube pain was associated with a higher degree of sensory and affective qualities than was ET pain. This reinforced findings from previous research (Paiement et al., 1979, Puntillo, 1990) as well as the investigator's clinical observations about the problematic nature of chest tube pain. One patient in the study graphically described his chest tube removal pain by saying, "when they pulled out that tube, it was like they were ripping out my soul."

Results also showed that patients received less chest tube pain relief from pre-procedural analgesics than from medications given at any other time. This is yet another indication of the severity of the pain. The intense nature of the pain and the lack of adequate pain relief may relate, in part, to the type and methods of analgesic interventions used for CT removal. Patients in this study received only small amounts of analgesics IV-- if any-- before chest tube removal.

Finally, in comparing the three types of pain measured, tonic pain was more pervasive than either chest tube or ET pain. Methodologically, patients were asked during tonic pain assessments to identify all body areas where they were feeling pain during the past several hours. Thus, pain from chest tube removal, ET suctioning, other procedures, headache pain and many other pain sources could all have been subsumed under the tonic pain measurement. Tonic pain, then, cannot be directly equated only with pain at the

surgical site but may be better seen as a reflection of a patient's entire pain experience.

Predictors of Pain

The relative contributions of age, gender, personality and analgesics to the amount of explained variance in pain were explored. One of these variables-- mean analgesic amount-- was able to explain a significant proportion of each of the four pain dimensions. According to the multiple regression analysis, the more analgesics received, the greater the pain experienced. Two explanations exist that make that relationship unlikely. First, this directionality would appear plausible if opioid tolerance was an issue. Tolerance occurs if a larger dose of opioids is needed to maintain the original effect from the medications (American Pain Society, 1987). Thus, the senario may be as follows: the more analgesics administered, the greater the tolerance, the less the effect from the analgesics, the greater the pain. However, these patients were opioid naive pre-operatively and received very small amounts of post-operative opioids, making the presence of opioid tolerance unlikely.

Second, the two variable scores used for multiple regression-- mean amount of analgesics and mean amount of pain-- would not seem to account for more analgesics being a predictor of more pain. That is, the analgesic score used was not the amount of analgesics administered just before a pain assessment was done. If that were the case, findings

might suggest that the nurse's discussion about pain at the time of analgesic administration might have increased patients' attention to and perception of pain. This may have influenced a patient's report of pain at the time the pain assessment was done by the investigator. Instead, the two variable measures were average analgesics administered and average pain. With these points in mind, the multiple regression results suggest that as pain increased, the amount of analgesics administered also increased-- not vice versa.

Of all of the treatment and illness mediators analyzed as variables, analgesic administration was the only one controlled by health care professionals. Specifically, the amount of medications given by critical care staff-- although very small-- was in relative proportion to the amount of pain patients experienced. This suggests that the staff was reasonably attentive to assessing patient pain and the need for analgesics. This is encouraging since prior non-critical care research has shown otherwise. For example, only 45% of a sample of 353 hospitalized medical-surgical patients with pain recalled ever having a nurse discussing their pain with them (Donovan, Dillon & McGuire, 1987). This same patient group received less than a quarter the amount of analgesics ordered, not a surprising finding given the lack of nursing pain assessments. In addition, in spite of a rather commonly held belief that cancer is a painful disease, hospitalized cancer patients fared no

better than the above-mentioned medical-surgical patients in regard to nursing assessment. Less than one-half of 69 cancer patients remembered any nurse talking to them about their pain (Donovan & Dillon, 1987).

The critical care nurses of patients in this present study may have used other nonverbal patient cues to identify pain in their patients. In addition to patient self-reports, information about pain can be communicated to health professionals through patient behaviors and physiological indices (Douglas, 1989; Rawal & Tandon, 1985; Wilkie, Lovejoy, Dodd & Tesler, 1988). In fact, Douglas (1989) found that pain behaviors exhibited by critically ill Mexican males were strong and significant predictors of pain associated with acute myocardial ischemia. In this same group of patients, however, the physiological variable of pressure rate product (systolic blood pressure x heart rate) was not a significant predictor of patient pain.

In addition to analgesics, it appears that gender accounted for some of the variance of pain sensation. That is, when gender was entered into multiple regression analysis first (and separate from age), gender explained 5% of the pain sensation variance. Females had higher pain sensation scores than males, but this difference was nonsignificant. Thus, the impact of this gender difference finding is difficult to assess. Perhaps the females in this study population were more willing to describe their pain

sensations in greater detail (that is, choose more sensory words) to a female investigator than were the males.

There was a negative correlation between age and each of the four pain dimensions, meaning that as age increased, pain scores decreased. The direction of the correlation is consistent with some previous studies (Schluderman & Zubek, 1962; Sherman & Robillard, 1960). However, this correlation was nonsignificant. Analgesic administration may have been a variable that confounded the relationship between age and pain since elderly have been known to be more sensitive to analgesic effects (Bellville et al., 1971).

In spite of research that suggests otherwise, the personality dispositions of patients in this present study seemed to have no significant effect on their pain. Personality characteristics have been mediating factors in experimental pain studies (Lynn & Eysenck, 1961). However, there is little or no research to support or dispute the present study's finding regarding the effect of personality on critical care patient pain.

The measurement of the "optimally adjusted personality" was a global view of personality, perhaps too global to be sensitive enough to detect personality and pain relationships. However, secondary analyses, in which Q-set subscales of anxiety, neuroticism, depression, extroversion, introversion and resilience were used as predictive personality measures in multiple regression models, also produced nonsignificant findings. (Neuroticism was also

indirectly assessed to be a nonsignificant measure here since there have been strong correlations between neuroticism and anxiety in prior uses of the Q-set) (S. Weiss, personal communication).

Since the California Q-set technique has been well validated, there are no indications that its validity should be questioned here. The Q-set technique of gathering data about attitudes, beliefs and characteristics has been used in multicultural nutritional studies (Simpson, 1989) as well as critical care patient stress studies (Ballard, 1981). In the latter, patients-- after transfer from critical care-- used a Q set method to ranked factors which caused them stress when they were in critical care units after surgery.

It may be, in fact, that general personality disposition has little influence on how critical care patients experience pain. It may be that present psychological status during the critical care time period has a more meaningful effect of the patient's pain experience, but that was not measured in this study. It may also be that family members who made these judgments about their critically ill loved one's personality could have been in a psychological state that distorted their ability to rank personality accurately. Given the significant time commitment involved in administering the Q-set and the frustration and impatience demonstrated by some family members as they completed the Q-set, it is recommended that other instruments be used to assess the personality and/or

psychological status of critical care patients in future studies. Since pain is an emotional as well as a sensory experience, it is essential to identify the emotions associated with pain and plan interventions to alleviate distress.

Other Mediators of Critical Care Patient Pain

The relationship between other potential mediators and pain in these critically ill patients was analyzed in this study. Investigated were the relationships between length of intubation and pain; pain relief and pain; and type of injury and pain.

Intubation and Pain

Baer et al. (1970), who studied pain assessment practices of various health professionals, noted that patients in pain had better "speak up" (p. 391). This suggests that intubated patients may have more difficulty in communicating pain, a usual antecedent to its relief. However, this study found impairment of patient communication by ET tubes was not associated with increased patient pain. In fact, patients who were intubated for longer time periods reported less pain sensation; that is, they chose less sensory words to explain their pain. Perhaps this was due to the effort required to respond to all of the sensory words. Too many questions of intubated patients may seem overwhelming to them (Belitz, 1983). In fact, critical care patients previously reported limiting

their communication during intubation time because of the difficulty involved (Gries & Fernsler, 1988).

A second hypothesis is that severity of illness may affect sensations. It is reasonable to assume that severity of illness was the reason patients in this study were intubated longer. The more seriously ill patients may be less able to express their feelings (Quittenton, 1987), and/or their illness may interfere with either perception or reporting of various sensory qualities. The relationship of prolonged intubation to critical care patient pain warrants particular study since many critical care patients undergo mechanical ventilation for longer periods of time than the patients in this study.

Finally, the lack of correlation of verbal communication status and patient pain may also speak well of caregivers' abilities to ascertain pain in their patients. These caregivers may rely on behavioral observations or changes in ANS parameters as indices of pain, expecially when their patients are unable to talk.

Pain Relief and Pain

Logically, as pain relief increases, pain decreases. This inverse relationship, however, was not demonstrated in the present study. Likely explanations for this finding include difficulties in measuring pain relief and lack of patient understanding of treatment regimes.

The instrument chosen to measure pain relief was a 0-10 NRS, with 0 meaning no pain relief from medications and 10

meaning complete relief of pain from medications. According to study protocol, the NRS-pain relief (NRS-PR) scale was administered immediately after either the NRS or VAS pain intensity scales. Although patients could not see their pain intensity answers, perhaps they had conceptual difficulties in switching from intensity to relief. That is, a 10 on the NRS pain intensity scale meant "worst possible pain," while a 10 on the NRS-pain relief scale meant "complete relief of pain." There may have been a carryover effect whereby the two scales were scored in the same direction.

Some patients, when asked about pain relief from medications, answered they were not getting any medications (n = 3 out of 247) or they had no pain (n = 19 out of 247). Moreover, 31 times the pain relief question was asked, patients said they didn't know if they had received any medications. This latter answer suggests a lack of communication between staff and patients about staff analgesic treatment practices, faulty patient cognitive processing-- poor memory, poor lucidity, time distortion-- or both.

In the first instance, hospitalized patients' pain relief has been enhanced by interactive communication practices of their nurses that emphasize discussions of pain relief methods and the probability of pain relief after treatment (Diers, Schmidt, McBride & Davis, 1972; McBride, 1967; Moss & Meyer, 1966). This effect, however, has not

been universal (cf. Chambers & Price, 1967). If pain relief is enhanced by specific nurse-patient interactions, part of this effect may be due to placebo analgesia which is believed to involve endogenous opioid systems (Levine, Gordon & Fields, 1978). Thus, patient pain relief may improve with patient awareness that medications are being administered and belief that the medications should have a beneficial effect on the pain.

In the second instance, the effect of memory deficits on the ability of patients to recall receiving medications is unknown. However, Raymond et al. (1984) reported a significant decline in the immediate and short-term memory of CABG patients tested one to two weeks post-operatively. Thus, some degree of memory dysfunction may have played a role in the inability of the present group to remember receiving medications.

When patients in this study were able to use the NRS-PR scale, they reported an approximate 60% pain relief from medications for tonic pain and 50% pain relief for procedural pain. That pain relief was less for procedural pain may have been due to the increased pain intensity of chest tube removal that the small amount of analgesics did not control. Also, lack of better pain relief from medications may relate to insufficient staff follow-up evaluation of degree of pain relief obtained following analgesia administration. In fact, 29% of nurses in a study of nurse-patient expectations about pain relief noted that

they did not assess patient pain relief (Graffam, 1981). They believed patients would let them know if their pain continued-- an assumption deemed inaccurate by Graffam's study patients.

Furthermore, beliefs about the goals of pain relief can influence medicating practices. Only 20% of physicians and nurses caring for surgical patients aimed for complete pain relief for their patients (Weis et al.., 1983). Yet, according to Marks and Sacher (1973), even when physicians stated that their goal for pain relief was 100%, their actual analgesic practices were quite contradictory. Health professionals may feel that less than complete pain relief is adequate or may fear the development of pulmonary complications in post-operative patients. However, a pain relief goal greater than "adequate" may better serve critical care patients, since prior critical care research has equated excellent pain relief with less post-operative complications (Hasenbos et al., 1985A, 1985B; Rawal et al., 1984).

Type of Injury and Pain

Study results showed that vascular patients had more pain than cardiac patients on almost all pain dimensions across the three post-operative days, with a significantly greater pain intensity on post-operative day one. This difference cannot be explained by type of incision since both groups had vertical incisions. However, the finding is consistent with published compilations of data regarding

pain associated with various surgical procedures. Steady wound pain of sternotomies has been estimated to be severe in 30-40% of patients, while steady wound pain after upper intra-abdominal incisions was severe in 45-75% of patients (Bonica, 1990).

Other differences in the cardiac and vascular patient populations may have influenced their different post-operative pain experiences. First, cardiac patients were in a different critical care unit, at least for their first post-operative day, than were most of the vascular surgical patients. Second, only three of the 14 vascular patients (versus all of the cardiac patients) were intubated during some of their critical care time. The influence of these differences on patients' pain is unknown, but differences in unit pain management philosophies and practices could play a role.

Pain and Patient Outcomes

Atelectasis was present in 67% of patients in the present critical care study. This corroborates prior research findings of increased atelectasis development in critical care patients when post-operative analgesia was less than optimal (Hasenbos, 1985A,B; Rawal et al., 1984). It also supports the pathophysiological model presented earlier that described pain's inhibition of thoracic diaphragmatic excursion, impairment of respiratory volumes, increased airway closure and subsequent effect on development of atelectasis. Caution is advised, however, in

equating the high incidence of atelectasis with pain in this patient population. Abnormal pre-operative pulmonary function, not assessed in this study, is frequently identified as an important predictor of post-operative pulmonary disease (Astiz, 1989; Bendixen, Egbert, Hedley-Whyte, Laver & Pontoppidan, 1965; Gass & Olsen, 1986) such as atelectasis. In addition, adverse respiratory effects of peri-operative anesthetic agents can decrease functional residual capacity (Tantum, 1983) that may precede atelectasis. Reduced diaphragmatic activity from altered neural reflexes during surgery has also been associated with atelectasis (Ford, Whitelaw, Rosenal, Cruse & Guenter, 1983). Finally, post-operative narcotic depression of alveolar ventilation (Craig, 1981) and abdominal distension, which hinders diaphragmatic excursion, can hasten airway closure (Modig, 1978) and lead to atelectasis. Nevertheless, there was a significant-- if not causal-- relationship between atelectasis and more intense pain, a finding which cannot be ignored.

Pain had very little relationship to other negative patient outcomes investigated in this study. For example, neither length of critical care stay nor total number of complications correlated significantly with any of the pain dimensions. Prior research has shown otherwise. Yeager et al. (1987) were able to find a decreased number of cardiovascular and infectious complications and shortened intubation time in critical care surgical patients treated

with epidural versus standard IV prn analgesia. Patient pain was not measured in the Yeager et al. study; yet the differences in complications were assumed by the investigators to be, in part, from better pain control.

The overall weak relationship between pain and negative physiological and psychological consequences deserves further comment. Many patients with post-operative physiological and psychological episodes were dropped from this study because of their inability to participate in the pain assessments (n = 18). Therefore, there may have been consequences of pain in these patients which were not identified. Furthermore, this was a descriptive study in which confounding variables, such as pre-operative morbidity status, post-operative sedative administration and post-operative cardiovascular parameters, were not controlled.

Significance

Widespread concern exists among critical care professionals about the possible ramifications of inadequate assessment and treatment of pain in critically ill patients. The present study is the first known in which critical care patient pain was extensively assessed and the effects of specific critical care illness and care factors that can influence pain were isolated. Study findings demonstrate that significant information on patient pain can be gathered -- even from intubated patients-- when proper assessment tools or communication instruments are used.

The study covered patient pain trajectories over three post-operative days. This longitudinal approach helped uncover the lack of pain improvement over this period. Study results also highlighted the importance of isolating and addressing treatment-related variables, such as analgesic practices, that impact upon patient recovery from pain.

Critical care patients are subjected to numerous, often life-saving, procedures during their stays in critical care units. Yet, in spite of previous patient reports of the significant stress associated with procedural pain, this is the first study to document the nature of iatrogenic pain in critically ill adult patients.

In sum, this study was marked by extensive documentation of iatrogenic pain and tonic, post-operative pain in critically ill cardiac and vascular patients. This methodology contributed in the following ways: (1) providing a scientific foundation for understanding pain in select critical care patient groups; (2) providing information about the validity, reliability and feasibility of pain measurement instruments tested in critical care patient populations; (3) generating new questions to be addressed through further critical care research; (4) providing support for the pursuit of new pain management interventions for critically ill patients in pain.

Limitations

Interpretation of the study results and assessment of the utility of research findings must be based upon a recognition of the study limitations. The study population of 74 was derived from one large metropolitan research university center. Patients were cared for post-operatively in critical care units with very high levels of patient acuity. Finally, study patients were limited to only two categories of surgical procedures-- cardiac and vascular. Therefore, the sample was not representative of the many types of patients with varying degrees of illness acuity in the many different critical care units that exist. These factors limit the generalizability of study results.

Other important limiting factors were cultural homogeneity and male over-representation in the sample. However, this sample of predominantly male Caucasions is representative of patients undergoing cardiac surgical procedures-- particularly coronary bypass surgery. In addition, study results suggest that gender may influence pain. If both genders had been more equally represented in the sample, the power of the analyses would have been increased with the potential for a greater effect of gender on other pain dimensions.

This research was a descriptive study of the pain of critically ill patients. The documentation process used patient self-reports, certainly the most direct measure of the subjective experience of pain. However, other patients

unable to communicate their pain through self-report methods were excluded either because of language, physiological or psychological barriers. Concurrent validity of the self-report measures of pain could have been increased through exploration of behavioral and physiological indices of critical care patient pain.

Finally, limited knowledge was derived on the influence of two important pain mediators-- personality and pain relief-- on the pain experience. Furthermore, the psychological state of the patients while they were experiencing their critical care pain was not addressed. Developing or choosing other measures of personality and pain relief and investigating psychological state may help increase understanding of their influence on pain in critically ill patients.

Implications for Nursing

One mission of nursing is to diagnose and treat human responses to alterations in health (ANA, 1980). Critical care nurses, who diagnose and treat pain, are powerful members of the critical care health professional team. Through their assessment skills, critical care nurses make diagnoses that drive intervention decisions. Interventions, in turn, can be either independent nursing actions or implementation of specific physician prescriptions. While analgesic prescription is not within the legal domain of nursing, critical care nurses have tremendous control over the frequency and amount of analgesics that patients

receive. With this in mind, findings from this study may help nurses to better understand the multidimensionality of patient pain and offer new methods to assess and treat these dimensions.

Two measures of one of pain's dimensions, intensity, have been validated in this patient population-- the VAS and the NRS. This validation has important clinical application in that either one of the instruments could be chosen to measure pain intensity in critical care patients. However, the NRS may be more useful clinically because of scoring ease, while the use of the VAS may be warranted when more precise measurement is essential.

Other dimensions of pain, location and extent, were assessed by the BOD. Clinicians can measure these dimensions and use this knowledge of pain location and extent of patient pain to choose pain relief measures that are effective locally as well as systemically. This information about usual location and extent of pain can also help nurses better prepare patients pre-operatively for their post-operative period through focused teaching strategies.

The affective dimension of critical care patient pain appears to be quite substantial when these study results are compared to other non-critical care surgical patients. That is, these study patients had higher affective scores-- especially in association with procedures-- than did other surgical patient populations. This finding has important

clinical implications. With this knowledge, nurses can make assessments of environmental, illness and treatment-related factors that contribute to the emotional discomfort of their patients in pain. Critical care health professionals aware of the emotional pain associated with various procedures can consider preparatory informational and psychological interventions to help alleviate some of the pain. They can institute changes in practice to decrease this discomfort through the use of information, distraction, relaxation techniques and touch.

The study has contributed specific knowledge about the pain of procedures that nurses routinely perform on patients-- endotracheal suctioning and chest tube removal. Even though nurses do not actually remove chest tubes, they participate in patient preparation and management during the procedure. Knowledge gained from this study on the pain experienced with chest tube removal can serve to direct nurses to improve patient comfort. For example, nurses can act as patient advocates for increased pharmacological support during chest tube removal and institute nursing comfort measures and psychological support to augment pharmacological analgesics.

Finally, patients in this study received very small amounts of post-operative and pre-procedural analgesics. Furthermore, patient pain did not diminish over time in proportion to the decreasing amounts of medications administered by nurses. Nurses can use this knowledge to

assess the scientific rationale for their own analgesia practice decisions. Changes in practice may result from these assessments and have a positive effect on critical care patient comfort.

Future Research

Knowledge about the pain of critically ill patients is beginning to emerge from clinical studies of this phenomenon. Delineated here are some specific suggestions for future research in critical care.

First, a study involving a longer operative course is warranted. Analysis of post-operative pain trajectories over the three day period uncovered changes that occurred in analgesic practices while measured pain stayed the same. This finding points out the need for future longitudinal studies that include both the peri-operative and a longer post-operative time period.

Second, there is more to be learned about measurement of critical care patient pain. For example, future research and clinical use of a body outline diagram to identify location and extent of pain is recommended. Researchers may identify, for example, certain critical care patient populations where pain extent is greater and demonstrate the significance of this finding to overall patient well-being. In addition, analysis is warranted of the specific body areas that the pain involves. This analysis may yield potentially important information such as sites other than incision that cause patients discomfort after surgery and

drive the choice of interventions specific to the area of pain.

Third, other mediators of pain need to be investigated. At most, 27% of the variance in pain was explained here, for pain sensation. What remains to be explored are the relative contributions of other factors to pain in critically ill patients. These factors may include patient ethnicity, mode of analgesic administration (such as systemic versus epidural), type and amount of peri-operative analgesia or amount of pain relief. In order to assess the relationship between pain relief and pain, consideration should be given to using a different type of instrument such as a word descriptor scale to measure pain relief (Sunshine et al., 1988; Wallenstein, 1984) so that more confidence can be given to study results. Finally, the relationship of gender to pain sensation is an intriguing area for future exploration, given the information obtained from this study about gender and pain sensation. At this point, there is more unknown than known about the mediators of critical care patient pain, a factor which justifies the pursuit of further investigation.

Fourth, this study has documented differences between two types of surgical patients-- cardiac and vascular. Future research is needed to identify possible causes, other than surgical site, of the greater pain intensity in vascular patients. Recommended for investigation is the effect on pain of different types, amounts and modes of

peri-operative and post-operative analgesics administered to cardiac and vascular patient groups.

Fifth, an investigation is warranted of the adverse effects of both administering and not administering analgesics to critically ill patients. Because of the nature of critical care patient physiological and psychological vulnerability, future research is necessary to discern potential risks of inadequately treated pain and to identify measures for optimal pain management. There was a significant relationship between atelectasis and high pain levels in these study patients. Along with this, study patients did not receive complete analgesia from medications. Factors such as metabolic energy, hemodynamic, respiratory and psychological costs/benefits related to higher versus lower analgesic doses need consideration. Specifically, what remains for investigation is how better analgesia can be attained while minimizing morbidity due to pain as well as analgesics.

Sixth, critical care analgesia studies should evaluate the use of different modes of analgesic administration, such as epidural analgesia and patient-controlled analgesia (PCA). Since some epidural studies which included critical care patients showed positive effects from epidural analgesia, this work should be extended. These extended epidural analgesia studies could include greater attention to pain measurement. The utility of PCA for selected groups

of patients in critical care units needs documentation through research.

Seventh, the pain of procedures certainly deserves further investigation. As noted earlier, patients in this study were extubated very soon after surgery (mean extubation time 23.5 hours). What remains for future investigation is whether ET suctioning becomes more painful as intubation time progresses over days. In addition, the painfulness of chest tube removal has been emphasized throughout this discussion. More research is needed to evaluate the effects of additional and/or alternate methods of promoting analgesia during the very painful procedure of chest tube removal. Studies to evaluate new interventions for pain relief are definitely needed. For example, an experimental design could serve to evaluate the relative effectiveness of the following interventions on chest tube removal: (1) local anesthetics administered through the chest tube prior to withdrawal; (2) local application of transcutaneous nerve stimulation prior to and during chest tube removal; (3) use of pre-procedural information about expected sensations as a pain modulator; (4) usual method of pain control; that is, the prn administration of IV opioids.

Eighth , assessing pain in pharmacologically paralyzed patients or in patients with altered levels of consciousness is particularly challenging to critical care clinicians. As stated earlier, the specific behaviors and physiological measures used successfully by critical care caregivers to

assess nonverbal patients' pain need delineation. Valid and reliable measures of pain in these patients are urgently needed. In an initial study, a comparison could be made among patient groups of pulse, blood pressure, pupil size measures taken before, during and after a known painful procedure (such as chest tube removal). This comparison may help to identify similarities among patient groups-- those paralyzed, those with decreased levels of consciousness and usual critical care patients-- in physiological changes that may be valid indicators of pain.

Finally, critical care pain research needs to be extended to other patient populations. What remains unknown is the nature of pain in other, less homogeneous and more ethnically diverse, critical care patient groups. Also, pain in patients with different diagnoses and conditions needs investigation. For example, while pain in burn patients has been the subject of some research, knowledge of pain related to trauma and organ transplant as well as pain in chemically dependent and addicted critically ill patients is almost non-existent.

To summarize, many questions about critical care patient pain remain unanswered. Pain in the critically ill is a very exciting and fertile field for future research. This research is a necessary prerequisite to improvement of critically ill patient comfort during times of both healing and dying.

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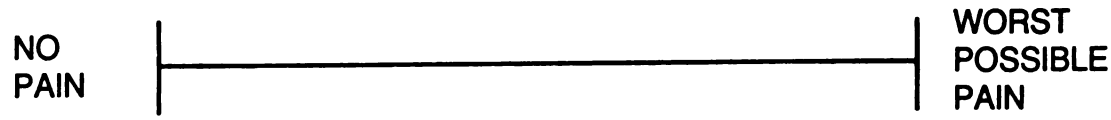
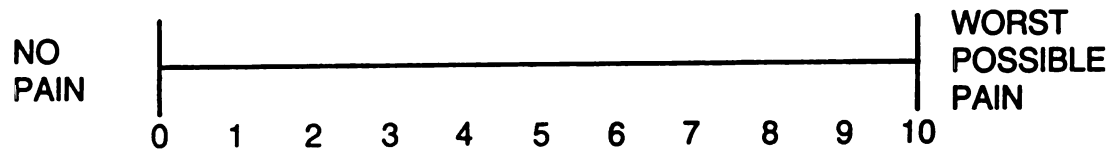
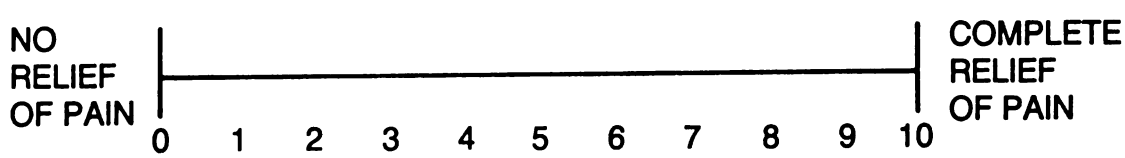
APPENDICES

Appendix A

Pain Intensity and Relief Scales

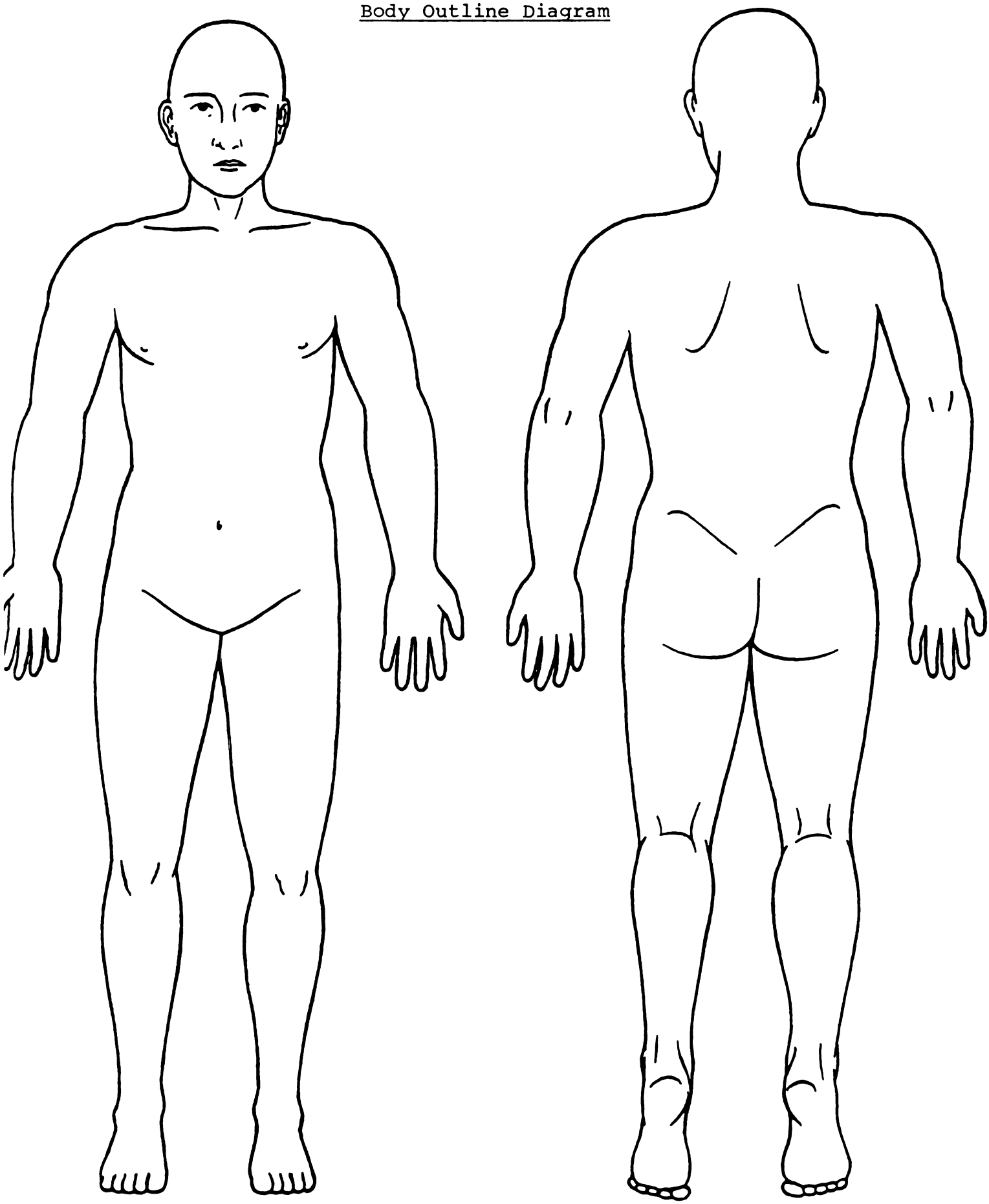






Appendix B

Body Outline Diagram



Appendix C

SHORT-FORM McGILL PAIN QUESTIONNAIRE

	NONE	MILD	MODERATE	SEVERE
THROBBING	0)___	1)___	2)___	3)___
SHOOTING	0)___	1)___	2)___	3)___
STABBING	0)___	1)___	2)___	3)___
SHARP	0)___	1)___	2)___	3)___
CRAMPING	0)___	1)___	2)___	3)___
GNAWING	0)___	1)___	2)___	3)___
HOT-BURNING	0)___	1)___	2)___	3)___
ACHING	0)___	1)___	2)___	3)___
HEAVY	0)___	1)___	2)___	3)___
TENDER	0)___	1)___	2)___	3)___
SPLITTING	0)___	1)___	2)___	3)___
T ING-EXHAUSTING	0)___	1)___	2)___	3)___
SICKENING	0)___	1)___	2)___	3)___
FEARFUL	0)___	1)___	2)___	3)___
PUNISHING-CRUEL	0)___	1)___	2)___	3)___

DATE:
TIME:
SEDATION LEVEL:
COMMUNICATION STATUS DURING DATA COLLECTION:
_____ V _____ NVET _____ NV

CHECK:	CHECK:	TYPE:
_____ TONIC PAIN #1	_____ PROCEDURAL PAIN #1	
_____ TONIC PAIN #2	_____ PROCEDURAL PAIN #2	
_____ TONIC PAIN #3	_____ PROCEDURAL PAIN #3	

*HRS.SINCE LAST ANALGESIC: _____
*TYPE/MODE/AMT OF ANALGESIC: _____
*HRS.SINCE LAST ANXIOLYTIC: _____
*TYPE/MODE/AMT OF ANXIOLYTIC: _____
AMT OF ANALGESIC IN 4 HRS. BEFORE PROCEDURE: _____

*ENTER "NA" IF NEVER RECEIVED OR IF REC'D >12 HRS. AGO

Appendix D

Interview Script- Procedural pain

"I'm going to ask you some questions about the pain you may have felt during (the time you were just suctioned) (the time when the tube was just removed from your chest). This should only take a few minutes, and I'll have a better understanding of what you are feeling."

BOD

"Please mark on this drawing the area or areas on your body where you may have felt pain."

VAS

"I would like you to make an up and down (vertical) mark on this line that would indicate how intense your pain was during that time, where the left of the line (point) is 'no pain', the other, right end of the line (point) is the 'worst possible pain'; or mark anywhere in between." (If they are unable to mark the line themselves, say, "put your finger on the place along the line that indicates how intense your pain was.")

NRS

"Please circle a number between 0 and 10 that would indicate how intense your pain was during that time, where 0 was 'no pain, 10 was 'the worst possible pain', or any number in between." (If they are unable to circle a number themselves, say, "put your finger on the number that would indicate how intense your pain was.")

MPQ-SF Word Descriptors

"There may be some words that describe the pain that you may have felt. I'm going to read some words, one at a time, out loud to you. I would like you to tell me if your pain felt like that. If it didn't, point to the word 'none', meaning you felt none of that. If your pain did feel like that, point to whether it felt mild, moderate or severe.

Did you feel (say a word from the list)?

Did the (say the word just used) feel mild, moderate or severe?"

NRS-PR

"Please circle a number between 0 and 10 that would indicate how much pain relief you felt from pain medications you may have received before (the procedure), where 0 was 'no relief of pain', 10 was 'complete relief of pain', or

any number in between." (If they are unable to circle a number themselves, say, "put your finger on the number that would indicate how much relief you received.")

Interview Script- Tonic Pain

"I'm going to ask you some questions about the pain you may have been feeling throughout today; over the past several hours. This should only take a few minutes, and I'll have a better understanding of what you are feeling."

BOD

"Please mark on this drawing the area or areas on your body where you have been feeling pain."

VAS

"I would like you to make an up and down (vertical) mark on this line that would indicate how intense your pain has been, where the left of the line (point) is 'no pain', the other, right end of the line (point) is the 'worst possible pain'; or mark anywhere in between." (If they are unable to mark the line themselves, say, "put your finger on the place along the line that indicates how intense your pain was.")

NRS

"Please circle a number between 0 and 10 that would indicate how intense your pain has been, where 0 is 'no pain, 10 is 'the worst possible pain', or any number in between." (If they are unable to circle a number themselves, say, "put your finger on the number that would indicate how intense your pain was.")

MPQ-SF Word Descriptors

"There may be some words that describe the pain that you may have been feeling. I'm going to read some words, one at a time, out loud to you. I would like you to tell me if your pain has been feeling like that. If it hasn't been feeling like that, point to the word 'none', meaning you've been feeling none of that. If your pain has been feeling like that, point to whether it has been feeling mild, moderate or severe.

Has it been feeling (say a word from the list)?

Has the (say the word just used) been feeling mild, moderate or severe?"

NRS-PR

"Please circle a number between 0 and 10 that would indicate how much pain relief you have been feeling from

pain medications you may be receiving, where 0 is 'no relief of pain', 10 is 'complete relief of pain', or any number in between." (If they are unable to circle a number themselves, say, "put your finger on the number that would indicate how much relief you have been receiving.")