Complex Decision Making in Providing Surgical Intensive Care

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Abstract

Decisions made by physicians in intensive care medicine are often complex, requiring the consideration of information that may be incomplete, ambiguous, or even contradictory. Under conditions of complexity and uncertainty, individuals may cope by using simplifying decision strategies. The research described in this paper examines the strategies used by physicians in coping with complexity in decision making. Six residents (intermediates) and three specialists in intensive care were each presented with 12 cases of intensive care respiratory problems of varying levels of complexity. The subjects were asked to think-aloud as they worked through the problems and provided a management and treatment plan for each case. The audiotaped protocols were coded for key process variables in decision making and problem solving. Despite the incompleteness and ambiguity of the information available, the confidence of physicians in their decision making was consistently high. The strategies used by intermediates and experts in dealing with the more complex cases varied considerably. Expert physicians were found to focus on the assessment of the decision problems to a greater extent than intermediates. Implications for research in decision making and medical cognition are discussed.

Introduction

Decision making in real-world domains, such as intensive care medicine, often involves making complex decisions in situations where information is incomplete, ambiguous and uncertain. Problems encountered in such domains are often ill-defined and subject to a number of real-world constraints. This paper focuses on a study of how intermediate and expert level physicians deal with complexity in decision making in the treatment and management of a frequently encountered respiratory condition. Diagnosing and treating this condition, known as pulmonary embolism, requires consideration of information from several sources and involves careful judgment in weighing clinical evidence with test results. This type of decision problem is typical of many diagnostic and treatment planning situations in medicine.

Under conditions of high task complexity (e.g., in choice situations involving many alternatives) or time pressure, particular simplifying strategies are likely to be adopted by decision makers (Payne, Bettman & Johnson, 1993). These strategies can be considered as methods for simplifying the search through the decision problem space, either by limiting the amount of information processed or by making processing of that information easier. Related research in the area of medical decision making has revealed the use of varied strategies by subjects in coping with complexity of real-life medical situations. For example, work by Patel and Leprohon (1993), involving the analysis of emergency decision making of nurses responding to 9-1-1 emergency calls, has indicated that high performance decision making was related to the decision maker's approach to the evaluation of the whole emergency situation. Consistent with this research, field studies of decision making in a number of naturalistic settings has indicated the importance of situation assessment in expert decision making (Klein 1993).

Research in medical decision making has typically examined decision making from a different vantage point than research in the area of medical problem solving. Although conceptually similar, problem solving and decision making have traditionally been studied using different research paradigms. A considerable body of research findings has accumulated in the cognitive study of medical reasoning and problem solving (Patel & Groen, 1991). Studies have indicated that physicians use a variety of strategies in dealing with uncertain and ill-structured medical problems (Patel, Arocha & Kaufman, 1994). In solving diagnostic problems, expert physicians have been shown to be capable of focusing on small sets of related hypotheses and are able to use efficient discrimination strategies for distinguishing relevant from irrelevant information in diagnostic reasoning (Patel & Kushniruk, 1992). The extent to which such research findings, emerging from the study of problem solving, can be extended to medical decision making remains to be more fully explored.

Recently, new methodological perspectives have emerged from which to view research in decision making.

A variety of observational field studies have appeared in the study of complex decision making (e.g. Klein and Calderwood's study of firefighters, 1991). However, there is also the need to further develop laboratory studies that are sensitive to the complexity of real-world decision making tasks and that are at the same time experimentally rigorous. Such research needs to take into account the varied contexts and complexity of decision tasks, as well as the level of expertise and knowledge of the decision makers. The approach taken in the research described in this paper extends the "expertise approach", from the study of human problem solving and reasoning (Ericsson & Smith, 1991) to the domain of complex medical decision making. The research involves the use of realistic tasks and subjects with varied domain expertise, within a controlled experimental design.

The purpose of this paper is threefold: 1) to determine how intermediate and expert physicians make decisions in dealing with complex tasks, 2) to determine what type of strategies are employed as the degree of task complexity changes, and 3) to determine the extent to which findings from this study are consistent with existing theories of decision making, problem-solving, and expertise.

Methodology

In this study, written case descriptions were presented to subjects of two levels of expertise 6 intensive care residents (intermediates) in training in a surgical intensive care unit, and 3 intensive care specialists (experts).

Preliminary observational analysis (Kushniruk, 1995) involved examining the types of information that are critical in decision making related to intensive care respiratory problems. This work indicated that lung scan evidence and clinical evidence are two factors that are essential in diagnosing a condition known as pulmonary embolism. The case descriptions used in the study were designed to systematically vary the levels of two critical types of evidence: (1) lung scan evidence for the presence of pulmonary embolism (characterized by three levels: low, intermediate and high probability of pulmonary embolism) and (2) clinical evidence for the presence of pulmonary embolism (two levels: low and high). Thus, in the experimental design, there were six types of cases, one for each combination of the three commonly encountered levels of lung scan evidence and two clinical evidence levels considered by physicians:

Case Type	Probability Lung Scan	Clinical Evidence
1	Low	Low
2	Low	High
3	Intermediate	Low
4	Intermediate	High
5	High	Low
6	High	High

Pulmonary embolism, a condition which can result in blood clots in lungs, is most readily identified by a combination of a high probability lung scan in conjunction with high clinical evidence. On the other hand, a low probability lung scan in conjunction with low clinical evidence, essentially rules out this condition. Complex conditions, i.e. decision situations that are ambiguous, requiring the careful consideration of complex qualitative data, occur with the remaining combinations (e.g. an intermediate probability lung scan in conjunction with low clinical evidence). Two case descriptions were designed for each of the 6 case types, and therefore 12 cases in total were designed.

As an example, one of the cases is given below. In this case (case type 6), the V/Q lung scan indicates a high probability of a pulmonary embolism (as indicated in the last statement in the case), coupled with high clinical evidence of pulmonary embolism (e.g. from the patient's history, physical exam, and lab results):

> A 72 year old lady, previously well, sustained a fractured femur when she fell off a kitchen stool. She was maintained in Buck's traction for six days at which time she underwent a femoral rodding. In the recovery room, difficulty was encountered maintaining her oxygenation and continued mechanical support was required. The nurse noted there were large amounts of blood stained sputum being suctioned from the ET tube. On examination she was unresponsive. Pulse 100; BP 110/70; Temperature 39.1 C. The incision was clean and there was no evidence of bleeding. There were no retinal or subligual hemorrhage and no petechiae. On auscultation breath sounds were diminished on the left and there was dependent dullness to percussion. EKG showed right axis deviation. HB 8; WBC 18,000. Chest X-ray showed multiple infiltrates on the left and a small effusion. A pleural tap resulted in the aspiration of 400 cc of blood-stained serous fluid. FI 102 100%; PO2 85; PCO2 38; V/Q scan showed multiple areas of mismatch with a high probability of embolus.

During the experimental sessions, each subject was presented with the cases, one after the other. The cases were initially ordered randomly. Each subject was asked to: (1) read the case and think aloud as they decided on a course of action to be taken in dealing with that case (i.e. provide the therapeutic and management plan), (2) indicate whether they would treat with the information given (and if not, what information would be needed), (3) suggest a differential diagnosis for the case, and (4) indicate how likely they think their diagnosis is correct. In addition, for each case, subjects were requested to indicate how confident they were in their judgment on how to proceed with the case, on a 7 point scale, ranging from very unconfident (1) to highly confident (7).

Data Analysis

The verbal protocols of the subjects were transcribed and coded for key aspects of clinical decision making and problem solving. For the present study, a scheme for coding the subjects' protocols was devised. The scheme includes categories for coding problem solving and reasoning strategies used, including generation and testing of diagnostic hypotheses (Patel & Groen, 1986; Hassebrock & Prietula, 1992). In addition, the analysis

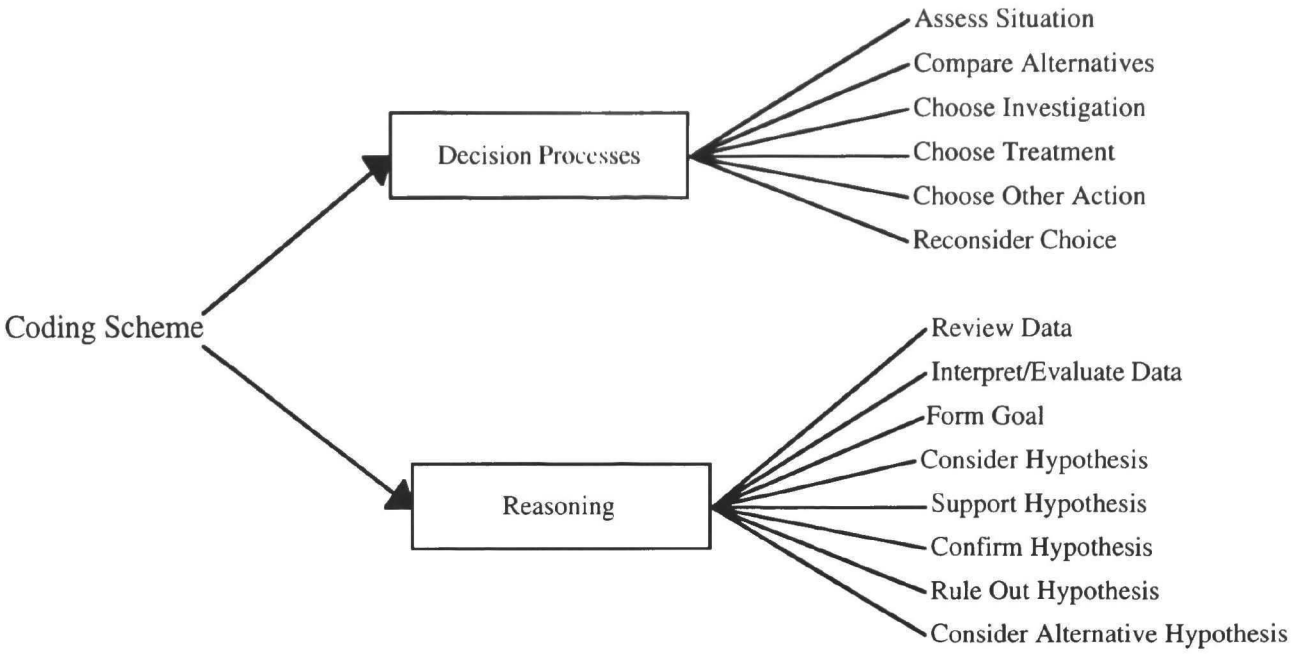

Figure 1: Coding Scheme

included coding for critical aspects of decision making. An important aspect of the coding scheme was the inclusion of categories for evaluating the subjects' situation assessment, defined as processes involved in the identification and clarification of the state of the decision problem (Klein & Calderwood, 1991).

Categories related to decision making were modified from those used by Kuipers, Moskowitz, and Kassirer (1988). The main categories included in the coding scheme applied by the experimenters are given in Figure 1 (complete descriptions of the criteria for coding for each category are provided in Kushniruk, 1995).

In addition to coding each protocol for aspects of decision making and problem solving, each protocol was characterized according to the strategies used by subjects. A decision rule was first identified for each protocol, based on the course of action suggested by the subjects for the six case types. More general strategies were also identified, using an approach based on that described by Elstein, Holzman, Belzer, and Ellis (1992) where strategies common to groups of subjects were identified.

Results

The results described below, deal with three areas: (1) coding of the protocols (2) determination of rules and strategies used by subjects, and (3) subjective confidence.

Decision Making and Reasoning

The results from the analysis of coded protocols are summarized in Table 1, which gives the percentage of total segments coded for each aspect of decision making

Table 1: Frequency and percentage of coded segments of verbal protocols

Code	Intermediates		Experts	
	Frequency	Percentage	Frequency	Percentage
Assess Situation	82	10.5	171	35.5
Compare Alternatives (concurrently)	9	1.2	5	1
Choose Investigation	64	8.2	20	4.2
Choose Treatment	139	17.8	38	7.8
Choose other action	12	1.5	5	1
Reconsider choice	9	1.1	12	2.5
Review data	113	14.5	56	11.6
Interpret/evaluate data	93	11.9	40	8.3
Form goal	26	3.3	20	4.2
Consider hypothesis	139	17.8	76	15.8
Support hypothesis	59	7.6	15	3.1
Confirm hypothesis	3	.4	4	.8
Rule out hypothesis	12	1.5	6	1.2
Consider alternative hypothesis	24	3.1	17	3.5

and reasoning in the coding scheme. The percentages are listed for both intermediate and expert subjects. The most notable difference between experts and intermediates was in the category of situation assessment, with expert protocols containing a greater percentage of segments dealing with this aspect of decision making.

An excerpt from an intermediate subject's think aloud protocol for one of the cases is provided below (codes are in boldface). This case consisted of a description of a patient with a high probability lung scan in conjunction with high clinical evidence of pulmonary embolism:

> Uhm, my impression is
> that she wasn't given any therapeutic subcutaneous heparin DVT
> anything like that
> so uhm, she is a high risk case for pulmonary embolus.
> **CONSIDER HYPOTHESIS : Pulmonary embolism**
> So I would definitely start uhm, on heparin
> because she seems to be very sick
> **CHOOSE TREATMENT: heparin**

In contrast, a portion of an expert's subject's protocol for the same case is given below:

> Uh, I'd want further history,
> specifically, uhm, starting with the acute event,
> **ASSESS SITUATION**
> uh, it mentioned that in the recovery room difficulty was encountered maintaining her oxygenation.
> **REVIEW DATA**
> I'd like to know whether there was any problems intraoperatively.
> Uh, specifically with oxygenation
> and/or hemodynamics.
> In addition, I'd want to know whether there was any difficulty intubating the patient
> for the operating room itself
> **ASSESS SITUATION**

In comparison to intermediate subjects, the expert subjects tended to stress the evaluation of situational aspects of the cases. This is reflected by the greater percentage of segments coded for situation assessment for expert physicians (see Table 1).

Decision Strategies

The decision rules used by the physicians for each of the six types of cases are presented in Table 2. For each type of case, the table gives the outcomes of the physician's management decision, as well as the number and percentages of cases where that treatment plan was recommended. As can be seen, for cases representing low probability lung scan in conjunction with low clinical evidence, and for cases consisting of high probability lung scan in conjunction with high clinical evidence, decision making was consistent across all physicians (e.g. all physicians recommended the same course of action in all of the 18 cases presented that were low probability lung scan in conjunction with low clinical evidence). In contrast, for cases involving the other combinations of clinical and lung scan evidence, the decisions varied considerably.

Table 2: Number and percent of subject-generated protocols described by decision rules (grouped by case type 1-6)

	Number	Percent
1. If low probability lung scan + low clinical evidence		
a. Do not treat for PE	18	100
2. If low probability lung scan + high clinical evidence		
a. Do not treat for PE (rule out PE)	5	28
b. Treat for PE immediately	3	17
c. If pending investigations are positive then treat for PE	7	39
d. Defer decision - assess further	3	17
3. If intermediate probability lung scan + low clinical evidence		
a. Do not treat for PE (rule out PE)	3	17
b. Treat for PE immediately	4	22
c. If pending investigations are positive then treat for PE	6	33
d. Defer decision - assess further	5	28
4. If intermediate probability lung scan + high clinical evidence		
a. Do not treat for PE (rule out PE)	3	17
b. Treat for PE immediately	9	50
c. If pending investigations are positive then treat for PE	4	22
d. Defer decision - assess further	2	11
5. If high probability lung scan + low clinical evidence		
a. Do not treat for PE (rule out PE)	7	39
b. Treat for PE immediately	4	22
c. If pending investigations are positive then treat for PE	3	17
d. Defer decision - assess further	4	22
6.If high probability lung scan + high clinical evidence		
a. Treat for PE immediately	18	100

PE = pulmonary embolism

Table 3 provides commonly applied global strategies used by subjects in dealing with the complex cases, where the level of lung scan evidence differed from the level of clinical evidence. These more global decision strategies were derived by noting that there were four approaches

Table 3: Higher-order strategies derived from physicians' decisions in responding to the complex case vignettes (cases type 2 -5)

Strategy	Subjects								
	I1	I2	I3	I4	I5	I6	E1	E2	E3
Strategy 1: Focus on lung scan	1	1	6	1	6	5	1	2	1
Strategy 2: Focus on clinical evidence	5	6	2	6	2	3	1	1	2
Strategy 3: Focus on risk factors	1	0	0	0	1	0	0	1	1
Strategy 4: Stabilize & defer decision	1	1	0	1	0	0	6	4	4

I = Intermediate E = Expert

common to groups of subjects. The majority of the intermediate physician's decision making could be described by three of the four strategies listed in the table; that is by focusing on lung scan evidence, clinical evidence or risk factors. In contrast, a strategy used by expert subjects involved the deferral of an immediate treatment decision, pending the results of a further assessment of the decision situation (i.e. results of tests and investigations).

Confidence in Decision Making

The means for the physician's ratings of confidence (on a scale from 1 to 7) in their decision making, for each of the six types of case vignettes, are given in table 4. The confidence in the subjects' judgments of their decision making was consistently high.

Discussion

An important finding of research in human decision making is that individuals use a variety of choice strategies (Payne, Bettman, & Johnson, 1993). In the present study decision making by physicians was examined in order to determine how they cope when faced with complexity in decision problems. In the study this complexity was represented in case descriptions by varied levels of clinical and lung scan evidence. From a theoretical perspective, strategies can be considered as methods for simplifying the search through the decision problem space. Different types of strategies were found to be employed by experts and intermediates in situations involving the complex consideration of various sources of evidence. Intermediate subjects were found to focus on selected aspects of evidence presented. In contrast, expert physicians tended to defer decision making, if possible, pending further information (i.e. if the patient can be stabilized). Although all subjects rated their confidence in decision making as consistently high, the results indicated that with complex cases, a variety of different decisions were made by physicians. Under emergency conditions, there may be a need for decision makers to feel confident enough to be able to act, as lack of confidence in emergency decision making could lead to potentially disastrous indecisiveness (Baumann, Deber & Thompson, 1991). Furthermore, the use of simplifying strategies in such domains could, in many cases be an adaptive response, ensuring that decision makers do not become overwhelmed by the amount and complexity of data to be processed.

Research in the study of expertise in medical reasoning has shown that there are basic differences in the approaches taken in problem solving by physicians of differing levels of expertise (Patel, Arocha, & Kaufman, 1993). Consistent with these findings in the areas of medical problems solving, the present study indicated that intermediate and expert subjects approached the decision problems in a different manner. Similar to research

Table 4: Confidence ratings of intermediate and expert level physicians, for each of 6 types of case vignettes (on a scale from 1-7)

Condition		Mean confidence in judgment	
Lung Scan	Clinical Evidence	Intermediates	Experts
Low	Low	5.78	5.63
Low	High	5.78	5.88
Intermediate	Low	5.35	5.50
Intermediate	High	5.64	6.00
High	Low	5.92	5.35
High	High	6.21	6.00

findings from studies involving the observational analysis of real-world decision making situations, including emergency nursing (Patel & Leprohon, 1993), it was found that expert subjects focused on developing a better assessment of the decision problem as a whole. According to Klein and Calderwood's (1993) model of expert decision making, experts process decision tasks by comparing them to previous experiences. In order to match to their knowledge base of previous cases, accurate assessment of the current situation is critical. From the analysis of the protocols it was also determined that rarely did either intermediates or experts compare choice alternatives simultaneously. This finding, from controlled laboratory research, is also consistent with results from naturalistic settings, indicating that in time limited and complex situations, experts tend to evaluate choice alternatives serially (Klein & Calderwood, 1991).

From the protocols, the problem solving nature of the decision makers' approach was readily apparent. Interspersed between consideration of choices regarding aspects of therapy, subjects spent a great deal of time in considering diagnostic hypotheses in developing explanations of the patient's underlying problem, as evidenced by the percentage of coded segments related to consideration of hypotheses. In the present study, the nature of the decision problems presented to subjects were ill-defined, as is the case in much decision making in real-world situations. Under such task conditions, it would seem reasonable that there would be a close relationship between what has traditionally been considered problem solving and decision making processes. In contrast to the use of experimental tasks where the options are presented to subjects, in the present study, problem solving processes had to be invoked in order to narrow the decision problem space. Thus operations such as goal formation, hypothesis testing and diagnostic reasoning were found to be closely related to the generation of decision options and selection of alternative actions.

In this study, the "expertise approach", involving the use of realistic tasks and experienced subjects, in a controlled experimental setting, was employed and the findings were found to be compatible with those emerging from both research in medical problem solving and naturalistic decision research. Important links are being forged between research in decision making and work in related areas such as human problem solving and human expertise. A convergence of both methodological approaches and theoretical frameworks shows great promise for increasing our understanding of the complexities involved in decision making.

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