

# MEDICAL PLAN-ANALYSIS: THE ATTENDING SYSTEM

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## ABSTRACT

The ATTENDING system has been developed to critique a physician's plan of anesthetic management, and is currently being used experimentally for teaching anesthesia residents. ATTENDING's approach, Medical Plan-Analysis, offers a number of potential social, medical, and medicolegal advantages over systems which simulate a physician's decision-making process, and which therefore have the clinical effect of trying to tell a physician how to practice medicine. Central to Medical Plan-Analysis is the need to identify, assess, and discuss any pertinent risks and risk tradeoffs.

## I INTRODUCTION

The ATTENDING system is designed to critique a physician's plan for anesthetic management, and is currently being used experimentally for teaching anesthesia residents. Traditional AIM systems (Kulikowski, 1980; Shortliffe, Buchanan, and Feigenbaum, 1979) have been designed to simulate a physician's decision-making process. From a clinical standpoint, these systems have the effect of trying to tell a physician how to practice medicine.

The ATTENDING system, in contrast, lets the physician outline the management he is contemplating, and then tailors its advice around this proposed approach. As a result, whereas traditional systems tell the physician, in effect, "This is how I think you should manage your patient.", ATTENDING says, "This is what I think of your management plan."

A number of AI research projects have explored the analysis of plans. Several of these (Sussman, 1975; Miller and Goldstein, 1977; Rich, Shrobe, and Waters, 1979) have addressed the analysis of computer programs (highly stylized plans to accomplish a task). Two projects dealing with other types of plans are NOAH (Sacerdoti, 1977) and MOLGEN (Stefik, 1981). No previous system, however, has applied this approach to medicine.

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There are a number of practical reasons why Medical Plan-Analysis (MPA) may be a valuable modality for computer advice.

1. The variation inherent in medical practice. There are frequently several ways to approach a patient's medical management, none necessarily right or wrong. Even "suboptimal" approaches may be adequate. The ultimate choice a physician makes may be quite subjective: reflecting the standards of the community where he practices, the institution where he trained, and his accumulated experience of what has worked well for him in the past. Most physicians develop their own styles of practice, and would not tolerate a system which did not allow them to practice medicine in their accustomed fashion.

2. The physician's ultimate responsibility for his patient's care. MPA forces the physician to grapple with his patient's problems himself, before turning to the computer for assistance. Since he must take the ultimate medical and medicolegal responsibility for his patient, it makes sense to give him the primary role in planning his patient's care, and let the computer provide feedback to help evaluate and optimize his approach.

3. Acceptability. MPA casts the computer in the role of a physician's ally, rather than a potential competitor.

## II AN EXAMPLE

The ATTENDING system implements Medical Plan-Analysis in the domain of anesthesia, in both a consultation mode and a tutorial mode. In the tutorial mode, the system first describes a hypothetical patient, for example:

A SEVENTY THREE YEAR, OLD MAN WITH A HISTORY OF CHRONIC HEPATITIS, MILD RENAL FAILURE, AND THREE PRIOR HEART ATTACKS, COMES TO EMERGENCY SURGERY FOR POSSIBLE ISCHEMIC BOWEL.

The anesthetist then outlines his plan by a process of menu selection. For example, in this case, he might propose: 1. induction of anesthesia with thiopental (a short-acting barbituate), 2. rapid sequence intubation using succinylcholine (a rapid-acting muscle relaxant), and 3. maintenance of anesthesia with enflurane

(an inhalational anesthetic), curare (a muscle relaxant), and nitrous oxide. The ATTENDING system currently critiques this plan as follows:

THERE ARE A NUMBER OF BASIC PRINCIPLES INVOLVED IN THIS PATIENT'S MANAGEMENT. FIRST, IN THE PRESENCE OF CORONARY ARTERY DISEASE, ONE MUST ATTEMPT TO PREVENT HYPOTENSION AND ISCHEMIA. SECOND, A PATIENT WITH A FULL STOMACH MUST BE PROTECTED FROM ASPIRATION. THIRD, IN A PATIENT WITH CHRONIC RENAL FAILURE, ONE MUST CONSIDER THE PROBLEM OF RENAL TOXICITY AND COMPROMISED RENAL EXCRETION OF DRUGS. ALSO, IN THE PRESENCE OF LIVER DISEASE, ONE MUST ATTEMPT TO PREVENT HEPATIC DAMAGE.

INTUBATION OF THIS PATIENT IS DEFINITELY APPROPRIATE BECAUSE OF A FULL STOMACH. RAPID SEQUENCE INTUBATION IS A REASONABLE APPROACH. THIS MIGHT, HOWEVER, HAVE THE RISK OF CARDIAC COMPROMISE. AN ALTERNATIVE APPROACH TO RAPID SEQUENCE INTUBATION WOULD BE INTUBATION AFTER MASK INDUCTION WITH CRICOID PRESSURE. THIS HAS THE ADVANTAGE OF HELPING AVOID HYPOTENSION. INTUBATION AFTER MASK INDUCTION WITH CRICOID PRESSURE MIGHT WELL BE PREFERABLE FOR A PATIENT WITH CORONARY ARTERY DISEASE, IF SEVERE, SINCE IT ALLOWS MORE GRADUAL INDUCTION WITH LESS DANGER OF SUDDEN CARDIAC DECOMPENSATION.

IN REGARD TO INDUCTION, INDUCTION USING THIOPENTAL INVOLVES THE CONCEIVABLE RISK OF HYPOTENSION DUE TO CARDIAC DEPRESSION. AN ALTERNATIVE APPROACH TO INDUCTION USING THIOPENTAL WOULD BE AN INHALATIONAL INDUCTION.

FROM THE STANDPOINT OF MAINTENANCE, THE CHOICE OF ENFLURANE COULD HAVE AT LEAST THE THEORETICAL RISK OF RENAL TOXICITY DUE TO METABOLIC RELEASE OF FLUORIDE ION. AN ALTERNATIVE WOULD BE HALOTHANE. HERE, HOWEVER, IN A PATIENT WITH LIVER DISEASE, THERE IS THE THEORETICAL RISK OF HALOTHANE INDUCED HEPATOTOXICITY.

LOOKING AT OTHER ASPECTS OF THE PROPOSED PLAN, CURARE IS WELL SELECTED FOR A PATIENT WITH CHRONIC RENAL FAILURE. ONE CONSIDERATION WORTH MENTIONING, HOWEVER, IS THAT CURARE COULD HAVE THE RISK OF HYPOTENSION DUE TO HISTAMINE RELEASE.

### III RISK: THE HEART OF MEDICAL PLAN-ANALYSIS

To analyze a physician's management plan, as outlined above, a computer must deal with issues of risk in a comprehensive way. The assessment of risk and the evaluation of risk tradeoffs lies at the heart of medical management.

In anesthesia, each underlying medical problem implies certain risks for a patient's management. Certain agents and techniques may increase these risks, others may decrease them. Furthermore, in complicated patients with several problems, risk tradeoffs frequently exist. Here, techniques which are beneficial for one problem may be detrimental to another and vice-versa. As

a result, to implement Medical Plan-Analysis, a system must be able to assess, manipulate, and discuss risk in a general, flexible way.

### IV HEURISTIC RISK ANALYSIS: THREE PRINCIPLES

The conventional approach to risk analysis, as used in economic cost/benefit analysis and clinical decision analysis (Weinstein et al., 1980), reduces risk to numbers. The difficulties inherent in this numeric approach to risk are well recognized. First, it is hard to assign values to many outcomes. Second, the likelihood values may be difficult to determine. In addition, it is often hard to know how general statistics apply to a given patient with a particular set of medical problems.

Instead of reducing the risks of anesthetic management to numbers, ATTENDING uses a heuristic approach based on three principles, which are applied at each level of decision and sub-decision in analyzing a plan. These three principles are discussed in turn below, together with ATTENDING's current implementation of each. As the development of ATTENDING continues, the implementation of the principles may well be augmented and refined. It is anticipated, however, that the principles themselves will remain constant.

#### Principle 1: Rough Criteria Eliminate Obviously Poor Choices

If one outlines all possible ways to accomplish a task, there are frequently choices which are clearly inferior. When a person is the decision-maker, many of these may be weeded out at an unconscious level. ATTENDING uses rough estimates of the "magnitude" of a risk to help it eliminate clearly inferior alternatives.

Each risk is assigned a rough magnitude: LOW, MODERATE, HIGH, or EXTREME. Thus, just as many diagnostic systems use rough estimates of diagnostic likelihood to drive their analyses (Szolovits and Pauker, 1978), ATTENDING uses rough estimates of risk. Formally, these magnitudes correspond to a rough estimate of a risk's likelihood multiplied by the value of its outcome. Clinically, risk magnitudes seem to conform naturally to the way an anesthetist thinks about risks, and are therefore quite easy to assign.

#### Principle 2: Domain-Specific Knowledge Focuses Attention on the Most Clinically Appropriate Alternatives

Using rough estimates of risk, ATTENDING is able to discard clearly poor choices. This broadbrush discrimination, however, may not be sufficient to let the system focus on the most clinically appropriate alternatives for discussion with the physician. More specific knowledge may have to be brought to bear.

To allow more selective focusing of ATTENDING's attention, the system uses "Contextual Preference Rules" (CP rules). CP rules allow ATTENDING to look at approaches which have the same risk magnitude (LOW, MODERATE, etc.) and selectively focus on a preferred approach in a given context. Each CP rule has four parts, which respectively state that 1) in the context of a particular medical problem, 2) a certain specified technique is most likely preferred to 3) another specified technique. The CP rule also states 4) the reason for the preference.

CP rules play two roles. First, they allow ATTENDING to focus selectively on certain approaches. Second, if the physician has proposed a "less preferred" choice, a CP rule gives ATTENDING a reason it can use in justifying its suggestion of the "more preferred" approach.

Principle 3: Discussion of Relevant Risks and Benefits in a Pertinent, Natural Way.

Risks have many facets. Not only do they have different magnitudes, they have other characteristic features which influence how the physician thinks about each risk, and therefore how that risk is best discussed. For instance, some risks are virtually certain, and others are remote. Some are unanimously recognized, others are controversial. Still others may be at best theoretical, and of little practical importance. Some may be so obvious as to be implicit in any discussion involving them.

These characteristics might most aptly be called "pragmatic features" of risks. Each risk has its own set of pragmatic features. ATTENDING must know about these features if it is to discuss risks intelligently with the physician.

Among the pragmatic features used by ATTENDING to characterize risks are: 1. IMPLICIT: Some risks are implicit in the techniques being described. 2. THEORETICAL: Some risks have only theoretical importance in that they probably never cause significant harm, even though they may often influence a patient's management. 3. REMOTE: Some risks, although acknowledged as real, may be perceived as remote possibilities.

Pragmatic features are necessary because the physician has different mental models of different risks. Wording must be chosen to tailor the discussion to his mental models. If ATTENDING discusses all risks in the same terms, then it sounds like a school child reciting facts which it has memorized but does not fully understand. If, on the other hand, the pragmatic features are used, and the discussion of each risk is appropriately modified, the anesthetist usually doesn't notice that the discussion of different risks is being phrased differently.

Using the heuristic approach outlined above, ATTENDING is able to identify, manipulate, and

discuss the risks involved in anesthetic management in a flexible way.

## V SUMMARY

The ATTENDING system implements Medical Plan-Analysis in the domain of anesthesia, and is currently being used experimentally for teaching. It is anticipated that the approach can be productively extended into other areas of medical management as well. The ability to deal flexibly with risk will be a central component of these systems.

Medicine is a rich domain for exploring issues of risk. Clearly, however, the development of a robust heuristic approach to risk analysis will have potential application in many areas other than medicine. The current ATTENDING implementation is a step in this direction.

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