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hanging healthcare environments require nurses to become more independent in their decision making, especially in advanced practice roles such as in nurse anesthesia. The ability to make appropriate clinical decisions is a hallmark of professional nursing practice. Judgments and decisions result from the skill of Certified Registered Nurse Anesthetists (CRNAs) in attending to and processing relevant information from clinical situations, based on their education and years of experience. Despite advances in perioperative care, adverse anesthetic outcomes continue to occur, albeit at a far lower rate than 20 years ago (eg, mortality rates estimated to be 1:200,000 currently versus 1:10,000 in 1980). It has been suggested that many adverse anesthetic (and other) outcomes relate to clinical misjudgments and flawed decision making.

Judgment and decision-making behaviors, however, are difficult to understand because the associated cognitive processes and activities are at an implicit level. Decisions often are based on “gut” level feelings or intuition rather than deliberate, considered evaluations of data and a systematic consideration of alternative courses of action. One aspect of decision-making behavior that may help improve clinical decision making is a clearer description of the types of cognitive errors that lead to inaccurate judgment. Descriptions of the errors clinicians make may provide important and useful insights to further understand the complex cognitive aspects of judgment, which will improve understanding of these errors and may ultimately lead to even better patient outcomes.

Literature review

- Theoretical framework. This study used information-processing theory (IPT) as a guiding framework. Information-processing theory is a descriptive theory of decision making that describes problem-solving behavior as an interaction between the information-processing system (the CRNA) and the judgment task. A major tenet of IPT is the concept of bounded rationality, which suggests that there are inherent limitations to human information-processing abilities, especially with respect to short-term working memory. This is a significant issue when CRNAs are providing care on call, with limited rest and the added stress of an emergency situation. Prompt recognition of a clinical problem and rapid recall of relevant differential diagnoses and appropriate treatment algorithms may be flawed with these constraints.
The other tenet of IPT is that long-term memory is a network of knowledge gained from education and experience, which is potentially infinite. Effective problem solving, therefore, depends on the degree to which the CRNA can adapt to the limitations of short- and long-term memory. Since both short- and long-term memory are limited, rarely used information, such as the treatment for malignant hyperthermia, may be difficult to access on occasions that require it.

The complexity of the judgment task, eg, differential diagnosis, determines the level of cognitive strain (determining the diagnosis and beginning treatment). It is mentally stressful to make difficult or complex decisions. The more complex the task, the greater the strain, and the system (the cognitive processing of the CRNA) attempts to develop strategies for dealing with this complexity. Elstein et al suggested that judgments are formulated using a 4-stage hypothetico-deductive process. These stages include cue acquisition, hypothesis generation, cue interpretation, and hypothesis evaluation. The judgment process is one in which the clinician access data (cue acquisition), generates hypotheses based on the data (cue interpretation), and then seeks data to further confirm the hypothesis (hypothesis evaluation).

Research has shown that experts perform better than novices on many tasks, except when the experts are confronted with novel situations. Even experts, however, were susceptible to cognitive errors such as overreliance on heuristics and biases. Because of limited cognitive capacity, people will rely on cognitive heuristics to improve the manageability of complex and uncertain data. Heuristics, or rules of thumb, do not always lead to valid estimates regarding clinical decision making. When clinicians rely excessively on heuristics, there is a risk for systematic errors in judgment. Many types of heuristics used by nurses have been identified. One example of how these errors occur in anesthesia care is when providers fail to use the most sensitive and specific measures, such as capnography for placement of an endotracheal tube. Table 1 presents some of the more common heuristics and biases.

- Clinical judgment and heuristics. Clinical judgment and decision making are complex cognitive tasks that require formal education and clinical experience. When clinical data are complex and uncertain, clinicians use problem-solving techniques called heuristics that decrease cognitive strain and simplify the information-processing task. Heuristics often are helpful, but they can lead to severe and systematic errors in judgment. When making probabilistic judgments, 3 fundamental heuristics predomi-
However, basic and continuing education emphasize the need to objectively evaluate information and make appropriate decisions under a variety of clinical conditions. The low anesthetic mortality cited earlier is a tribute to the abilities of practicing CRNAs to accurately process information and make appropriate clinical decisions. This research endeavors to contribute to patient safety by identifying the sources of rarely occurring events in practice.

- **Adverse anesthetic outcomes.** Anesthetic mortality has been estimated at 1:200,000 and is rare today because of technological and pharmacological advances, as well as improved education of anesthesia providers. Adverse anesthetic outcomes, however, may occur at any time during the career of a CRNA, with devastating effects for both the patient and the anesthetist.

Anesthesia closed claims analyses examine damaging events and the resulting adverse outcomes. For instance, a damaging event, such as an undetected esophageal intubation, can lead to an adverse outcome such as brain damage. Closed claims research findings show that adverse anesthetic outcomes are clustered in 3 areas: death, nerve damage, and brain damage. Closed claims databases provide investigators with valuable data that allow the study of how the process of care can lead to adverse outcomes.

Closed claims analyses conducted by both the American Society of Anesthesiologists (ASA) and the AANA Foundation (AANAF) have found that the majority of cases in these databases involve healthy adults undergoing elective surgery. These patients are not medically or surgically compromised, and their underlying diseases did not have a role in the adverse outcome. In the ASA study, with more than 4,000 files from some 35 insurance carriers, respiratory damag-

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<th>Term</th>
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<tr>
<td>Base rate neglect</td>
<td>Involves the prediction of whether a patient has a particular disease, given a test result, the accuracy of the test, and the prevalence of the disease within the population. Studies have shown the inappropriate use of base rate information in predicting the presence of disease for a given patient.</td>
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<td>Anchoring</td>
<td>The tendency not to deviate from an early diagnosis and to ignore contradictory evidence. Investigators have found that both experts and novices were influenced by anchoring.</td>
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<td>Ego bias</td>
<td>Warping probability estimates in a self-serving way. For example, in one study, surgeons underestimated the mortality rates for their own patients compared with comparable cases of other surgeons.</td>
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<td>Hindsight bias</td>
<td>Reacting to new information with the feeling that it was known all along. This bias is reflected in the tendency to assign higher probabilities to an outcome after hearing that the outcome occurred than would be assigned if the outcome remained unknown.</td>
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<td>Framing</td>
<td>Decisions are influenced by the presentation or framing of actions and outcomes. The same clinical outcome can be framed as a loss (10% chance of mortality) or as a complementary gain (90% chance of survival). Framing effects are difficult to avoid because there is no optimal method for presenting statistical information to patients.</td>
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<td>Representativeness</td>
<td>This heuristic causes people to think that the probability that “A” belongs to a given class “B” is directly related to the degree to which “A” resembles “B.” A manifestation of this heuristic is the inability to appreciate regression to the mean. Whenever one deals with a measure that fluctuates, an extreme value at time 1 is likely to be followed by a less extreme value at time 2. The time 2 value is said to regress toward the mean. This regression is simply a consequence of probability and the passage of time. Regression to the mean has long been recognized as an impediment to the correct interpretation of clinical data. A clinical example of representativeness: The expectation that a clinical event is more likely related to something recently observed, rather than one of several possibilities in a true differential diagnosis.</td>
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<td>Availability</td>
<td>Used for estimating probabilities. This heuristic is manifested by equation of the ease of remembering specific instances with the probability that such instances will occur. Although common events may be remembered more easily, many instances that can be recalled easily are not common. Clinicians using this heuristic may overly rely on their own clinical experience, perhaps ignoring the prevalence of certain diseases. An example of this would be failure to include anemia in the differential diagnosis of tachycardia.</td>
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ing events comprised one third of the damaging events. Limitations of this type of research include its retrospective nature and the potential for reviewer biases. Prospective, multicenter, longitudinal anesthesia outcome studies would have greater generalizability. Important variables related to patient satisfaction and the physical and mental status of involved providers also could be captured with this type of research design.

Existing research findings demonstrate that adverse anesthetic outcomes do not seem to be related to patient acuity or procedural complexity. Investigators who studied anesthesia risk found that more than 60% of adverse anesthetic outcomes were due to human error, such as substituting an unintended syringe of medication. Consequently, clinical judgment is implicated as one possible source of adverse outcomes. To date, clinical decision making is not an area that has been studied in anesthesia closed claims research.

Methods
The purpose of this study was to describe the types of cognitive errors made by CRNAs that contributed to adverse anesthetic outcomes. Questions related to this purpose were as follows:

1. What cognitive errors are exhibited by CRNAs whose clinical decisions have contributed to adverse anesthetic outcomes?
2. What adverse anesthetic outcomes are related to a failure of CRNAs in the AANAF database to use available clinical information?

- Sample selection and human subject approval. A loss control analyst at the St Paul Fire and Marine Casualty Company (St Paul Company) conducted a computerized data search of St Paul regional service centers nationally. All medical liability claims that were filed against CRNAs who were primarily insured by this company that closed before data collection were sought. Due to the “long-tail” nature of malpractice insurance coverage, most of the claims concerned incidents that occurred before data collection. Contents of closed claims files were examined in 13 cases that met inclusion criteria for the clinical decision-making study, eg, contained depositions or written statements from the insured CRNA. These data were restructured chronologically to re-create the natural environment in which damaging events occurred. Coding categories for clinical decision-making behaviors were developed from the heuristics and biases literature. Pilot data collection with 8 cases not included in this sample refined and directed the data collection and analysis plans for phase 2.

Chronological restructuring of the data was accomplished using the anesthetic phases of preinduction, induction, maintenance, emergence, and postanesthesia recovery. Examination of the research data led to the development of a research methodology specific to clinical decision making in this data set. Coding categories were developed and corroborated with an experienced qualitative researcher.

- Instrument. The data collection tool for phase 1 was developed by AANAF researchers. Content validity was established by comparing items with the Scope and Standards for Nurse Anesthesia Practice and the AQ+ instrument (developed by the staff of the original AANA malpractice insurance subsidiary), which is one measure of anesthesia quality. Multiple anesthesia
records from a cross-section of geographic locations also were reviewed during the construction of this instrument, and investigators reviewed typically measured parameters. The AANAF tool was developed with items found on representative anesthetic records from across the United States. Since the research team of 8 CRNAs was selected based on criteria developed through a Delphi technique, their expertise from the academic and practice realms as item writers helped assure content validity.

Through pilot work and extensive group process, a 6-page research instrument was developed. The components of the instrument are as follows:

1. Patient information such as age and sex.
2. Provider information, including age, sex, and year of certification.
3. Preexisting patient conditions, such as hypertension, reactive airway disease, or gastroesophageal reflux.
4. Anesthesia information, including the anesthetic agents and technique(s) used.
5. Basis for the lawsuit, eg, the damaging event that led to an adverse outcome.
6. Disposition of the claim, eg, settlement, jury verdict.
7. Summary of events: a written summary of the clinical events.

The instrument was refined based on group analysis of the pilot data, and a code book for completion of the data collection was developed. The instructions contained in the code book also were jointly authored and later revised by members of the research team. The research protocol was pilot tested to ensure content validity of the instrument. Minor revisions were made following piloting and testing that resulted in the instrument used for the present study.

Interrater reliability was evaluated for specific questions in the tool. A correlation coefficient of 0.75 was calculated for reviewers on an instrument item that asked whether the anesthesia care provided was appropriate. Overall interrater reliability on all instrument items yielded a correlation coefficient of 0.72.

• Data collection procedures. Once the claim files were selected, claim representatives at regional St Paul Company service centers sent these files to corporate headquarters in St Paul, Minn. The original 8 CRNA members of the closed claims research team met in St Paul to review the files, which had to be examined closely to ensure that documents specified by the inclusion criteria were present. The data collection process included assessing the nominal, ordinal, and interval-level quantitative items and writing a summary of the relevant clinical events. Data were collected from only primary research sources such as medical records, expert reviews, and depositions.

Items from the AANAF instrument examined for phase 1 were as follows: (1) adequacy of preinduction activities; (2) patient monitoring; (3) preexisting patient conditions; (4) the basis for the lawsuit, eg, the types of damaging events and adverse outcomes experienced by the patient; (5) the ability of the records to provide data for understanding the event named in the lawsuit; (6) the probability that better technical monitoring or provider vigilance would have prevented the event named in the lawsuit; (7) whether the event named in the lawsuit was preventable; and (8) whether the anesthesia care was appropriate.

• Data analysis. For phase 1, χ² was used for dependent variables measured on a nominal scale. The Mann-Whitney U test was used in lieu of an independent t test or analysis of variance for data that were not normally distributed because of the sensitivity of the test to measures of central tendency and to the distribution of the scores. The Spearman correlation coefficient was used to measure linear associations with data measured at least at the ordinal level. A significance level of .05 was used throughout.

For phase 2, the previously described methodology was used to re-create the damaging event. Components of the damaging event were coded as physiologic, action, or decision-oriented. Finally, the clinical decision making of the involved CRNA was analyzed in terms of IPT and the literature related to heuristics and biases.

Analysis of the physiologic, decision-oriented, and action categories involved the following steps:

1. Obtaining frequencies.
2. Organizing the categories on matrices by case.
3. Reviewing depositions and other primary research sources in the closed claims files.
4. Determining how to categorize clinical decisions using IPT and the literature related to heuristics and biases.

Results

Items from the AANAF research instrument that potentially were associated with suboptimal clinical decisions included adequacy of preinduction activities, preventability of the damaging event, and inappropriate anesthesia care. Statistical testing for associations between these items and the occurrence of damaging events and adverse outcomes yielded the results reported in Table 2.

With respect to phase 2 findings, failure to use available clinical information was evident in 5 of 13 cases studied. The clinical information that was avail-
able but not used included preoperative physical examination findings, such as airway pathophysiology. Abnormal diagnostic findings, such as cardiomegaly on a preoperative chest film, were available but not incorporated into the anesthetic plan in these cases.

Anchoring was the most frequently observed cognitive bias, seen in 9 of 13 cases studied. Despite unfolding clinical events suggestive of serious problems, subjects often were reluctant to deviate from their initial impression that a minor perturbation was occurring. In some cases, other personnel present during the damaging event repeatedly asked the anesthetist if he or she needed help since clinical deterioration was evident, and the anesthetist refused offers to get help.

Hindsight bias was noted in 2 of 13 cases. An example of this was incorporating information gathered following a damaging event in documenting the event, eg, a differential diagnosis that was not considered during the event. In 1 case, medical records were altered to reflect this retrospectively gathered information.

The availability heuristic was present in 5 of 13 cases. In these cases, differential diagnosis was incomplete. Clinical information such as bradycardia or tachycardia was treated symptomatically without consideration of underlying problems that the practitioner seemed not to consider, eg, hypoxemia or anemia. Because clinical information was related to conditions more common in the experience of the practitioner, less common causes were not considered.

The data set studied for phase 2 did not reveal evidence of framing or use of the representativeness heuristic. However, other clinical decision-making studies have demonstrated use of the representativeness heuristic.

**Discussion**

Patient acuity, as measured by ASA physical status, and the complexity of the surgical procedure did not have statistically significant associations with the occurrence of damaging events or adverse outcomes. Age and year of certification for the CRNAs in this sample were not related statistically to adverse outcomes.

Suboptimal clinical decision making was reflected in areas such as incomplete preanesthetic assessments and lack of attention to available diagnostic data. Appropriate use of clinical data and differential diagnosis were manifested in cases in which a constellation of clinical changes indicated impending disaster. The cognitive bias of anchoring was most frequently observed in this sample: clinicians did not deviate from an early diagnosis and ignored contradictory evidence. Ego bias was operant in cases in which probability estimates were warped in a self-serving way, such as not acknowledging an esophageal intubation or airway obstruction.

Since the clinical world is unpredictable, the inherent variability in clinical situations is better captured when actual cases are studied. Closed claims research with analysis of the statements of the involved clinicians is 1 step in that direction. It would be ideal to interview subjects who were involved in cases with adverse outcomes after the case to more accurately determine their thinking processes, including the use of heuristics and biases.

While anesthesia malpractice premiums have fallen in recent years, individual CRNAs may be interested in how to minimize their potential exposure to malpractice claims, litigation, and having their names entered in the National Practitioner Data Bank. Involvement with malpractice litigation as a defendant and entry of one’s name in the National Practitioner Data Bank are stigmatizing and can require clarification when requesting practice privileges.

Teaching of decision science and reinforcement of the Scope and Standards for Nurse Anesthesia Practice at both the basic and continuing education levels potentially can help minimize malpractice exposure. Based on the findings reported herein, it would be beneficial to teach healthcare providers how to make optimum clinical decisions by using, for example, preclinical and crisis management education with whole body simulators. Lectures and group discussions that incorporate principles of optimal clinical decision making also would be beneficial based on our findings. A voluminous amount of information is needed to practice clinically; retaining and accessing that information are formidable challenges for anesthesia providers. It stands to reason that cognitive psychology-based strategies to teach optimal information access have roles in basic and continuing nurse anesthesia education.

Findings from the AANAF closed claims study have been and will continue to be published in the
AANA Journal. The AANAF closed claims investigators are committed to enhancing patient safety and to positively influence practice, education, and research.

REFERENCES

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