Clinical Decisionmaking: Opening the Black Box of Cognitive Reasoning

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INTRODUCTION

Henry David Thoreau said, "If one advances confidently in the direction of his dreams, and endeavors to live the life he has imagined, he will meet with a success unexpected in common hours."

We humbly thank *Annals of Emergency Medicine* for offering us the opportunity to advance in the direction of our dreams and serve as resident fellows for 2006-2007. The *Annals* editorial board created a Resident Fellowship position 10 years ago, in a noble effort to increase resident participation in *Annals*, and to develop the careers of residents interested in academic emergency medicine. This year, the editorial board has graciously extended the award to 3 residents, which is further testimony to the board's interest in reflecting the voices of the next generation of emergency physicians. We are honored to have the opportunity to represent our peers on the *Annals* editorial board, and we look forward to working together on publication of the "Residents' Perspective" column.

The "Residents' Perspective" column has provided a sounding board for ideas and issues important to junior members of our specialty, which may resonate not only with our fellow residents, but also with the entire spectrum of *Annals* readers including attending physicians, medical students, EMS providers, and emergency department nursing or research staff. Previous articles in this column have reviewed the literature around pertinent resident issues, examined the impact of various issues on residency training, and made strong cases for new ideas in emergency medicine education and practice. This rich tradition of exploring unique perspectives and novel ideas offers us an exciting opportunity to build on the success of our predecessors with creative and important contributions to academic emergency medicine.

We hope to strengthen the voice of residents in *Annals* by increasing the number of "Residents' Perspective" articles accepted for publication in 2007. We plan to personally solicit articles from our peers, and we encourage residents in emergency medicine training programs worldwide to contact us with ideas, insights, comments, or criticisms. Additionally, we aim to encourage collaboration between residents and faculty mentors with similar interests who may be located at different institutions. By pooling our resources, we may be able to produce articles more efficiently. This will also engender camaraderie and future collaboration among the next generation of emergency physicians.

Over the next year, we hope to revisit some topics previously examined in the 10-year lifespan of the column. For example, since the case was made for universal emergency medicine resident training in sonography (*Ann Emerg Med.* 1999; 34:105-108), new situations may exist, such as increasing use of ultrasound for procedural guidance by residents who are not yet credentialed, variation in levels of attending supervision, questions about appropriate documentation, and challenges in resident research. The topic of medical malpractice and the emergency medicine resident (*Ann Emerg Med.* 2000; 36:631-633) might also be revisited from a risk management perspective, to explore pitfalls in supervising junior residents as well as in working under supervision. Additionally, a primer on medical participation in criminal prosection, including what to expect when interviewed by the District Attorney's office or called to testify in court, could be considered.

We are also interested in a myriad of new topics previously unexamined in the column. Examples include but are not limited to topics such as "Early goal-directed therapy in the ED: A vehicle for both aggressive patient care and an aggressive resident education"; "DNR Orders: Far from 'Do not treat' and even further from widespread use"; "Morale: the undervalued importance of positive feedback in medical education"; and "Resident's perspective on disparities in health care." With a

field as burgeoning as emergency medicine, the canvas of possible topics is as limitless as the subject matters are challenging. With your support, we relish this time to embrace the science and art of this exciting specialty.

Please contact one of us if you are interested in writing or collaborating on an article for the Residents' Perspective column. We may be able to connect you with other residents or faculty mentors in your area of interest. We will also be available to help edit drafts of your articles prior to submission. All articles are peer reviewed, and your contribution may fulfill part of your residency program's academic project requirement. For those residents interested in an academic career, this may be an opportunity to publish your first article in a medical journal, with the assistance and feedback of editors who are also residents. Even more importantly, written communication and publication offers you a chance to make an impact on your profession, an opportunity to reach many people worldwide, different from the daily challenge of taking care of one patient at a time in the emergency department. Whether your interest is education, public health, health care policy, or scientific research, we encourage your submissions to this column.

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The cognitive path on which physicians embark between the uncertain, inexperienced medical student and the confident, competent physician after years of dedicated academic and clinical work remains largely shrouded in mystery. Because many experienced emergency physicians lack insight into their own thought process in making complex medical decisions during a limited time with minimal information, even the best instructors may find the dissemination of real-time clinical decisionmaking processes to their physician-students difficult. *Rosen's Emergency Medicine* references 4 patterns of clinical decisionmaking: pattern recognition, rule-using, hypotheticodeductive, and event driven.

Whether individual physicians or groups of physicians use any or all of these decisionmaking models remains uncertain. Analysis of clinical decisionmaking has largely been the domain of cognitive educational specialists and has rarely translated to the fast-moving environment of clinical medicine. Physicians may benefit from a better understanding of the decisionmaking ladder experienced clinicians use as they move from the accumulation of data to the ordering of diagnostic information and the disposition of the patient.

Physician educators may benefit from a better dissemination of decisionmaking techniques to medical students and residents as they transition from the accumulation of background knowledge in didactic learning to the foreground data acquisition of evidence-based medicine. Physicians may also benefit from a higher use rate of validated clinical decision tools as preexisting thought processes are incorporated into the decision aid. Additionally, recognition of a particular thought process might uncover potentially avoidable errors in medicine, which would facilitate the preemptive instruction of the "best" clinical decisionmaking process for future physicians. Although we cannot bridge the gulf between what we know and how we use that knowledge to arrive at logical clinical decisions, future research techniques may narrow this gap.

INTRODUCTION

Clinical reasoning describes the thought processes involved in medical decisionmaking.[1,2] The cognitive pathway that empowers the skilled physician to surmise a diagnosis from an array of information sources and competing possibilities is the most significant of clinicians' tasks.[3] Effective decisionmaking is especially important in the uncertain and often chaotic environment of the emergency department (ED), where patient safety may be compromised.[4,5] Emergency medicine has one of the highest decision densities and diagnostic uncertainties of all medical fields,[2,4] although a recent survey of emergency physicians revealed little training of or independent study by practicing emergency physicians in clinical decisionmaking.[6] The variety of clinical decisionmaking strategies emergency physicians likely use will be outlined in this article. In addition, this article will review the advantages and disadvantages of alternative paradigms in clinical decisionmaking.

Although the extent of error in EDs is largely unknown,[4] emergency medicine has a higher proportion of preventable errors, which are most commonly diagnostic errors.[7,8] The reasons for diagnostic errors vary, but the majority of errors appear to be due to cognitive faults in clinical reasoning.[9–12] The 2000 Institute of Medicine report on errors in medicine[13] should prompt an increased emphasis on learning more about and teaching decisionmaking strategies, as well as emphasizing the cognitive phenomena that underlie these strategies, to help emergency physicians' clinical decision process become more efficient and less prone to error.

The objectives of this article are to introduce the theories lunderlying cognitive reasoning to unfamiliar readers; elucidate for readers why this topic is important in error reduction, resident education, and lifelong learning; outline various hypothetical methods of clinical decisionmaking; and propose future research initiatives within this field.

What Is Cognitive Reasoning?

Consider the following illustrative vignette:

> A 58-year-old man with a history of longstanding hypertension and congestive heart failure presents to the ED with severe shortness of breath and orthopnea. On physical examination, he is found to have jugular venous distention and bibasilar rales with a 5/6 harsh, crescendo-decrescendo, holosystolic murmur radiating to the left axilla. After the administration of intravenous furosemide and sublingual nitrates, the patient deteriorates clinically and is endotracheally intubated. Subsequently, the patient develops clinical signs of cardiogenic shock. Intravenous dopamine and subsequent norepinephrine fail to improve his hypotension. Although several physicians are baffled

and expect the patient to succumb, another physician notices a spike and dome configuration of his arterial tracing, with a brisk bisferiens carotid pulse. The astute physician diagnoses asymmetric septal hypertrophy,[14] discontinues all drugs, and administers intravenous saline and phenylephrine. The patient recovers promptly from the hypotensive episode.

In the above clinical vignette, one physician displays more effective clinical decisionmaking than the others. The physicians who embarked on the erroneous diagnostic and therapeutic pathway committed critical errors in their approach to this case. In contrast, the latter physician appears to have a commendable knowledge of cardiovascular diseases and various shock syndromes and was able to more accurately integrate this knowledge into the novelty and exigencies of the clinical situation, an important skill. As this example illustrates, decisionmaking errors likely extend beyond knowledge deficiencies into the realm of inappropriate decisionmaking paradigms.

Although cognitive skills are the basis of every diagnostic, therapeutic, and prognostic action physicians use, medical sciences have developed few methods to facilitate the acquisition and development of these essential skills.[3] Kassirer and Kopelman[3] lamented the painfully slow progress in the teaching of clinical decisionmaking: "Instead of learning how diagnostic hypotheses are initiated and refined and how treatment decisions are formulated, teachers of clinical medicine have substituted standardized histories and physicals, book chapters that list myriad causes of individual symptoms, an apprentice system in which the student is expected to imitate others, formal approaches to recording patient problems, and lock-step algorithmic charts for blind guidance, none of these methods focusing on essential reasoning processes, critical to optimal performance."

The last several decades have witnessed considerable growth in the understanding of human reasoning, largely from work done in the nonmedical sciences. Research in cognitive sciences, decision theory, computer science, and artificial intelligence provides insight into the critical cognitive processes that underlie the day-to-day workings of physicians. Significant contributions to our current understanding of clinical decisionmaking have also come about through the work of Kassirer and Kopelman[3] and others.[2,4,9,10,15–17]

Physicians arrive at diagnoses through a series of inferences derived from medical history, physical examination findings, and laboratory data. Rather than depending on analytical or formal decisionmaking, experienced physicians instead make extensive use of heuristics, which can be shortcuts, rules of thumb, intuitions, or abbreviated decisionmaking, to minimize unnecessary testing and data gathering. Heuristics offer significant advantages and are usually effective, but they occasionally fail, with catastrophic consequences. A classic example may be the patient with a leaking abdominal aortic aneurysm who is erroneously diagnosed with renal colic according to the initial complaint of severe, nonreproducible flank pain with or without hematuria.[18]

A critical aspect of clinical reasoning is the physician's awareness of whether he or she is reasoning in an analytical or intuitive mode.[10] Physicians should therefore develop a deeper awareness of what they are thinking while they are thinking, a phenomenon known as metacognition,[19] which is vital for improving the individual clinical decisionmaking process. As physicians become cognizant of their thought processes, they are likely to make decisions more efficiently and subsequently reduce errors,[5,9] although these endpoints have never been formally analyzed in emergency medicine.[20] Although "cognitive pills for cognitive ills" exist, garnering acceptance for such potential solutions will necessitate that the pills be "sufficiently sugared."[9] The process whereby physicians develop awareness and comprehension of how they use diagnostic findings in reaching treatment and disposition decisions is somewhat analogous to visual illusions. Once the illusion is explained, one can focus his or her attention on the critical aspects of the signal by avoiding the distracting influence of the visual noise.

Emergency physicians are required to make a large number of decisions during the course of their shifts. In part, this stems from a high degree of uncertainty in the ED, combined with multiple interruptions, insufficient historians, frequent shift changes, and little time with which to make crucial decisions.[4] Most emergency physicians subconsciously reach diagnostic and therapeutic decisions by combining heuristics with the various methods of clinical decisionmaking discussed below. Seasoned physicians may downplay the importance of better understanding cognitive pathways, but such physicians may benefit from such comprehension; whereas one recent study suggested an inverse correlation between the level of experience and tendency to error,[6] another suggested a lower quality of care among physicians who have been in practice longer.[21]

Unfortunately, it is often difficult for expert physicians to put their exact thought processes into words,[22] creating difficulties in teaching novices insights into effective clinical decisionmaking. Depending on the clinical situation, the emergency physician may recognize a familiar pattern en route to making a doorway diagnosis, or he or she may put forth various pathophysiologic hypotheses accounting for a particular presentation and then select various diagnostic tests to prove or disprove them. An enhanced understanding of how to learn, teach, and react to various clinical scenarios and thereby apply best-evidence principles to appropriate situations should optimize outcomes while minimizing medical errors stemming from misguided logic. Cognitive psychologists have hypothesized about several different patterns of clinical decisionmaking, which hypotheses are summarized in the Table and discussed below.

MODELS OF CLINICAL REASONING

Hypotheticodeductive Method

The hypotheticodeductive method[3,16,23] is the most widely studied method of clinical decisionmaking. The physician makes a series of inferences about the nature of the patient's

Table. Clinical decisionmaking strategies in emergency medicine.

Cognitive Strategy	Key Features	Key Shortcomings	Key Advantages
Hypotheticodeductive	Inference based on preliminary findings Idea modification based on subsequent findings, response to therapy, and exclusion of competing possibilities	Faulty hypothesis can precipitate dangerous actions Premature closure can result in erroneous conclusions Heterogeneous pathway and conclusions: difficult to teach	Flexible
Algorithmic	Preset diagnostic or therapeutic pathway based on preestablished criteria	Inflexible Removes independent thinking	Prephysician initiation Standardized care Easy to teach
Pattern recognition	Combination of salient features establish likely diagnosis with corresponding evaluation, management, and disposition plan	Anchoring bias Confirmation bias	Rapid assessment and clinical plan
Rule out worst-case scenario	Consideration of preexisting mental list of "cannot miss" diagnoses for a given presenting complaint	Incomplete differential diagnosis list missing less common disease entities Overtesting Anecdotal practice Value-induced bias	Increased probability of considering/recognizing presentations of critical illness
Exhaustive	Accumulate facts indiscriminately and then sift through them for the diagnosis	Excessive resource use Time consumption	Thorough evaluations
Event driven	Treat symptoms and then reevaluate with further evaluation, depending on response to therapy	Dangerous actions possible if faulty hypotheses Potentially inefficient	Flexible Accommodates ED environment

disease process according to data from the presenting complaint, medical history, vital signs, and physical examination results. Through this process, the physician identifies a working diagnosis sufficient to establish a prognosis and dictate a therapeutic action. The diagnostic hypotheses are then refined as ancillary data become available. The physician then verifies or refutes the hypotheses according to the patient's clinical course and the results of various diagnostic tests. During verification, the physician tests the hypotheses for adequacy (is the presentation consistent with the hypotheses?), coherency (appropriateness of causal or pathophysiologic links?), and parsimony (do the hypotheses offer the simplest possible explanation for the patient's presentation?). It is not always important for emergency physicians to complete hypothesis verification, because emergency physicians frequently seek to eliminate rather than confirm competing hypotheses. Faulty hypothesis generation and premature diagnostic closure are the major shortcomings of this method. In the vignette presented at the beginning of this article, the physician who correctly diagnosed the patient likely hypothesized that the patient's dyspnea may have been the result of diastolic dysfunction and included asymmetric septal hypertrophy as one of the probable causes of diastolic dysfunction. The physician then confirmed the diagnosis by the presence of the characteristic murmur and arterial tracing, as well as by the detrimental blood pressure response to inotropes and diuretics.

Algorithmic Method

In the algorithmic method, algorithms or flow charts are used to simplify the decisionmaking process into a series of steps. One example of this method is using Bayesian probability theory to determine the likelihood of a diagnosis of pulmonary embolus.[24] The algorithmic method is being increasingly used in various other situations in the ED, as in triage tools such as the Emergency Severity Index[25] or in the management of critically ill sepsis patients cared for by early goal-directed therapy.[26] Although many consider the algorithmic method to be less intellectually challenging, it offers the potential advantage to save considerable time and anxiety when clinicians must make rapid decisions in life-threatening situations. For the optimal use of these protocols, physicians must familiarize themselves with the scientific basis behind the algorithms. Diagnostic and treatment protocols exist in most EDs for various common presenting complaints such as chest pain. A treatment algorithm for congestive heart failure, however, led physicians in the example to give nitrates and diuretics to the patient. Although such algorithmic management of systolic dysfunction congestive heart failure might improve the uniform management of most heart failure patients, if the algorithm ignored the possibility of diastolic dysfunction and septal hypertrophy, some patients would be adversely affected. Still, in many situations, the algorithmic approach considerably improves efficiency in the ED.[27]

Pattern Recognition

A typical example of the pattern recognition method is the "doorway diagnosis" of renal colic made in a patient who walks into the ED with severe flank pain, hematuria, and diaphoresis. The underlying problem prompting patient presentation to the ED for the disease, illness, or injury is often quite obvious, and

the initial diagnostic clues are most often visual. The fault with this method is that the clinician may be vulnerable to premature and erroneous diagnostic closure (also known as anchoring bias).[16] Physicians may subsequently ignore additional data that refute their initial diagnosis, a phenomenon known as confirmation bias, which may have devastating consequences when combined with the premature diagnosis of anchoring bias.[2] In this case, the patient's presentation could also be due to a leaking abdominal aortic aneurysm, a diagnosis that can be fatal if missed.

Rule Out Worst-Case Scenario Method

In using the rule out worst-case scenario method,[2] emergency physicians maintain and review a mental list of high-mortality diagnoses that must be excluded for the patient's presentation. For example, in evaluating a patient with chest pain, the physician attempts to exclude potential causes such as pulmonary embolism, acute myocardial infarction, aortic dissection, pneumothorax, and Boerhaave's syndrome. Although these lists are not all-inclusive, these diagnoses must be excluded for safe, efficient disposition of most patients. Rule out worst-case scenario is a useful strategy of decisionmaking in the ED because one of the maxims of emergency medicine is that physicians must not miss life-threatening diagnoses. In this method, physicians ensure that all critical diagnoses have been considered for a particular patient presentation. The principal shortcoming of this method is that physicians may only consider diagnoses with which they are most familiar. Novice physicians may therefore miss less common diagnoses, a phenomenon labeled the *availability heuristic*.[2] For example, the novice emergency physician may not consider the diagnosis of early varicella zoster as a cause of unilateral flank pain. In addition, indiscriminate use of this method may lead to overuse of resources.

Exhaustion Method

The exhaustion method uses an excessive gathering of patient data, followed by sifting through the data for a likely diagnosis.[28] Such a strategy is most often used by medical students[16] and may also characterize a regressive style of decisionmaking by experienced physicians when they are fatigued or sleep deprived.[29] It may also be used by experienced physicians when a more esoteric diagnosis is being considered, or when the physician is seeking additional thinking time when uncertainty is high.[30] The obvious disadvantage of this method is that it is laborious and time consuming.

Event Driven

The event-driven method[24] is a pattern of clinical decisionmaking that closely mirrors the ED environment. An example of this strategy is the ED treatment of a hypotensive and unresponsive patient. Before beginning to establish a diagnosis, the emergency physician will quickly try to establish a definitive airway, obtain a reliable central intravenous access, and use fluids and vasopressors to improve the patient's blood pressure. Often, the actual diagnosis will not have been established before the patient is moved to the ICU because the emergency physician focuses on emergency therapeutic actions rather than diagnostic possibilities. The event-driven strategy is often combined with the rule out worst-case scenario strategy to rapidly stabilize patients and transfer them for further treatment to the ICU.

In the clinical vignette at the beginning of the article, the astute physician's correct diagnosis resulted from the recognized pattern of the spike-and-dome arterial tracing in the setting of a hypotensive patient with a harsh holosystolic murmur. The other physicians, perhaps less familiar with this pattern, might have had more diagnostic success had they used the hypotheticodeductive method to differentiate whether the patient's congestive heart failure was due to pump failure or diastolic dysfunction. They could also have considered various hypotheses about the cause of the patient's murmur, and perhaps after noticing the increasing intensity of the murmur after the administration of nitrates, they would have arrived at the correct diagnosis. Instead, they followed an event-driven approach that, when combined with an erroneous algorithmic approach to congestive heart failure, led them down the wrong path toward a potentially fatal outcome.

The Table summarizes the key features of each clinical decisionmaking strategy. No research has yet defined the prevalence of any of these cognitive paradigms within emergency medicine. Researchers and educators do not yet know which intuitive pathways may best serve individual physicians and particular clinical situations. Many physicians, in emergency medicine and in other areas, probably use all of the methods of clinical decisionmaking individually or in combination, depending on the different clinical situations. In addition, emergency physicians often use heuristics to reach clinical decisions.[1,31] Although the use of heuristics tends to limit the cognitive reasoning process, heuristics may be critical in improving the efficiency of clinical decisionmaking in the very-high-decision-density environment of the ED.[1,4] These rules of thumb that clinicians develop with experience help them sift through the often discrepant information and quickly arrive at a treatment plan while significantly decreasing the time and expense in the search for the patient's diagnosis. The rapid response rate of heuristics, however, is offset by the risk of excluding rare but deadly diagnostic alternatives, which might be more effectively captured by the rule out worst-case scenario or exhaustive methods.

Any clinical decisionmaking strategy can be associated with faulty medical reasoning.[32] Physicians must therefore learn to recognize the circumstances under which their strategy failures occur.[9] Physicians may use a cognitive forcing strategy[17] to avoid erroneous reasoning; for example, when the first fracture is identified, one learns to then conduct a search for additional fractures or other significant soft tissue injuries. Other cognitive and affective debiasing strategies to minimize diagnostic error have also been proposed, including developing insight into cognitive

bias, decreasing reliance on memory, using specific training and simulation strategies as mental rehearsals for real situations, and providing rapid and reliable feedback to decisionmakers.[10] From an educational perspective, it is also essential to acknowledge that emergency medicine residents may mimic the biases and decisionmaking failures of their mentors. Hence, it is even more important for supervising physicians to be aware of their thought processes to explain them to their students.

Learning More About Clinical Decisionmaking

Further research is needed to better understand the cognitive strategies emergency physicians use. Unanswered questions are many, but include:

a. Is cognitive reasoning external to the clinician—a function of one's environment, expectations, and disease prevalence? Alternatively, does cognitive reasoning reside internally, necessitating a better understanding of individual mental processes?
b. What influences a clinician's cognitive reasoning? Is it dependent on disease prevalence or one's experience with the disease presentation?[33]
c. Can an enhanced understanding of cognitive reasoning, in conjunction with cognitive forcing strategies, help reduce medical errors?

Perhaps a first step in addressing these questions would be observational studies on experienced emergency physicians during their evaluations of common ED presentations. Cognitive strategies used could then be compared to bring out the beneficial and detrimental differences of each, which might then be taught to novices. A variety of strategies has been suggested to overcome cognitive failings,[10,17] and these may shorten the process toward the attainment of clinical expertise. Work has already begun on training emergency medicine residents in the recognition of cognitive pitfalls and in using cognitive strategies to avoid them.[20] The Figure summarizes a list of available resources within the realm of cognitive reasoning.

Emergency physicians probably use a variety of clinical decisionmaking strategies consciously and subconsciously. The extent to which individuals use different techniques is purely speculative, as is the degree to which a better understanding of cognitive working patterns might elucidate better teaching strategies and minimize error. The 21st-century reality of ED overcrowding, in conjunction with a renewed call to reign in health care spending while minimizing errors in medicine, will force clinicians to search for ever-improving diagnostic and therapeutic efficiency. A better understanding of how decisions are made might open an unrecognized door to these objectives, but the research agenda remains elusive and the funding scarce for this esoteric field.

Although the theoretical groundwork has been laid by cognitive psychologists during the last 30 years, the burden of applicability now falls on clinicians to expand on these concepts. An enhanced understanding of how experienced physicians transform an ever-evolving constellation of signs, symptoms, and ancillary tests into a likely diagnosis offers the potential to revolutionize teaching strategies and medical education. Perhaps more important, this understanding may also minimize preventable errors and provide a better understanding of how we travel and expand on our intuitive highways.

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Organizations

Society of Medical Decision Making (available at: http://www.smdm.org): founded in 1979; offers an annual symposium on clinical decisionmaking, as well as a bimonthly periodical, educational modules, and numerous interest groups.

The Brunswik Society (available at: http://www.brunswik.org): informal organization of researchers interested in understanding and improving human judgment and decisionmaking.

Decision Analysis Society (available at: http://faculty.fuqua.duke.edu/daweb): promotes the development and use of logical methods for improvement of decisionmaking.

Society for Judgment and Decision Making (available at: http://www.sjdm.org): dedicated to the study of normative, descriptive, and prescriptive theories of decision.

Center for Adaptive Behavior and Cognition (available at: http://www.mpib-berlin.mpg.de/abc): explores cognitive strategies (including social and emotional components) with which people make judgments and decisions in the face of uncertain situations.

Figure 1. Resource list.

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