Surgical Decision-Making

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There are **people** who **make things happen**, there are **people** who **watch things happen**, and there are **people** who wonder what **happened**. To be successful, you need to be a person who **makes things happen**.

Jim Lovell

One of the most difficult aspects of microsurgery to teach trainees is intraoperative decision-making. While a master surgeon subconsciously analyzes intraoperative data and intuitively selects the best course of action, an assistant or observer might be stymied by changing intraoperative conditions or, worse, might not even realize that a decision must be made or a bad decision was just made. A surgeon's self-awareness of an error is one of the most detrimental errors that affects the patient severely.

As with other nontechnical skills, many of the key tenets of critical

decision-making have been studied most extensively in the field of aviation, because pilots must make countless decisions during a flight, many of which have grave consequences and must be made with limited data at a moment's notice. These concepts have been applied to surgery recently in an effort to create a framework for intraoperative surgical decision-making.

WHAT IS SURGICAL DECISION-MAKING?

It is every surgeon's goal to have most decisions about an operation made before the patient is ever brought into the operating room; the process of making these preoperative decisions includes accurately diagnosing the condition, considering the patient's preferences, deciding whether to operate at all, choosing the surgical technique/approach, and creating an operative plan. True experts mentally rehearse making all of these decisions and focus on producing a detailed mental framework of each surgical maneuver they perform, including analyzing how likely it is that uncertainty will be encountered. Preparation to manage unexpected findings or to deal with intraoperative complications are the key landmarks for effective surgery.

Most surgical atlases, manuals, and textbooks focus heavily on helping surgeons build these frameworks. However, rarely discussed is intraoperative decision-making, defined by the Non-Technical Skills for Surgeons (NOTSS) system as “considering options, selecting and communicating option[s], and implementing and reviewing decisions” during the course of a surgery. These skills are seldom explicitly taught to trainees in medical school or residency programs, and trainees are often left pondering why a senior surgeon chose a particular strategy or maneuver, especially if he or she does not articulate the thought process behind the decision. If surgical education is to evolve beyond just attributing good outcomes to a surgeon's excellent instincts or intuition, the mental processes underlying intraoperative decisions must be studied.

A framework based on the theory of naturalistic decision-making, or the process of making decisions in a team setting under conditions of uncertainty, limited resources, inadequate information, changing

objectives, intense time pressure, and high risk, has been developed for surgical decision-making. In this model, as soon as a decision point is reached or a change in the operative environment arises, a surgeon should stop to *assess the situation* (What is the problem? How does this change my plan? How much risk is involved? How much time is there?), *determine a course of action* (What do I do now?), and *check the result* (Are my actions working?).

While a junior surgeon might require an actual pause in the movement of an operation to consider these questions, and a trainee might not even notice that a decision is required, an experienced surgeon can proceed automatically without consciously thinking about the decision at hand.

I have witnessed some experienced surgeons, often affected by the intense operative moments, make inappropriate decisions as the operative surgeon often suffers from expanded emotional and operative blind spots. Making good decisions under difficult circumstances defines the master surgeon.

Surgical intelligence is difficult to define, but it is the ability to monitor one's own operative maneuvers, to discriminate among different operative strategies for efficient handling of the lesion, and to use momentous intraoperative findings to guide the overall plan under difficult circumstances.

Complicating the instruction of surgical decision-making is the finding that experts might be consciously aware of only approximately 30% of the decisions they make during a procedure. It is incumbent on senior surgeons to articulate their thinking before, during, and after an operation, especially if it is a trainee's first time participating in a given procedure or working with that surgeon.

The importance of debriefing is underscored by the fact that the cognitive demands of in-the-moment decision-making can preclude detailed narration of steps and thought processes; even a brief postoperative meeting can be of immense value to trainees in reinforcing crucial decision-making points and subsequent actions. Metacognition, or

thinking about thinking, can be useful to both senior surgeons, many of whom find it difficult to communicate their thought processes to trainees during an operation, and to junior trainees, who often lack insight about their own abilities and therefore can benefit from meticulous analyses of operative maneuvers.

WHAT IS THE PROBLEM?

One of the most critical aspects of the decision-making process is having an awareness of changing situations (*situational awareness*) or, in other words, ascertaining variance from the established mental framework of an operation. Master surgeons interweave the changes in the operative environment with the decision-making necessary to adapt to them. Whether during the course of their own operation or that of a colleague who has asked for an intraoperative consult, rapidly assessing the situation at hand is necessary to understand the current state of affairs.

Experience speeds up this assessment, because familiarity with anatomical nuances, characteristic warning signs of impending danger, and adverse events and their trajectories can aid in matching a new situation with a pattern in memory that might, in turn, help summon the appropriate course of action. Even if the precise diagnosis of an intraoperative problem cannot be made (eg, a sudden drop in blood pressure while tunneling a peritoneal catheter could represent damage to any one of several different organs,) the warning sign might clearly indicate the need to abandon a procedure.

A changing circumstance can also be misunderstood, misinterpreted, or deliberately ignored as a result of any number of factors, including inexperience, fatigue, time pressure, emotional state, and/or risk tolerance. An extreme case of minimal risk tolerance can also adversely affect the patient and lead to lengthy or unnecessary secondary procedures.

WHAT DO I DO?

The next step in the decision-making process is selecting the appropriate

course of action, and studies have identified 4 fundamental processes by which experienced surgeons can do it, often by fluidly switching between strategies throughout the course of an operation.

Intuition—Synonymous with the concept of "system 1" from behavioral psychology and popularized by Daniel Kahneman's *Thinking, Fast and Slow*, intuition (or "gut feeling") relies on quick retrieval from memory of previously encountered situations and the actions associated with them. It is frequently a subconscious process that requires no active analysis; thus, it is more likely to be readily available to surgeons who are stressed or fatigued.

Although it is often used in situations without any time pressure, it is the most rapid process used by experienced surgeons to arrive at the appropriate actions to take in a time-pressured high-risk situation. Examples abound in neurosurgical practice, from the mundane, automatic use of bipolar electrocautery to stop subcutaneous bleeding on a spinal exposure, to the rapid application of suction in the event of an intraoperative aneurysm rupture.

Rule-based decision-making—Although it plays a large part in formulaic or standard operating procedure-based industries such as manufacturing, rule-based decision-making (or assessing a situation and determining from a manual or other source the most applicable procedure to follow) does not figure prominently in neurosurgery. The scope of complex nuances in patient anatomy and physiology is generally too broad to be covered by a finite set of rules or protocols.

Analytical decision-making—This style of decision-making involves the accurate assessment of a situation, the selection of several possible next steps, and an active contrast of advantages and disadvantages of each possibility to ultimately arrive at the most appropriate action. Parallel to Kahneman's "system 2" or "thinking slow," this method, along with intuitive thinking, is likely the most common used by surgeons and trainees, especially at the lower end of the experience spectrum, when intuition has not yet had time to develop. Several strategies for sifting through a large selection of possible actions are available; in medicine, the

most common process is Bayesian/probabilistic thinking.

Creative decision-making—Although innovation is critical for advancing surgical theory and practice, intraoperative creativity is not frequently encountered in the neurosurgical realm. True creativity in the operating room often takes time and significant mind-sharing, resources often limited during even routine surgeries. Untested innovation can introduce new risk to an operation, and a large-enough deviation from standard practice might push the boundaries of informed consent.

IS IT WORKING? WHY OR WHY NOT?

Actions taken in the operating room must be evaluated continuously to determine if they have worked according to plan or if further intervention is required. Even "simple" or "routine" procedures require this level of reevaluation; indeed, they might only appear simple in the hands of experts because each step is monitored meticulously for success and corrected immediately if a problem arises. For example, a watertight dural closure is often challenged with a Valsalva maneuver, but continuous surveillance for the possible emergence of clear fluid into the surgical field is performed throughout the final steps of the operation.

Failure to properly evaluate the outcome of intraoperative interventions (perhaps out of worry that changing the plan will be too mentally or physically taxing, especially near the end of an operation) can lead to inappropriate adherence to an initial plan despite emerging warning signs. The sunk-cost fallacy can play a role, causing a surgeon to become locked into an inappropriate strategy. Experts are proficient at continuously reevaluating outcomes, even after the establishment of a diagnosis or course of action, thus mitigating the "lock-in" or anchoring effect.

Factors that influence the success of intraoperative decision-making include the surgeon's experience with the operation at hand, anatomical expertise, dexterity, technical knowledge, and proximate experiences with similar cases, institutional traditions or preferences, operating room team dynamics, the presence of observers, and surgeon stress or fatigue.

Analytical thinking can become particularly impaired under adverse conditions, when tunnel vision can obscure possible approaches, lower working-memory capacity can hinder the selection process, and slower memory can force the surgeon to rely on heuristics. However, data from aviation studies show that simply having an awareness of impairment from fatigue or stress can lead to safer, protective behaviors such as double-checking work, relying on checklists to ensure completeness, and increasing averseness to risk.

WHAT'S MISSING?

It goes without saying (although there is now a wealth of data behind the assertion) that the emotional state of a student or trainee during a learning experience can significantly affect the depth and breadth of the knowledge acquired. A medical student or resident in fear of being berated—or, worse, completely ignored—by a senior surgeon or operating room staff during an operation will not be as receptive to learning as one who is confident in the collegiality of the work environment. All members of the surgical team should strive to foster an environment of open inquiry and discussion, which can maximize the value of the learning experience and, at the very least, remove poor team dynamics as a contributor to impaired decision-making.

Contributor: David Purger, MD

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