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Clinical decision making: how surgeons do it

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Abstract

Clinical decision making is a core competency of surgical practice. It involves two distinct types of mental process best considered as the ends of a continuum, ranging from intuitive and subconscious to analytical and conscious. In practice, individual decisions are usually reached by a combination of each, according to the complexity of the situation and the experience/expertise of the surgeon. An expert moves effortlessly along this continuum, according to need, able to apply learned rules or algorithms to specific presentations, choosing these as a result of either pattern recognition or analytical thinking. The expert recognizes and responds quickly to any mismatch between what is observed and what was expected, coping with gaps in information and making decisions even where critical data may be uncertain or unknown. Even for experts, the cognitive processes involved are difficult to articulate as they tend to be very complex. However, if surgeons are to assist trainees in developing their decision-making skills, the processes need to be identified and defined, and the competency needs to be measurable. This paper examines the processes of clinical decision making in three contexts: making a decision about how to manage a patient; preparing for an operative procedure; and reviewing progress during an operative procedure. The models represented here are an exploration of the complexity of the processes, designed to assist surgeons understand how expert clinical decision making occurs and to highlight the challenge of teaching these skills to surgical trainees.

Introduction

As a core competency of surgical practice,[1,2] clinical decision making (CDM) employs an extensive set of conscious and unconscious thinking processes, which are essential if a clinician is to respond competently and consistently to the demands of clinical work. This paper describes some of the complexities around CDM within the contexts of (i) making the decision to operate; (ii) preparing for the surgical procedure; and (iii) monitoring operative progress.

Processes of clinical decision making

Decision making involves two distinct types of mental processes, which are usually employed by experts in a complementary fashion. When seen as part of a continuum, they represent its ends although individual decisions are usually reached by a combination of each, according to the complexity of the situation and the experience/expertise of the clinician. An expert can move effortlessly along this continuum, as needed.

At one end of this continuum, there is a subconscious, intuitive, automatic type of decision making based on pattern recognition, which is continuously matched to the clinical or operative context. With increasing experience and ability to recognize patterns that are familiar, this approach is fast, frugal and consumes little mental energy.[3,4] At the other end of the spectrum, there is a conscious, analytical, logical and deductive approach, which tends to be slower, thoughtful and which consumes a large proportion of one's mental capacity.[5,6] Doctors may move along this continuum a number of times during any CDM process.[7] Inexperienced clinicians rely most heavily on an analytical and deductive approach because of their limited previous experience.

Rule-based or protocol-driven decision making lies between these two extremes.[8] To use a rule or protocol, one must both learn of its existence and determine whether it fits or applies to the clinical situation. The decision to use a rule may result from either pattern recognition (where experience enables understanding that the rule may be applied) or analytical thinking (where one works out by considering the available evidence that the rule may be applied) or both.

The definition of a 'competent' surgeon in relation to how clinical decisions are made has been the subject of research for over two decades.[9–13] Depending on the task and the context, expert surgeons flexibly and effectively switch between intuitive and analytical approaches (sometimes called 'fluidity').[4,14,15] Experts match their thinking and decision-making strategies to the dynamics and pace of each task.[13,16–18] Also, expert clinicians across all disciplines consistently apply insight and self-assessment as part of a large repertoire of thinking processes using this to moderate their decisions.

Surgeons need to understand how their thought processes influence their performance, that of those around them and, ultimately, how they affect patient outcomes. Many past attempts to articulate how surgical decisions are made in practice have underestimated the complexity of the process, particularly overlooking the need to recognize variance from the expected. As a result, the models proposed have had significant limitations. This paper addresses some of those deficiencies and also incorporates some concepts from complexity science and metacognition, which have recently been applied to medical education.[19–21]

Complexity science introduces concepts of ambiguity, constant change and dynamic interaction, which are relevant to understanding the context in which surgeons work and the way in which they are required to think on the run.[19] 'Metacognition' has been defined as the ability to know, understand and monitor one's own thinking and is sometimes called 'mindfulness'. Such thought processing can function at either a conscious or subconscious level.[22,23]

During training, novice surgeons improve their decision making as they increase their knowledge base and broaden their clinical experience. This enables them to apply their knowledge and reasoning to clinical situations in an analytical manner and increasingly to apply rules and follow algorithms. As experience is gained, they recognize the similarities and patterns in surgical presentations and increasingly employ pattern recognition in an intuitive or subconscious manner. Surgical education and training is designed to provide the knowledge base and experience necessary for the novice to develop competency in clinical decision making, so that they have a foundation in analytical and deductive decision making. This is augmented by an ever increasing body of clinical experience that facilitates their ability to employ subconscious intuitive and pattern recognition processes.

Expert surgeons try to avoid overloading conscious working memory.[24] One of the most recognizable differences between a novice and an expert clinical decision maker is the faster speed and greater fluidity of expert thinking.[4] Martin *et al*.[3] found a significant difference between the extent to which a novice and an expert call on subconscious 'intuitive' pattern recognition or 'recognition primed' approaches. Experts identified pattern recognition as their preferred approach when making straightforward clinical decisions. Pattern recognition draws on previously stored schematic representations based on knowledge, understanding and experience without the need to analyse each step or reduce decision making into its components.[25]

During the process of clinical assessment or operative intervention, the movement between subconscious and conscious decision making depends on the surgeon's past experience with that clinical situation or surgical condition, the operative intervention that is required and the patient's anatomy, physiology and well-being. This is done in a series of moment-by-moment reviews of 'progress' during any clinical assessment or operative intervention. An unexpected finding or response would trigger the surgeon to stop, reassess, reconsider and adapt his/her plan. The expert surgeon is thus efficient and effective in the early detection of variance.

For experts, the level of consciousness is not an either-or dimension. Rather, they make rapid cognitive and metacognitive decisions as they simultaneously, or in a sequence of iterative steps, move between subconscious pattern recognition and more conscious information processing. They successfully negotiate the succession of cycles through which their thinking progresses.

Three contexts of a surgeon's day-to-day clinical practice are used as examples to examine the complexity of CDM and outline the different processes the expert surgeon uses in the clinical or operative situation.

(1) Context 1: 'Diagnosing and managing a patient' explores the cognitive processes used to determine the specific problems the patient has and how they should be managed.
(2) Context 2: 'Preparing for a procedure' is a representation of the thinking processes required to prepare for an operation and consider the range of eventualities that may ensue.
(3) Context 3: 'Monitoring the progress of a procedure' reviews the cognition of an expert surgeon during a procedure, including coping with unexpected findings or occurrences.

Context 1: diagnosing and managing a patient

Data interpretation can occur at either/both a conscious and subconscious level. In the initial contact with a patient, or their medical data, a surgeon deals with an array of information, which is often incomplete, and a provisional diagnosis, or a range of diagnoses, is generated. Relevant discriminating features are identified and used to test the initial diagnostic hypothesis(es). Almost simultaneously, an expert weighs the significance of each of those features and 'intuitively' recognizes previously experienced patterns with their spectrum of likely diagnosis, management plans and risks.[18] In comparison, as identified in Figure 1, it may be necessary for a novice to consciously move through the analytical steps several times before an appropriate diagnosis and management plan is established.[26]

A key subconscious element throughout this CDM process is the surgeon's capacity to deal with uncertainty. An expert is likely to continue to interpret the information even after having established a likely diagnosis, by deliberately scanning for inconsistencies and being willing to accommodate evidence to disprove their hypothesis. In contrast, the novice and non-expert are more likely to seek certainty, even at the expense of overlooking information that does not fit, and at the risk of moulding the clinical information to fit their provisional diagnosis.[27,28]

Because an expert is more comfortable than the novice working within complexity and uncertainty, he/she is able to take a comprehensive view of the patient and their circumstances and better

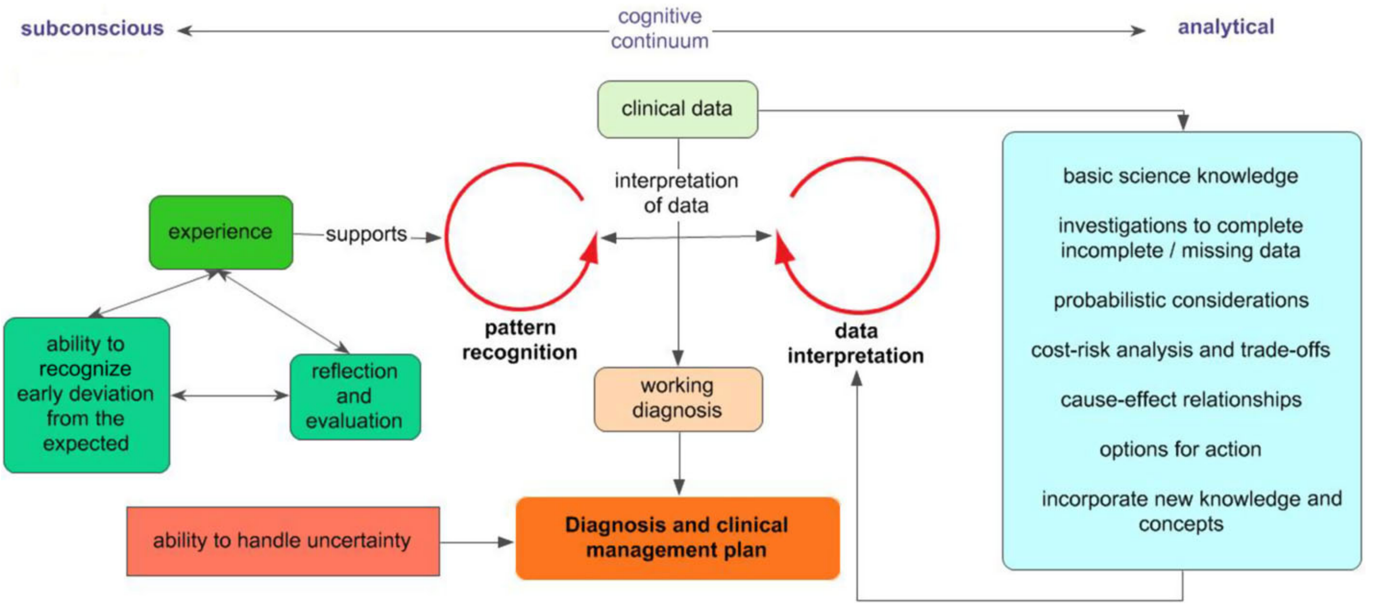

Fig. 1. A model of the CDM processes of experts while diagnosing and managing a patient.

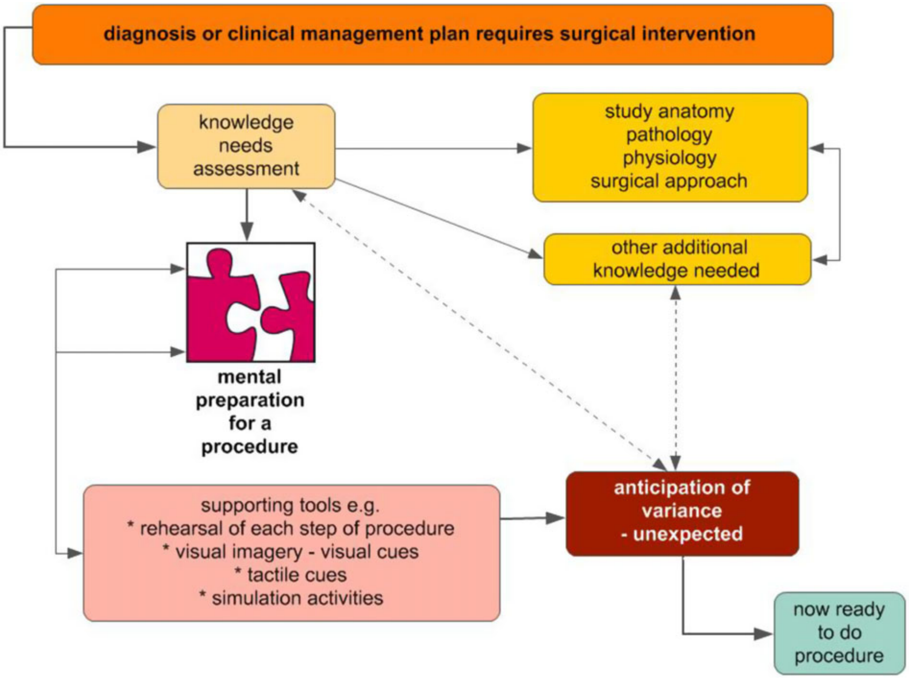

Fig. 2. A model of the thinking processes required for effective preparation for a procedure.

anticipate potential difficulties.[4] This ability involves the use of a range of cognitive skills including being able to look at problems from different perspectives and/or to view issues holistically,[17,29] flexibly and appropriately adapting and applying their skills to each specific problem.[18]

Context 2: preparing for a procedure

Preparation, practice and pre-emptive visualization will increase competence, confidence and compose and reduce cognitive load.[30]

A preoperative briefing by the supervising surgeon both assists preparation of the team and enhances the learning experience of trainees. It also contributes to improved safety of the procedure. Figure 2 is a representation of the key elements required for effective preparation for a procedure.

Surgeons at all levels of experience benefit from mental rehearsal prior to carrying out a procedure. Novices probably need to do this prior to every procedure, whereas experts rehearse for procedures they have not done for some time, or when the patient's underlying condition or the complexity of the surgical procedure may present a particular challenge.

Trainees generally read up on the relevant basic sciences and the sequence of steps before they attempt a new procedure or progress from assistant to primary operator. That process involves identifying possible areas where their knowledge or understanding is deficient and rectifying those deficiencies prior to undertaking the surgery. In this way, they are completing the first step of the sequence outlined in Figure 2. If their preparation stops at this point, however, it can be assumed that the trainee is working on a limited algorithm of CDM.[26]

The routine preoperative analysis of an operative procedure required to anticipate variance or the possibility of difficulty and minimize the likelihood of complications is another feature that distinguishes an expert from a trainee or novice surgeon. This step should automatically follow on from the rehearsal stage and lead back, if necessary, to a search for additional information and/or resources. The mental anticipation of, and preparation for, any critical situation has the potential to reduce its seriousness and the risk of an adverse operative outcome.[30]

The second step in this phase of CDM, moving between the textbook knowledge and mental rehearsal, provides essential links in the cognitive preparation.[31] The value of these processes is in:

(1) Complex visuospatial organisation – the process of imagining and reviewing the anatomy in three dimensions, identifying key landmarks and developing a clear mental picture of their relationships. It also involves thinking about how they may have an influence on each step of the procedure.

(2) Somatosensory memory – includes recalling perceptions as the procedure unfolds: the feel of contact with a patient's different anatomic structures, as well as the personal sense of specific body positions, weight, muscle tension and movement. There is also recall and sensory familiarity with the specific steps and stages of the procedure.

(3) A detailed inventory of every step of the procedure. This inventory includes:
   - information about the specific patient that may have an effect on operative decision making
   - anticipation of any difficulties (technical or otherwise),[31] or unusual and unexpected operative findings (including anticipating at what point in the operation they might occur), and
   - the identification of critical decision points.

The purpose of these processes is not to create a rigid framework; indeed, this would be counterproductive. Instead, it is to create a conceptual map, which is flexible enough to adapt during the procedure depending on the operative finding and progression of the procedure. Step-by-step rehearsal, in which it is possible to anticipate cues, will reduce the load on working memory and enhance the surgeon's ability to monitor progress and to respond to variance.

Teaching a novice or non-expert this step-by-step rehearsal and recognition of the critical decision points or eventualities is essential. For some surgeons, it can be part of an effective preoperative briefing between the surgeon and their team, or between the surgeon and the anaesthetist. Unfortunately, from a training perspective, while there is opportunity during the team briefing before the commencement of surgery, this frequently loses its utility. This is because the more subconscious and automatic the mental processing of the expert surgeon, the more inaccessible that processing may be to both the expert and those being taught.[32] In other words, expert surgeons – as distinct from expert teachers – may not be fully aware of the automatic or intuitive cognitive processes involved in their decision making; and as a result, they cannot effectively convey their mental pictures and/or their thinking steps to their trainees.

Because experienced surgeons are not always good at articulating the steps in their own decision making, it can be difficult for a trainee to identify what it is missing from theirs. This indicates that the whole field of surgical heuristics warrants further research: there needs to be greater clarity about exactly what the expert surgeon does, and how they can more effectively teach, or help trainees to learn their art.

Context 3: monitoring progress during a procedure

The apparent simplicity of a 'routine procedure' only seems so because experts are able to monitor their progress through continuous subconscious metacognitive processing involving several simultaneous and/or recursive steps. Throughout any operation, many significant decisions are being made, usually 'automatically' and often very rapidly at a subconscious level; and these may influence operative outcomes.

The presence of a supervisor in the theatre is reassuring ('that looks good, it's safe to leave that now') to a trainee. The supervisor is fulfilling a 'monitoring of progress' role for the trainee. The trainee does not need to monitor progress as actively and can free mental energy to concentrate on and complete the procedural task at hand – often the monitoring of progress is subconsciously delegated to the senior.

Figure 3 is a representation of the interconnectedness of the many cognitive processes, which are interwoven into the monitoring process. All may need to occur simultaneously during any procedure. Pattern recognition and data interpretation have already been outlined in Figure 1.

During a procedure, when expert surgeons are making decisions, they continually undertake reviews of all information and its ongoing relevance; this is part of the process of monitoring the consequences of their decision making. This monitoring process encompasses situational awareness, which is 'the capacity to continuously maintain a dynamic awareness of the situation (own progress, patient condition, team activity, time, equipment), to sift out the salience of different cues, understand what they mean and predict what might happen.[33] Doing a routine procedure, the expert surgeon is guided through by a subconscious cognitive map of what to expect. It is only when something unexpected happens – either in the patient or the environment – that the expert surgeon is likely to move into conscious monitoring and a possible re-assessment of the initial hypothesis and/or operative plan. The more exceptions encountered, the more the expert considers and responds to what is unusual or does not fit.

An expert can draw on and apply complex cognitive processes.[3,13,16] For example, part of the repertoire of the expert surgeon, and the reason that they can depend on their subconscious monitoring, is that they have learned to identify appropriate situational cues

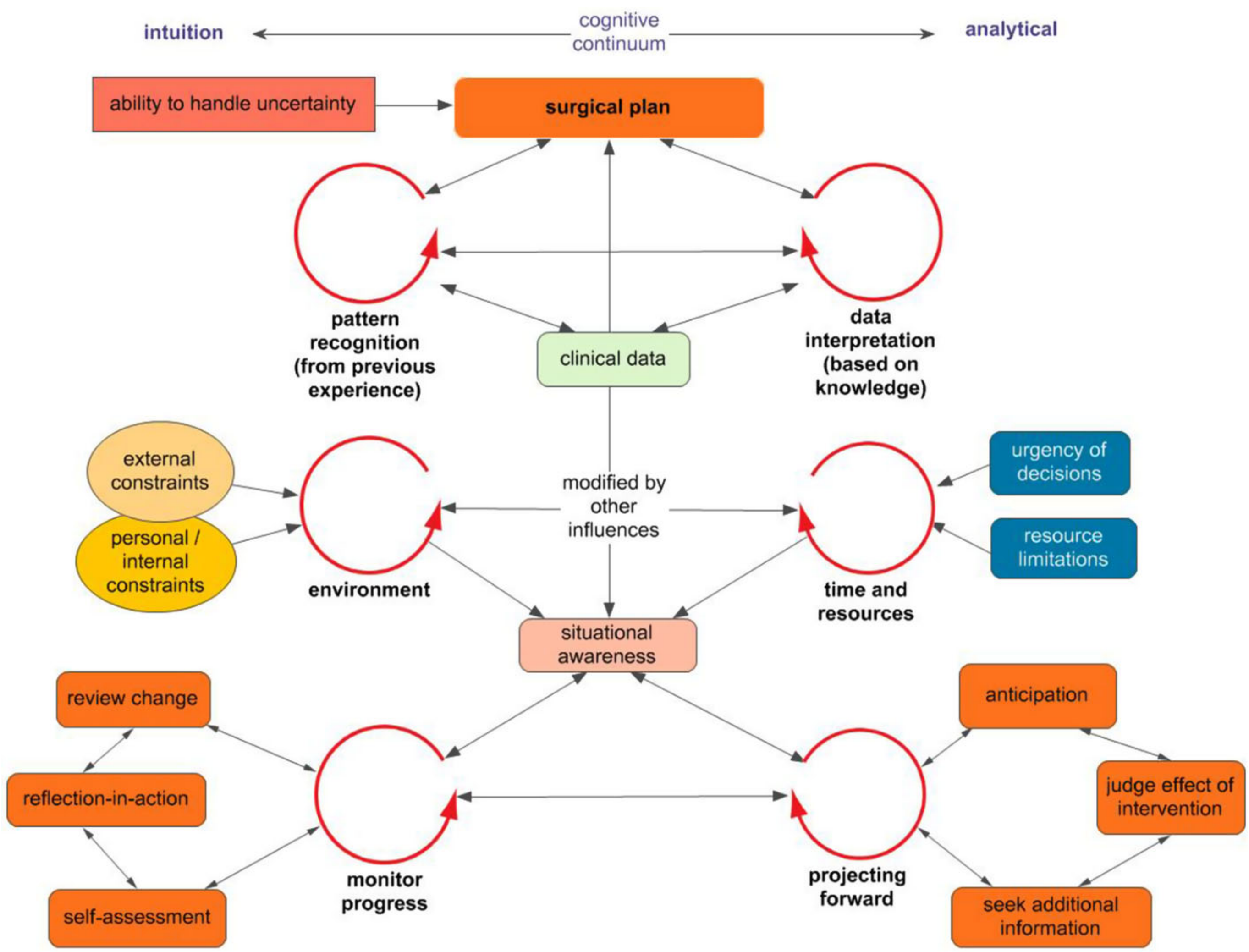

Fig. 3. The complex decision-making cycles involved in monitoring the progress of a procedure.

and to respond to them consistently. Novice and non-expert surgeons may rely on formulaic thinking and/or not have developed these skills.[34,35] As a consequence, they need to give more conscious attention to gathering, understanding and evaluating information. Trainees can improve their monitoring by considering the patient's pathology and physiology and the clinical context, the facilities available for treatment, as well as other external factors during the preparation phase.

Another difference between a novice and an expert that some surgeons struggle to achieve is the ability to anticipate and recognize variance early, and to recognize and manage potential or actual complications promptly. The expert surgeon detects and responds to any variance more quickly than the less expert surgeon. The novice has less ability to correctly identify and deal with the complexities of any situation. Although the clues are there, they are not seen or their significance not recognized until later. This means that any response is late – and this may have adverse consequences for the patient.

If a situation changes during a procedure, then both the expert and the novice need to reconsider their provisional diagnosis or plan of management in the light of the new findings, and re-evaluate their options accordingly. Expert surgeons work to a plan (following the script) unless there is an unforeseen change in the patient or the situation; and any such change is detected promptly. Being able to 'project forward' and anticipate events enables early recognition of deviation. This leads to a transition from subconscious to conscious thinking[35] and to reconsidering options, risks and likely consequences.

Self-assessment is the 'glue' that holds all of the other cognitive process together. It enhances the quality of the interpretation of information, as accurate interpretation is the precursor of correct operative decision making. Self-assessment can perform two different functions: (i) as an essential activity to provide continuous feedback during a clinical encounter; and (ii) to enable review of the whole process.

The former function aligns with Schön's reflection-in-action and the latter with reflection-on-action.[36,37] Reflection-in-action, combined with situational awareness, enables a surgeon to continuously monitor the progress of a procedure. Data interpretation and/or pattern recognition inform anticipated events and detection of deviation from the expected. These processes may variously focus on the accuracy and appropriateness of the working diagnosis, re-evaluation of the operative findings, progress of surgery, the effectiveness of the intervention and the aptness of the surgeon's own skills. Even during routine procedures, the cycles outlined in Figure 3 have an essential role in ensuring that the integrity and standard of the procedure is maintained. In more complex procedures, it can function both as a monitoring tool and provide an early warning that a problem might arise.

However, under direct supervision, trainees may be subconsciously reassured (or assume) that the more senior surgeon is likely to tell them if the exposure is not adequate, the ligatures are not secure, the intended plane of dissection is not safe or the tumour extent is greater than expected. This allows them to proceed faster and with more confidence, perhaps at the expense of self-assessment.

To enhance their skills in self-assessment, less experienced surgeons can train themselves to question their own progress through each procedure with a series of questions such as 'Is this incision in the optimal position?' 'Have I placed the incision or lines of resection correctly?' 'Is the exposure of the vessels and nerve sufficient?' Are the ligatures secure?' 'Is it safe to dissect in this plane?' or 'Is this tumour extension exactly as I anticipated it would be?'[38] This self-questioning should enable the surgeon to proceed with more confidence and not lead to paralysis by anxiety or indecision.

In establishing a true assessment of the situation, the surgeon needs to recognize any mismatch between what is observed with what was expected or has been assumed. Gap analysis of this type is another aspect of CDM that distinguishes the expert from the novice. When following a pattern recognition process, it is the ability to respond to the gap between what is happening and what was supposed to be happening (recognition of subtle variations from the expected and readjusting the clinical weighting of information accordingly) that increases the quality of this process: either a different pattern needs to be considered or a switch to a more analytical approach to examine carefully the relevance of each piece of data is required. When following the analytical reasoning process, the surgeon must respond to the fact that B has not followed A, and that either the operative findings need to be reinterpreted, more information needs to be obtained or the anticipated pattern does not fit.

Regrettably, research indicates that a proportion of medical practitioners is poor at self-assessment, overconfident and/or lack insight into their own levels of ability.[39–43] Their ability may also be limited by distractions, fatigue or competing interests. Such a combination is often compounded by a lack of awareness (or acceptance) that there is a problem. In short, they lack insight. They don't know that they don't know; they are ignorant of their ignorance, so their decision making is error-prone. This lack of insight into the limits of their own ability poses a significant risk to the patient, predisposes to poor operative judgement and results in delayed acceptance of variance. That leads to poor patient outcomes.

Sometimes the inability of a trainee to learn how to make clinical decisions is not because they cannot learn, but because they are less able to appreciate the differences between their own performance and that of others.[32,36] Fortunately, there is some evidence to indicate that training, which increases a doctor's metacognitive competence, their ability to understand and reflect on both the context of decision making, and the underlying thinking processes they are employing can improve their overall performance.

Conclusion

Clinical judgement, clinical decision making and metacognitive skills, as represented in each of the three models, are interlinked and overlapping. A lack of knowledge of, or attention to, one facet can have serious repercussions in another. For example, a lack of preparation for a procedure could mean that a trainee is not able to adequately monitor the progress of a procedure or to recognize variances or to deal with unexpected findings. This may be exacerbated by the lack of awareness of potential complications, overloading mental capacity, delayed incorporation of relevant additional information and/or the ability to reflect on one's own performance.

Unfortunately, experts in CDM are not necessarily effective teachers of that skill. Each surgeon's ability to recognize and reflect on their subconscious decision making (metacognition or 'mindfulness') varies enormously. Yet, this valuable skill, when present, enhances learning and teaching capability.

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