Decision making in laparoscopic surgery: A prospective, independent and blinded analysis

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ABSTRACT

Aims: Correct decision making is pivotal and an integral part of surgical competency. To date there has not been an attempt to assess surgeons making decisions whilst operating. In our present study we aim to assess operative decision making by trainee and expert surgeons by using hierarchical task analysis (HTA) as a method to map out decision making in surgery.

Methods: One hundred and forty live laparoscopic operations were prospectively analyzed, independently and blindly. The operations were compared to an operative HTA, and individual case reasons for deviations noted. Factors in the operating theatre which may influence the surgeons’ decisions whilst operating were assessed using a checklist.

Results: One hundred and nineteen elective and 21 emergency laparoscopic operations performed by 12 consultants and 14 registrars were analysed. Factors from the HTA and theatre environment checklists were categorised. Inter-rater reliability was $k = 0.95$, $k = 1.00$ for sub-tasks and tasks, respectively, and 0.98 between the surgeon and independent observer for the operating theatre checklist. From these data sets a psychomotor surgical decision making model was constructed. Face and content validities of the model were verified by experts in surgery and decision making.

Conclusions: Dynamic surgical decision making is a multi-faceted and intricate process. We have used HTA to map this process and we present a model in surgical decision making. By understanding the mechanisms and factors which influence this process we may use it for effective, focused surgical training. We aim to use and test our model also on open major complex surgery.

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1. Introduction

Accurate clinical decision making is pivotal in the delivery of effective and safe surgical healthcare. Most of the research in surgical decision making has mainly been on decision trees, static or sequential decision making, laboratory based analysis or data derived dynamic modelling.1-10 Performing surgery involves many complex and intricate clinical decisions, mainly dynamic. In decision making literature ‘dynamic’ is termed as a series of decisions, the problem state changing autonomously, and as a result of the decision maker’s actions.

Surgery is a high risk speciality, and it has been shown that it may have a detrimental effect on patients with one study
surgical decision making as being complex,18 and another studies have concentrated on ‘risk taking’ decision making, published to ascertain the reliability of the observations.21

operation using HTA and using a scoring system previously assessment on the significant decision making aspects of the cal experience), and compared with the operating surgeon as- 
dotically reported.20

decision making for the surgeon which was previously anec- 
dotically reported.20

Pelvis. This means that the surgeon needs to make decisions related to the equipment used in laparoscopic surgery, e.g. level and flow rate of carbon dioxide, clarity and functionality of the laparoscope, etc. As laparoscopic surgery is a good example of surgical decision making on the operating table as well as in the surrounding operating theatre environment, we have chosen this surgical technique to explore which factors may influence a surgeon’s decision making.

This paper attempts to outline the factors which may influence decision making in the performance of laparoscopic sur- gery. Using this data we will construct a psychomotor model that outlines which factors affect intra-operative decision making in laparoscopic surgery.

2. Methodology

One hundred and nineteen elective and 21 emergency general surgical laparoscopic operations were analysed prospectively over a 4-year period 2003–2006. The live operations were prospectively blindly analysed by an independent observer on DVD (experienced surgeon with >12 years postgraduate surgical experience), and compared with the operating surgeon assessment on the significant decision making aspects of the operation using HTA and using a scoring system previously published methodology.21,22 The HTA was also evaluated and modified if required by each of the surgeons participating to assess whether it differed from their own prescribed set of tasks for completion of the operation. The task analysis was performed to a level which described the tasks and sub-tasks which had to be completed to achieve the goal, but did not de- scribe the technique and instruments that should be used. This was done so that the natural style of the surgeons was unbiased. We have previously shown that the essential steps of the operation (tasks) do not differ between surgeons but sub-tasks do, e.g. type of suture used do slightly.21 The actual operations were compared to these operative hierarchical task analysis, and reasons for deviation noted.

2.3. Theatre environment checklist

Factors in the operating environment which influence the sur- geons’ decisions whilst operating were recorded using a checklist. This checklist was formed as a result from a previ- ous questionnaire study on dynamic decision making.23 That initial study asked consultant general surgeons and various grades of higher and basic surgical trainees which factors influenced decision making in the operating theatre. The ob- server noted these facts prospectively in theatre and verified this with the operating surgeon post-operatively. Table 2 con- tains a summary of aspects in the surgical theatre environ- ment which were assessed and their occurrences.

2.4. Statistical analysis

Data was collated in an Excel® database (Microsoft, Redmond, WA, USA). Statistical analysis was carried out with SPSS® soft- ware statistical package (SPSS, Chicago, IL, USA). For reliability studies between the observer and surgeons in the hierarchical task analyses and theatre checklists, non-parametric kappa coefficient was used; k > 0.61 was deemed significantly reli- able, p < 0.05.

3. Results

One hundred and forty laparoscopic operations were ana- 
yzed, 119 elective, 21 emergency operations performed by 12 consultant surgeons (6 ≤5 years, 6 >5 years) and 14 regis- trar trainees (6 junior HST years 1–4, 8 senior HST years 5–6) were analyzed. One hundred operations were performed by consultants and 40 by registrar surgeons. There were no major intra-operative or post-operative complications for the pa- tients. Table 1 summarises the number and types of laparo- scopic operations performed.

Mean inter-rater reliability was k = 0.95 (range 0.92–1.00), p < 0.05 for sub-tasks and k = 1.00, p < 0.05 for tasks in the hier- archical task analyses. k = 0.98 (range 0.97–1.00) for theatre checklists between the independent observer and surgeons. The percentage occurrences of each theatre checklist factor is summarised in Table 2.
4. Constructing psychomotor decision making model

Factors influencing operative decision making in laparoscopic surgery were categorised from the hierarchical task analyses and theatre checklists. From the checklist the main categories were: personal, work-related, communications, physical environmental factors, ergonomics, equipment-related, instrument-related. From hierarchical task analyses the main categories were: levels of surgical competency, team performance and technical skills (generic and specific).

From this data and a previous questionnaire study, a model outlining factors which may influence surgeons’ making dynamic decisions whilst operating was constructed (Fig. 1). Face and content validities of the model were tested and verified by surgical and decision making experts. The following is a description of the elements of the psychomotor model.

4.1. Specific input

At the time of formation of the idea to perform a technical task the cerebral cortex receives simultaneously sensory information as a specific input. This sensory input is mainly from the eyes, ears and the cutaneous sense organs in the skin of the hand (touch, pressure, hot and cold sensors).

4.2. Visual spatial perception

This part is situated mainly in the right cerebral hemisphere and a right-hemisphere interpreter is dedicated to construct a representation of the visual world. However there is a less dominant part in the left hemisphere. A consideration of the constructive nature of visual perception, and the organisation of the visual system in the two hemispheres suggests that asymmetries are likely to arise relatively late in visual processing in areas that represent both sides of visual space. It has been shown that surgeons have a more developed visual spatial perception compared to the general public, and this suggests surgeons may have a better ability to perform highly technical manual tasks.

4.3. Cerebral cortex

Once the specific input is received in the sensory centre in the cerebral cortex the motor centre in the cerebral cortex is activated. Depending on the task to be performed, specific motor areas are activated. This may involve a combination of mobilisation of large and small muscle groups if the task requires the arm and hand to follow a long path length or only small muscle groups in the hand if the task is delicate and has an intended short path length. However the cerebral cortex’s motor area is influenced directly by motivation, emotion, sleep and memory and indirectly by personal and work factors.
4.4. Psychological aspects

Psychological aspects such as risk analysis, risk taking and outcome were incorporated into the model after researching the topic.12–19

4.5. Personal and work factors

During the daily life of a surgeon he or she can be subjected to various stressful factors which can influence their performance in decision making, team interaction and technical skill. Work related stresses include fatigue due to sleep deprivation, high workload and long commutes (driving a car, motorcycle or bicycle); hierarchal bullying, time constraints, and poor supervision, communication and teamwork.19 Personal stresses may include fatigue due to sleep deprivation as a result of a waking baby, excessive socialising, poor personal fitness or health, e.g. early Parkinson’s disease, partner relationship problems, family illnesses and difficulties, financial strains, and alcohol.20 All these stressful factors

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Fig. 1 – Psychomotor surgical dynamic decision-making model.
influence the cerebral cortex in performing the technical task, and may increase the risk of errors made by surgeons and compromise their decision making in theatre.

4.6. Theatre factors

The main categories in this element were: personal, work-related, communications, physical environmental factors, ergonomics, equipment-related, instrument-related from the checklist data set.

4.7. Memory

When performing a technical task memory influences the execution of the task. Depending on the experience of the person performing the task, the ratio of the habit and recognition memory changes.\(^{25}\)

4.7.1. Habit memory

For someone performing a task repeatedly over a consistent period of time, some parts of memory of the task become habit. Less concentration is required in parts which become automated, however very delicate tasks cannot be performed automated. This aspect is more fully developed in those very experienced compared to the novice or the intermediate.

4.7.2. Recognition memory, pattern recognition and hierarchical task analysis

This aspect is essential usually in performing a technical task. It is assumed when a doctor performs a technical task (operational or non-operational) he or she has learnt about it. This may be either reading books or articles, watching tasks (on video/DVD, theatre, in other areas in the hospital), assisting someone senior in performing the task or performing the task with close senior supervision. The recognition memory aspect is more essential in novice and intermediate performers of tasks. A person who is competent in a task has imprinted in their memory a hierarchical task analysis of the task. Table 3 demonstrates an example of some aspects of a hierarchical task analysis of a laparoscopic cholecystectomy.

4.8. Motivation

Motivation controls the speed of the task, completion, incompleteness, and abortion of the concerned task. This factor interacts with the other factors intimately, e.g. memory, emotions, sleep, etc.

4.9. Emotions

This aspect depends on the operator’s state of mental milieu at the time of performing the task. The operator may be angry, upset or even happy which closely interacts with the

<table>
<thead>
<tr>
<th>No.</th>
<th>Task</th>
<th>Plan</th>
<th>No.</th>
<th>Sub-Tasks</th>
<th>Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Position patient, prep and drape abdomen, position and attach laparoscopic instruments and equipment</td>
<td>Do sub-tasks 1.1, 1.2, 1.3, 1.4 in consecutive order</td>
<td>1.1</td>
<td>Position patient supine Prep abdomen</td>
<td>Repeat 1.1 to 1.4 if necessary in consecutive order if any sub-tasks fails</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.2</td>
<td>Prep abdomen</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.3</td>
<td>Drape abdomen</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.4</td>
<td>Position and attach laparoscopic instruments and equipment (camera, gas and diathermy leads, monitor and camera)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Inform the anaesthetist that you (the surgeon) intends to start operation</td>
<td>Do sub-tasks 2.1 to 2.2</td>
<td>2.1</td>
<td>Speak to anaesthetist that you intend to start</td>
<td>Anaesthetist says not to start, wait for approval and repeat 2.1 to 2.2 in consecutive order</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2.2</td>
<td>Acknowledge anaesthetist has given approval</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Create CO(_2) pneumoperitoneum</td>
<td>Do sub-tasks 3.1, 3.2, 3.3 in consecutive order</td>
<td>3.1</td>
<td>Open technique</td>
<td>Pneumoperitoneum not created repeat 3.1 to 3.3 in consecutive order</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3.2</td>
<td>Insert 10 mm umbilical port without trocar</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3.3</td>
<td>Insufflate abdomen with CO(_2)</td>
<td>Ports not inserted correctly</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3.4</td>
<td>Insert 10 mm port (epigastric)</td>
<td>Repeat 4.1, 4.2, 4.3 as required</td>
</tr>
<tr>
<td>4</td>
<td>Insert laparoscopic ports</td>
<td>Do sub-tasks 4.1, 4.2, 4.3 in consecutive order</td>
<td>4.1</td>
<td>Insert 10 mm port (lateral)</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>4.2</td>
<td>Insert 5 mm port (lateral)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4.3</td>
<td>Insert 5 mm port (lateral)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Laparoscopy, retraction, dissect and expose Calot’s triangle (cystic artery, cystic duct)</td>
<td>Do sub-tasks 5.1, 5.2, 5.3 in consecutive order</td>
<td>5.1</td>
<td>Laparoscopy of abdomen</td>
<td>Abnormal intra-abdominal pathology, decide to continue or not. Bleeding from port site, rectify before proceeding.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5.2</td>
<td>Retract gall bladder</td>
<td></td>
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<td></td>
<td></td>
<td>5.3</td>
<td>Dissect adhesions to gallbladder</td>
<td>Graspers detach from gallbladder, reapply graspers. Any significant bleeding during sub-tasks 5.3 to 5.6 will need correcting</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5.4</td>
<td>Hartmann’s pouch</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>5.5</td>
<td>Dissect and mobilise Hartmann’s pouch</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5.6</td>
<td>Dissect and mobilise cystic artery</td>
<td></td>
</tr>
</tbody>
</table>
motivational aspect and may distract the operator in executing the task well.

4.10. Sleep

The amount of sleep affects the consciousness and alertness which allows perception possible. Adults require a minimum of 6–8 hours sleep a day to be adequately rested. There are two patterns of sleep, rapid eye movement (REM) and non-REM sleep. When sleep is interrupted at the REM stage of sleep, humans become irritable and anxious. This is seen for example when doctors have incomplete sleep with interruptions whilst on-call. This has been shown to affect surgeons performing tasks.

4.11. Specific output

Once the motor output is sent, simultaneously sensory output is also sent at the time of task execution. This is in the form of visual, hearing and cutaneous sense organs and allows depending on the dynamics of the task to re-adjust or adapt prior to task execution.

4.12. Muscle groups

If the technical task involves large movements then large muscles of the hand and or arm are used, e.g. picking up a swab. Small muscles of the hand perform more delicate tasks, e.g. suturing. Large and small muscles of the arm and hand are used synchronously if the task involves large and small movements in sequential sequence, e.g. picking up a scalpel from the receiver bowl and incising the skin.

4.13. Next task and sub-task/recovery/adaptation

If the performance of the task or sub-task was successful then the next step in the technical task or sub-task can proceed. The cycle can be repeated as many times as required until the complete procedure or task is achieved.

At the time of execution of the dynamic task or sub-task there may be adjustments required or aspects of the task have changed while the process of task execution was being done. In this case the whole cycle must be repeated until the technical task can be performed. If the technical task was not performed completely correctly a recovery cycle going through the cycle must occur as many times as required until the task is completed successfully.

5. Discussion

The process by which surgeons make decisions has been described as ‘the integration of evidence, inference and experience’. For example, in deciding whether to perform a primary anastamosis or a Hartmann’s procedure for a particular patient, the surgeon would use data from clinical trials (evidence), logical reasoning using his biological knowledge (inference), and awareness of his own capabilities and the patient’s preferences and needs (experience). All three sources of input can complement each other, but controversy arises when they are contradictory or when one is lacking, e.g. the absence of rigorous trial data. It is in these situations where the ability to make an accurate decision is most crucial.

Currently, surgeons are trained to make intra-operative decisions through feedback in the classroom, the laboratory (simulators), the clinic, multi-disciplinary meetings and in theatre. Advances include the use of virtual reality simulation, particularly in the teaching of laparoscopic techniques, which have allowed trainees to develop their decision making skills before they perform on real patients. Serious trauma is a situation which calls for rapid and effective decision-making and there are various training courses available which aim to teach the recognition and management of trauma in a structured and systematic manner; these include Advanced Trauma Life Support (ATLS), Care of the Critically Ill Surgical Patient (CCTISP) and Definitive Surgical Trauma Skills (DSTS). However, in general terms there has been a lack of emphasis on the structured teaching of the so-called ‘non-technical skills’, with recognition that “decision making, as an entity in its own right, is poorly tutored”. Additionally, trainees often only get the chance to apply their decision making skills when they are actually in the operating theatre, a high pressure environment which is not ideal for learning. Nor is it ideal in terms of safety, since the trainee is dealing with a live patient.

Consultant surgeons have been shown to regard many cognitive skills as even more valuable than technical skills in surgical trainees and have ranked decision-making ability as the most important personality trait required for a competent surgeon. It has been said that 75% of the important events in an operation are related to making decisions and only 25% to manual skill. Therefore, it has become necessary to look at innovative ways of training junior surgeons to develop skills that normally take many years to amass, especially considering the European working-time directive which will limit the experience that trainees have in theatre.

The assessment of decision-making ability in trainee surgeons is currently carried out via written and clinical examination (MRCS and Intercollegiate FRCS). In recent years, assuring the public of the competence of surgeons has become ever more important. Competency in surgery is said to be a combination of technical skill, teamwork and decision making and to date, research has largely concentrated on the assessment of technical skills in surgery. Now that the General Medical Council (GMC) is currently moving towards a system of compulsory revalidation for all surgeons in the UK, there is a need for a reliable, valid and feasible means of testing dynamic decision-making skills while avoiding subjective bias. HTA may be a method of assessing these skills.

6. Conclusions

Competent surgical decision making is a combination of didactic knowledge, technical skill judgements and the decision making ability of the operator during the procedure. These three elements are required in unison for a surgeon to be able to operate independently.

Clinical decisions are the end product of a multi-faceted interchange between the clinician, the patient and specific types of information presented. Surgery involves an intricate
The myriad of overlapping clinical decisions. Decisions made in the operating theatre by the surgeon is a culmination of a cascade of decisions made in the organisational, surgical, theatre and theatre team environments. The surgeon’s scalpel is the tip of an ever changing and evolving decision making process. This involves dynamic decisions and behavioural responses which all live symbiotically with one another. If we are to deliver effective and safe healthcare to our community we must ensure that surgical decisions are made which benefit the patient in their overall outcome.

By implementing safeguards into our healthcare systems so we can improve the quality and safety of our healthcare, we must fully understand the clinical surgical decision making process. As surgery is constantly being scrutinised worldwide in the courts, press and media, it is important that the surgical component of decision making is accurate and effective for each individual patient.

In this present study we have attempted to assess intra-operative decision making by the surgeon in laparoscopic surgery and the factors which influence them. Using our data we have constructed a novel psychomotor surgical decision making model and how the factors can affect a surgeon whilst operating, and influence his or her decision making.

By understanding the process we can train current and future surgeons how to come to effective and accurate surgical decisions. This can be done in the classroom, laboratory, clinic, virtual reality, and in simulated and real theatre. By creating a feedback cycle the surgeon can critique his or her own clinical decisions and hopefully improve and build on their decision making skills. Creating such a decision making learning environment can only improve the quality of surgical care and improve each individual surgeon’s clinical skills.

We aim in the future to analyse a larger group of operations encompassing open, laparoscopic and endoscopic surgeries, and therefore further test our psychomotor model in surgical decision making in the real environment.

Conflicts of interest

None.

Funding

None.

Ethical approval

None.

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References


