



REVIEW

Human factors in the operating room – The surgeon's view

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Keywords:
Communication
Distractors
Stress and fatigue

SUMMARY

The quality of surgical performance depends not only on the technical skills of the surgical team, but also on non-technical skills. Identification and improvement of such non-technical skills is an important aim to improve overall surgical outcomes. Non technical skills primarily include three factors. The first factor is efficient communication among a multidisciplinary team. This requires strong leadership and coordination of role-related tasks for the surgical team members. The second factor is coping with distractors in the operating room. Distractors may impact team performance and must be identified and reduced to ensure maximum concentration in the most of unavoidable distractions. The third factor is the impact of stress and fatigue of the surgical team. Potential methods of addressing these topics include training, procedural support for human factors requirements, and specified phases for information reflection as well as for mental recovery.

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1. Introduction

Surgery places high demands for quick decision-making and for accomplished technical skills of the surgical team. A multidisciplinary surgical team includes surgeons, anesthesiologists, nurses, technicians, and other specialists. Members of the surgical team must focus on a diversity of non-technical aspects, which may be defined as “critical cognitive and interpersonal skills” that complement their technical abilities.¹ Such skills include effective cooperation in a multidisciplinary team, ability to control distractors and mastering communication and stressful events. “Communication”, “teamwork”, and “situation awareness” have been established as the core set of non-technical skills for surgeons, anesthesiologists, and scrub nurses.^{2–4} While there is a common goal of the entire surgical team, sub-teams have their own specific tasks and pursue their own objectives during surgery. While being an active member of the team himself, leadership of such a multidisciplinary team and assuring cooperation across sub-teams presents additional challenges for the surgeon.

Distractors, such as noise, potentially impact concentration and communication of the surgical team and may ultimately have negative effect on patient outcome. Team members have to

maintain concentration despite noise and other distractors, such as stress, and fatigue. These challenges show that the quality of surgical performance depends not only on the medical proficiency of the surgeon and the operating room (OR) team, but also on non-technical skills.

The aim of the present review is to assess and discuss: (1) aspects of teamwork and leadership in a multidisciplinary surgical team in relation to surgical performance, and (2) the importance of distractions on concentration and decision-making in the OR. We will also address aspects that may aggravate the situation, such as (3) the role of stress or fatigue, and provide an outlook on potential procedural and training interventions.

2. Coordination of a multidisciplinary team

Communication is fundamental for patient safety and successful surgical outcomes in the OR. The communication skills of individuals are not the only concern but the communication culture in the OR is a major factor as well. Both communication and teamwork have traditionally been organized in a hierarchical structure in the OR.⁵ Communication failures have measurable negative effects, such as inefficiency, resource waste, delays, and procedural errors.⁶ Potential causes include poor timing, inaccurate information, unresolved issues, or the fact that leading persons were not included in the exchanges of major importance.⁶ Communication and teamwork breakdowns have been shown to be an important

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contributing factor in 38% of incidents in non-emergency procedures, and may impact up to 59% of incidents in emergency situations.⁷ Another study identified communication breakdowns as a contributing factor in 72% of malpractice cases analyzed.⁸ Aspects of communication that are particularly prone to enhance the risk for harm in the OR include transfer of patients, non-patient relevant communication, and team-members hesitating to speak.^{8–12}

Team coordination and leadership. When working as a team, group members shift their focus of attention between the execution of their individual assignment and group coordination, which constitute separate tasks.¹³ Surgery requires a high level of mental concentration as well as decisional and sensory–motor demands from the surgeons. Thus, the mental capacity, to provide attention to other group members or processes the involvement of the entire team may be limited.¹⁴ Impaired teamwork and communication may consequently require leadership from a specific member of the surgical team; this role can be achieved by the surgeon. Strong leadership undoubtedly plays an important role in the OR.¹² Leadership has behavioral and role-related aspects.

Specific roles are required for optimal leadership skills, which are embedded in a complex structure of the surgical team. One's professional role influences not only their responsibilities but also perception and interpretation. Thus, surgeons, anesthesiologists, and nurses have different perceptions and expectations with regard to teamwork and leadership in the OR. For example, surgeons and anesthesiologists perceive multiple teams in the OR, whereas two-thirds of the nurses perceive the surgical team as a single unit.¹⁵ Satisfaction with the role distribution within the surgical team also differs widely. Many surgeons expressed high satisfaction regarding collaboration anesthesiologists (84%) and with nurses (87%); high satisfaction regarding collaboration with the surgeons was reported by 70% of anesthesiologists but less than half (48%) of nurses.⁵ Given these differences in perception, teamwork and communication failures between sub-teams may be particularly important between sub-teams. Indeed, one study found that failure to include a key recipient was responsible for about 20% of communication shortcomings in the OR.⁶ Friction also tends to occur between different sub-teams; most frequently between surgeons and nurses.¹⁶ Interestingly, friction in the OR was not related to the ongoing procedure in most cases; rather, the most friction occurred regarding broader issues of organization and coordination, such as room turnover and delivery of the next patient, resource conflicts about equipment, or attribution of personnel.^{16,17} The majority of the directives delivered by the surgeon are for the benefit of the surgical team (other surgeons and the scrub nurse), followed by the general OR team, and less than 10% are addressed to the anesthetists directly.¹⁸ Leadership behavior is reflective of the case complexity, whereby the strongest leadership performance is usually observed in complex cases.¹⁸ Moreover, the quality of leadership is inversely related to the duration of operation.¹⁹ As of yet no study has investigated the impact of leadership behavior in the OR with respect to clinical outcome parameters.

An important part of the structure is hierarchy. Hierarchy is not the only factor creating thresholds for speaking up, it is however one of the most important factors, in that, people of lower status are less likely to voice concerns vis-à-vis higher ranking people, such as surgeons.^{12,20} This is emphasized by the finding that nurses showed as much disruptive behavior in the OR as did surgeons, but they directed it less often toward surgeons than toward other professionals in the OR.²¹ Surgeons may be more open to being questioned in the OR than their team-members perceived them to be.²² This implies that some criticism may be actively hidden from surgeons, which may be one reason why they judge the quality of collaboration with nurses higher than nurses do themselves.²³

3. Distractors

Non-routine or challenging parts of the operation require high concentration and the focused attention of the entire surgical team.¹ In the OR, this attention is often threatened by different distractors such as noise, case-irrelevant communication, and interruptions.^{11,23–25}

Distractors can impair surgical performance and are associated with a prolonged operation time and a higher error rate.²⁶ Importantly, these effects were more pronounced for less experienced surgeons than for senior surgeons, as experienced surgeons learn to shield themselves from the negative effect of distractors to a certain degree.²⁷ The ability to concentrate despite a high frequency of distractions may be more difficult for longer and more complex surgeries. In a previous study, we showed the effect of potential distractors such as loud noises, changes within surgical team members, movements in the OR, and the presence of visitors on the incidence of surgical site infections.¹⁰ The effect persisted after controlling for risk factors related to the patients-specific morbidity and type of procedure. In a more recent study, we showed the relationship between noise-levels in the OR and the occurrence of surgical site infections in patients undergoing elective major abdominal surgery.¹¹ Higher noise levels were associated with more non-patient relevant conversations within the surgical team, but not with more unfocused conversations of the anesthesiologists.¹¹ Median sound levels were moderate (below 45 dB) even for surgeries resulting in surgical site infections, which is clearly below noise levels that generally cause concern.²⁸ Both studies suggest the need to deal with distractions, either by limiting the amount of distractors in general or at specific phases, thereby allowing the surgeons to maintain full concentration even in a noisy environment.

4. Stress and fatigue

In the OR, surgeons must need to deal with various key stressors, such as technical complexity, unforeseen surgical problems, such as bleeding or equipment malfunction, distractions, time pressures, and external visitors.²⁹ The most frequent stressors are distractions and interruptions, followed by patient, technical, and equipment problems.³⁰ Patient, technical, and equipment related problems were rated as particularly stressful. Despite the high frequency of stressful events, only a few studies have examined the impact of acute stress on surgical performance. The current literature indicates that a more stressful surgical technique (i.e. laparoscopic versus open surgery), especially in novice surgeons, may indeed impair technical performance, whereas a moderate stressor, such as an exam, improves performance.^{31,32}

Stress levels are also determined by the hierarchical position in the OR (main surgeon, assistant surgeon) and by experience. Main surgeons, who perform the operation, have higher stress than assistants surgeons.¹⁶ Comparing surgeons in the same role, more experienced surgeons were less stressed and were better able to cope with distractors and multiple task requirements.^{33,34} Although surgeons see chronic stress as a factor that can impair performance, most of the surgeons assess themselves as invulnerable to negative effects of stress and fatigue during surgery.^{5,22,35} This may be one reason why surgeons are less likely than other members in the OR to inform others if their workload becomes excessive.²²

There is also evidence that the way surgeons cope with intra-operative stress influences their performance.³⁶ For example, negative coping (e.g. avoidance, resignation, and rumination) was related to lower performance and to more errors in a simulator study.³⁷ However, coping with intraoperative stress depends not

only on individual differences but also on available resources, concerning fatigue for example.

Fatigue is a common complaint of surgeons and relates to poorer performance on psychomotor and cognitive tasks.^{38,39} Fatigue can also lead to operative inefficiency because of poor planning and therefore prolong operative time.⁴⁰ On the other hand, regular breaks during routine laparoscopic surgeries were related to lower stress reactions, both in terms of perceived stress and in terms of biochemical markers, such as cortisol; it also correlated with fewer intraoperative events and reduces errors in a postoperative concentration test.⁴¹ Furthermore, additional breaks did not prolong the duration of the operation.⁴¹ Again, surgical experience seems to moderate the impact of fatigue on surgical performance. Surgical residents may be particularly vulnerable to performance decrements of fine motor skills and impairments of cognitive skills when fatigued.³⁸

5. How to improve non-technical skills

Given the importance of non-technical skills (communication, leadership of multidisciplinary team, coping with distractors and stress) for surgical performance and patient safety in the OR, different tasks have been suggested to support the acquisition and use of non-technical skills. They include changes in surgical protocols, minimization of distractors, and specific training.

5.1. Protocol change

The introduction of pre-operative briefings or checklists, such as time-out procedures, as recommended by the World Health Organization is now becoming standard in many hospitals.⁴² The main goal of pre-briefings is safety, such as preventing wrong side surgery or assuring antibiotic treatment. However, several studies found further positive effects of pre-briefings on teamwork performance. For example, attitudes toward teamwork and communication became more positive, and there were decreased communication failures and equipment issues as well as exchange of nurses after the implementation of pre-briefings in the OR.^{18,43,44} A large multi-site study showed impressive decreases in complications and in-hospital mortality after the introduction of a multidisciplinary checklist procedure.⁴⁵ Although many studies show that implementation of pre-briefing procedures may not be easy, and that surgeons seem particularly reluctant to comply, pre-briefings may be particularly useful for improving collaboration of the interdisciplinary OR team.^{43,46} Anesthesiologists and nurses showed the largest increase in information about patients and procedures after introducing checklist briefings.⁴⁷

5.2. Minimize distractors

To minimize negative effects of distractors during surgery, several authors recommend coping mechanism and regulations to minimize the impact of different distractions, particularly in critical phases of the operation, but also to enhance awareness of the potential effect of distractors.⁴⁸ Surgeons may use very different strategies to initiate moments of heightened attention to the procedure (called “slowing down”) – these were either proactively planned reflections related to important steps of the procedure or adaptive responses to situational changes.¹ However, developing formal rules (for example calling “silent phases”) might also be useful, because many surgeons seem to be reluctant to report overload during procedures.²² Distractors cannot be completely controlled or nor entirely avoided. However, surgeons can learn to ignore a portion of distractions, and surgical training under noisy conditions has been found to be efficient.⁴⁹ Interestingly, although

the prevalence of distractors in the OR is well established and widely recognized as a problem, there are very few studies investigating effects of distractors on clinical outcomes.

5.3. Specific training

Training in non-technical skills and teamwork is gaining popularity in medicine, although it is less common for surgeons than for other medical fields. Many of these team trainings are modeled after crew-resource-management trainings used in aviation.⁵⁰ In the surgical context, most are combined with the introduction of pre- and post-briefings or checklists.⁵¹ Although there are still too few sound empirical studies investigating the effects of training in a surgical context, the available multi-site controlled studies are promising, showing that the combination of training and introduction of checklists led to lower complication and mortality rate.^{45,51} An observational study showed that non-technical skills training led to a significant reduction in technical and procedure related errors, although it was not associated with a shorter duration of operation time. Specific trainings may be classroom-based or include exercises, case studies, or simulations.⁵⁰ Nevertheless, in the future more interdisciplinary trainings are required that integrate technical and non-technical skills in the same training sessions, as well as continuous training and feedback related to everyday surgical practice.^{23,52}

Such recommendations are plausible and deserve to be tested and evaluated in detail. Difficulties of implementation should be acknowledged and analyzed seriously. For instance, many procedures such as checklists or time-outs involve a rather unfamiliar behavior, because they require “communicating the obvious” by repeating well known information; they are therefore time consuming. Furthermore, the communication failures they are meant to prevent occur very rarely. This may result in uncertainty to implement the procedure, at least until things are so routine that they become a recognized part of daily practice. These aspects need to be taken very seriously and not simply be interpreted as “resistance”.

6. Conclusions and outlook

The core aspect of human factors in the OR is the acknowledgment that surgery involves coordination of an interdisciplinary team. Coordinating and leadership of a surgical team requires skills and competences not only by the main surgeon but also by members of the entire surgical team. Definition of the team leader is required as they must be aware of team coordination and be able to respond to team members. At the same time, leaders must fully concentrate on the surgical procedure, be capable of dealing with complex requirements under potentially stressful conditions and distractions, and ensure that the main focus is not disrupted, but rather supported, by the entire surgical team.

Research discussed here has shown that non-technical skills influence team cooperation, team member well-being, stress, satisfaction, and ultimately patient outcome. In particular, the impact of non-technical skills on outcome needs to be explored in further clinical studies. These skills cannot be taken for granted (highly talented individuals notwithstanding) but require training. In addition, human factors considerations need to be supported by the implementation of procedures, with the use of checklists, for example, and by providing phases for information and reflection (time-out), as well as phases for recovery (breaks).

Research on these issues may profit from investigation and experience in other areas, such as aviation. However, the specific context and requirements of surgery including a large multidisciplinary team and a large variety of different types of procedures should be considered. Such research requires studies to be done

directly in the field (i.e. in the OR) to better understand the causes of communication failure, stress, and fatigue in more detail. Furthermore, these clinical studies also help to understand the difficulties in implementing certain non-technical strategies that have to be taken seriously. Results will help to evaluate and potentially implement novel methods designed to improve non-technical skills of the entire surgical team, to reduce errors, and complications and thus improve patient outcomes. Surgeons play a decisive role in this endeavor, and in order to achieve progress it is pivotal that they support these efforts.

Financial disclosure

Drs. Anita Kurmann, Franziska Tschan, Norbert K. Semmer, Julia Seelandt, Daniel Candinas, and Guido Beldi have no conflicts of interest or financial ties to disclose. This work was supported by the Swiss National Science Foundation (grant 138273).

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