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# 2 Safety in the Operating Theatre

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Human performance is not without error, at best the risk is 'as low as reasonable possible' (ALARP) [1]. As a consequence, errors occur. The most common site for adverse events in hospitals is the operating theatre (OT) [2, 3]. Studies have shown that 30–50 % of errors can be prevented [2, 3]. Although patients and their different condition, pathology and anatomy play and important role, many errors occur due to e.g., the complex non-standardized OT environment, the many people having to work together, the workload, the urgency and uncertainty of decisions, and the large variety of (non-ergonomic) instruments and instrumentation [2, 3, 4, 5]. In other words, the latent conditions in the system can easily lead to active operator errors, which are to be expected and are inevitable [2, 3, 4]. Adopting a system approach (opposed to a persons approach) could reduce the occurrence of preventable patient safety incidents by learning from errors, improving quality of equipment and technology, training of professionals (both technical and non-technical skills), and implementation and compliance to protocols and checklists [2, 3, 4–7]. Furthermore, it could be used to identify which technology needs to be developed or adapted to further improve patient safety.

There are many models describing the system approach and its different interrelated components surrounding the patient and influencing patient safety [3–5, 8]. The components Task, Individual, Team, Physical Work Environment, Organization & Management, and Political & Regulatory were used as a framework for describing safety in the OT in this chapter (see Fig. 2.1).

## 2.1 Task

Task performance can be supported by the use of checks. The most common ones are checklists. Checklists reduce the reliance on memory; they reduce the mental workload for the primary skill based task, saving capacity for the secondary rule and knowledge based tasks [3, 4, 6]. Several paper, electronic, and computer-based checklists can be used for several stages of a surgical procedure [3, 4, 6, 8]:

Pre-operative equipment checklists to check the availability and the safety status of OR devices, anaesthesia equipment, and laparoscopic instruments and apparatus [4, 6].

Pre-operative briefings to check and double-check important patient and procedure related factors before surgery to improve the safety attitude and to improve situation awareness. Some examples are the Surgical Safety Checklist, the SURPASS (SURgical PAtient Safety System), and TOP *plus* [3].

Intra-operative collaborative cross-checks (or double-checks, or the two-challenge rule). Cross-checks are performed by at least two people who examine each others' actions and observable behaviour to assess its validity and accuracy (e.g. critical view of safety during laparoscopic cholecystectomy) [3, 6]. Cross-checks detect erroneous actions, reduce perceptual errors, and improve coordination [3, 9]. Cross-checking also stimulates residents to recognize and respond faster to error prone situations and to 'speak up' [3].

Procedure-specific checklist to perform (and assess) subsequent clinical actions during a surgical procedure.

Post-operative debriefings to discuss and evaluate, with the entire OT team, the surgical procedure performed and dis-

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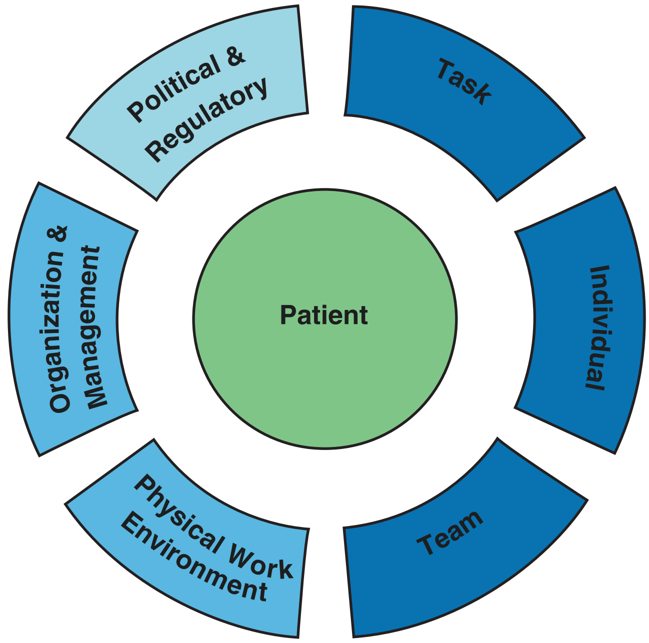


**Fig. 2.1** Six interrelated components of the system approach surrounding the patient and influencing patient safety (Based on [3–5, 8])

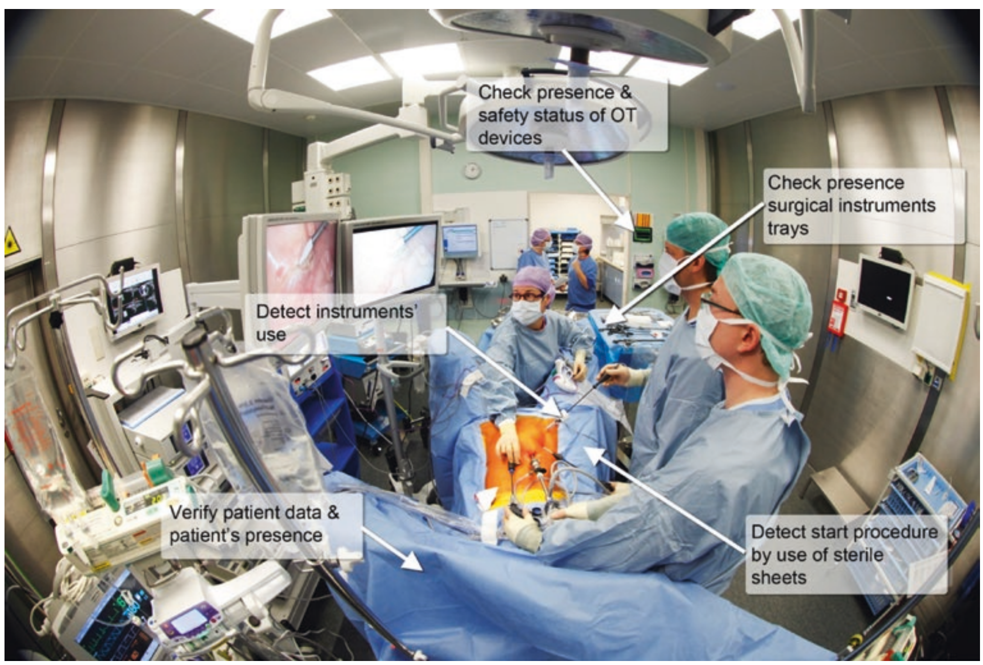


**Fig. 2.2** Using technology to automatically check and detect devices, patients and instruments and instrument use in the operating theatre

cuss possible near misses and recommendations for the future to learn from errors made. Checklists, such as the Surgical Safety Checklist, the SURPASS and TOP*plus* include these team debriefings [3].

Checklist can also be used to check important steps during the entire surgical trajectory. Furthermore, smart technology can be used to support healthcare staff during these checks, by e.g., RFID tracking to automatically check the presence and safety status of OT devices, and the location and presence of patients (see Fig. 2.2).

## 2.2 Individual

Surgeons and OT staff have to be competent and must have adequate knowledge and skills to perform a successful surgical procedure. Performing minimally invasive surgery requires a more complex set of skills (skill based, rule based, and knowledge based behaviour) than open surgery due to e.g., non-ergonomic instruments, limited freedom to manipulate, and limited indirect view on the operative field [3]. Although these skills and behaviour can be trained 'on the job', they are best to be trained 'before the job' in order to prevent patient harm. Individual technical skills can be taught by means of e.g., box trainers, Virtual Reality Simulators, and Augmented Reality trainers [3, 4, 10]. Simulated *common* scenarios can be used to train skill- and rule based behaviour and simulated *crises* scenarios can be used to train all types of behaviours, including knowledge based behaviour [3]. Besides preventing patient harm, training technical skills using simulation also has the advantage that it can provide objective feedback on the individual's technical performance (personal assessment) [3].

Surgical performance and technical skills can be assessed by means of supervision and feedback, and by means of more objective methods, such as: retrospective chart review, procedure-specific checklists, global rating scales, objective structured assessment of technical skills (OSATS), motion analyses, virtual reality simulators or video assessment [3].

## 2.3 Team

Seventy to 75 % of errors in OT are attributed to the non-technical skills of the OT team (communication, teamwork, leadership, decision-making, situation awareness) [3, 11]. OT team members have discrepant perceptions of teamwork and team members are sometimes discouraged to speak up because of traditional hierarchical structures, authority, social barriers, or differences in professional training and responsibility [3].

There is emerging evidence that team interventions that include both technical as well as non-technical skills support safe surgery [3, 12, 13]. Training aspects of team interventions, such as basic Human Factors Training, Medical Team Training or Crew Resource Management include: no denial/avoidance of the fallibility of human performance, acknowledge errors are made, no blame and shame for the actor of error (legal and ethical issues), situation awareness and vigilance (controlling external distractions, anticipating future events, using all team members for input), leadership and management (assertiveness, inviting input, horizontal authority, flat hierarchy), teamwork and cooperation, problem solving and decision making, and communication [3, 4, 7, 14]. Advantages of trained teams are tension free cross-checks (instead of directly addressing each other, which can be seen as offensive), naturally following guidelines and protocols as 'team dialogue' (now these documents are often not used or known), converting traditional vertical hierarchy into functional flat hierarchy, alternating leader-follower roles, and improve the working atmosphere.

Training individual technical skills as well as non-technical team skills can be done by means of interdisciplinary simulation in an operational environment, for instance e.g. the 'simulated operating theatre' [3]. Here, both common and rare crises scenarios can be trained. Especially for crises scenarios, this simulated environment provides a safe environment, without endangering the patient's safety [3]. However, training of these technical skills can also be done by means of cross-checks or team checks during both simulations as well as during actual surgical procedures [3].

Non-technical skills can be evaluated by means of several methods and techniques, e.g., Surgical Non Technical performance (NOTECHS), Anaesthetists Non-Technical Skills assessments (ANTS), Non-technical Skills for Surgeons (NOTSS), Scrub Practitioners' List of Intra-operative Non-Technical Skills (SPLINTS), Situation Awareness Rating Technique (SART), Situation Awareness Global Assessment Technique (SAGAT), Observational Teamwork Assessment for Surgery (OTAS), and Judgment Analysis [3, 7].

## 2.4 Physical Work Environment

The OT environment is not standardized and has changed drastically over the last decade, from OTs designed for open procedures only, to specially designed OTs for minimally invasive surgery and/or robotic surgery [3]. More and more technology is incorporated, which is not adapted to the users. This (unergonomic) working environment leads to health risks for both OT staff and patients and leads to inefficient processes. Besides following ergonomics guidelines to e.g. set-up the OT (Chap. 1) other environmental work conditions should be taken into account to reduce complexity and improve control of the OT environment [3, 4].

Both ambient temperature and air condition are important to prevent bacteria growth, patient's hypothermia, discomfort amongst team members, and airborne infection risk of all people in OT. The ambient temperature is kept low (20–23 °C) and high ventilation rate of the plenum or laminar airflow systems are set to reduce contamination. Furthermore, sterile areas, such as the operative table and sterile instrument table, should be placed in this airflow. In order to maintain an optimal airflow, staff movements, door movements and placing obstacles in front of the ventilation vents should be reduced to limit infections.

Staff and patients are exposed to many sounds in OT produced by apparatus and people [15]. Noise (unwanted sounds) affect both patients and OT staff. Particularly, non-predictable and non-controllable sounds and background conversation interfere with the performance of complex tasks, and have an instant and continuing effect. Additionally, noise impairs (critical) conversation. A solution to mask ambient OT noise is to play background music. Music can reduce patients' anxiety, pain levels, and sedative requirements, but can also distract (novice) surgeons performing new tasks [15].

One of the basic necessities to perform safe surgery is good vision of the operative field and related to that the quality and intensity of lighting [16]. Surgical lights should be focused on the operative field taking into account blocking of the light beam by OR staff. The nominal luminance produced by the ambient lights should be approximately 1000 lux, bright enough for the circulating OT staff and anaesthesia staff to perform their tasks. During the endoscopic part of minimally invasive procedures, the surgical lights are often switch off and the ambient lights switched to green light to enhance viewing on the flat screens.

## 2.5 Organization and Management

Hospitals have to become a learning organization [14]. This requires an organizational safety culture to change the attitude towards errors of both individuals as well as organizations [3, 4]. Staff should be actively engaged and encouraged to report patient safety errors [3, 14, 17]. Currently, incidents are underreported caused by fear of blame, time pressure, resource constraints, perception that reporting is unnecessary, and lack of clear definition [3, 14]. Therefore, reporting should not be used for punitive purposes and reporting errors should be facilitated by providing easy-to-use standardized electronic reporting systems or e.g. video- and audio recordings and new technology should be developed for automatic monitoring [3, 4, 14]. Furthermore, safety and safety significant events and issues have to be given the highest priority and must be constantly assessed by means of self-analysis of the organization [3, 4]. Errors should be analysed and solutions to problems should be planned, using combinations of different risk-assessment methods and incident analyses (e.g., retrospective chart review, event audit, observation, root cause analysis) [3, 4, 17]. Staff should also receive feedback information and recommendations based on these error analyses so they can train and learn from operational experience, leading to a proactive approach of error prevention [3,14, 17].

## 2.6 Political and Regulatory

In the OT, many protocols and guidelines are used to perform surgery, facilitate training, support clinical decision-making, and support maintaining professional standards in daily practice [2, 18]. These protocols are established by international and national surgical associations and are influenced by demands of e.g., healthcare inspectorates and insurance companies. Following protocols and guidelines also improves communication between team members by clarifying tasks and direction needed to perform safe surgery and increases task-efficiency (less operating time). Protocols also form the basis for information and communication technology for e.g., the electronic medical record and digital operative notes. Developing and implementing methods for (automatic) monitoring to check whether protocols and guidelines are followed properly will further improve patient safety in the OT.

**Conclusions**

Improving safety in the OT requires changes on different system levels and includes factors related to task performance, individual capability and training, teamwork, the physical work environment, learning capabilities of the organization and management, and political and regulatory demands on (inter)national level. Future interventions should take into account all these system levels, however, focusing first on teams and team skills, smart technology to support the OT team and ‘training before the job’.

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