Review

Learning non-technical skills in surgery

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Summary Skills other than technical or clinical competences are also recognized as essential in surgery. Most serious adverse events in health care are related to non-technical skill (NTS) failures. This has fostered interest in teaching surgeons about NTS. Reproducible evaluation scales, inspired by management strategies in the air transportation industry have been created in health care and some have been fashioned and validated specifically for surgeons. The list of NTS varies according to authors but one usually finds the same division into two main categories: social skills (communication, teamwork, leadership) and cognitive competences (situational awareness, decision-making). Stress and fatigue affect the implementation of these skills. Simulation is an efficient manner to teach NTS. The goals and exact modalities of how to teach NTS remains to be defined.

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Introduction

Acquisition of technical skills and competence is one of the main vocations of interns and residents during their training. Many efforts have recently been made to improve and standardize the technical aspects of training, essentially in the domain of simulation [1]. Notwithstanding, the skills necessary to become a good surgeon go beyond simply mastering technical skills or clinical knowledge. According to a study published in 1999, the capacity of communication, of reasoning and team-work are recognized as indispensable competencies in the formation of a good surgeon [2]. Several studies have since shown the strong relationship between non-technical skills (NTS) and the onset of iatrogenic adverse events [3–5]. A recent study identified NTS as a key element that surgeon must bring into the operating room [6].

These data have led the medical community to progressively understand that technical and clinical competencies are not enough and that acquisition of NTS should be integrated into the medical education program.

Non-technical competencies

The notion of non-technical skills originates from the air transportation arena in which the highest level of security is constantly sought. Analysis of aviation accidents unrelated to technical problems has clearly identified NTS failures as
a major contributing factor. This observation has led to the development of various strategies to minimize the risk of human errors in a specific potentially stressful environment. Consequently, Crew Resource Management (CRM) training was created with the goal of acquisition or reinforcement of the climate of safety culture among the aviation personnel, based on the recognition of the importance of NTS: situational awareness, teamwork, leadership, decision making and ability to cope with stress and fatigue. The underlying idea of the CRM training method is to foster communication and anticipation among the pilots in a crew in order to foresee and solve the problems before they turn into a dramatic situation [7]. The main advantage of CRM is to be able to qualitatively evaluate behaviors. This same strategy, integrated into the training and culture of pilots starting in the 1980s and 1990s, has since infiltrated other high-risk domains (nuclear industry, oil-drilling industry, fire-fighting forces...) and health care [8].

Non-technical skills in health care

Medical errors occur frequently. Adverse events without any relationship to the underlying disease occur in approximately 10 to 15% of hospitalized patients, and half are avoidable [3]. According to an American study conducted in three University hospitals, a communication failure between health care professionals was implicated in 43% of medical incidents [4]. A large proportion of these events occur in the operating room; the pre-operative check-list was initiated to prevent such avoidable errors. The efficacy of this check-list system has now been demonstrated in a highly robust manner [9,10]. However, in spite of its adoption, reports of poor (38%) use of the check-list have surfaced [11]. These data underscore the cultural differences in safety culture and risk perception between medical personnel and pilots [12].

The importance of NTS in health care has been recognized only recently. The initial studies concentrated on identification of inadequate competencies, based on reports of incidents or observational studies, in real environment or during simulation [13]. The first studies of NTS in health care showed that it was not possible to directly superpose the Crew Resource Management program used by pilots; it had to be adapted to the medical context and to identify the NTS specific to each specialty of the medical profession. In a pivotal publication in 1992, David Gaba (who is an anesthesiologist but also a longstanding pilot) transformed the aviation concept of CRM to one that could be used in anesthesiology by creating the Anesthesia Crisis Resource Management (ACRM) [14]. The principles of CRM used in aviation are found in Table 1.

Thus the anesthesiologists were the first specialty to formalize the importance of NTS by integrating them into their training program and by developing an evaluation system specific to the NTS required in anesthesiology (Anaesthetists’ Non technical skills, ANTS) [15,16].

Currently, there are several definitions of NTS in medicine. One of the most well-known was proposed by the team from Aberdeen (Rhona Flin and Georges Fletcher) that included two categories of NTS [13]:
- cognitive: situational awareness and decision-making;
- social: Organization of the workplace and teamwork.

### Table 1 Examples of definitions of the components of non-technical skills (NTS).

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<tbody>
<tr>
<td>Task management and designation of responsibilities</td>
<td>Planification</td>
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<td>Evaluation of priorities</td>
<td>Recognition of an event</td>
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<tr>
<td>Surveillance and cross-check</td>
<td>Medical knowledge relative to the situation</td>
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<td>Utilization of information</td>
<td>Initial management of the crisis</td>
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<td>Communication</td>
<td>Leadership</td>
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<tr>
<td>Leadership</td>
<td>Communication</td>
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<tr>
<td>Evaluation of problems</td>
<td>Distribution of tasks</td>
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<td>Elimination of pre-occupations</td>
<td>Concentration attention</td>
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<td>Call for help</td>
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<td>Evaluation and re-evaluation of patient situation</td>
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<td>Preparation for next steps</td>
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To this must be added two factors that promote NTS failure: stress and fatigue.

In 2018, the French High Health Authority (HAS) produced a training model called ‘Crew Resource Management in Medicine’ [17]. The elements are listed in Table 1. A comparison between the classifications shows that the differences are minimal.

### Evaluation systems for NTS

Evaluation scales with definitions of surgery-specific NTS have subsequently been developed. Currently, several important evaluation tools have been published. Their characteristics and reproducibility are detailed in a recent literature review [18]. Following the creation (and validation of the ANTS scale), the University of Aberdeen (Scotland) School of Psychology proposed an approach specifically for surgeons, highlighting the reproducibility of an evaluation that could be performed by non-experts in NTS called NOTSS (Non-technical skills for surgeons) [19]. This behavior marker system is the most widely used today [18]. Its inter-observer reproducibility and usefulness have been validated [20]. In reality this scale is quite close to that elaborated by the anesthesiologists. The NOTSS and ANTS scales are summarized in Table 2. The NOTSS and ANTS scales are made such that they evaluate the NTS of an individual, not of a team. Other markers are available to evaluate the NTS of a team, which can be considered a privileged target for a change in culture (more than the behavior pattern of any one individual). Certain classifications are generic, for example: the Team Performance Observation Tool, included in the overall TeamSTEPPS 2.0 (https://wwwahrq.gov/teamstepps/instructor/reference/tmptot.html) project is usable in all domains. Others have been constructed to evaluate teamwork in specific settings. If one wants to use a scoring system that specifically measures teamwork in

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1 Translator’s note: British spelling.

2 Translator’s note: British spelling.
the operating room, the NOTSS, described above, however, should not be used. The Oxford NOTECHS scaling system has been validated in the specific operating room environment and evaluates operative team NTS (surgeon, anesthesiologist, and nurses), according to quality metrics criteria. The Oxford NOTECHS [21] and NOTECHS II [22] tools have been proposed by the University of Oxford. These tools are useful for team evaluation, both to identify the weak points and to follow progress. Collaboration with experts in the aeronautic domain has led to the development of an observation and team evaluation instrument for surgical operations (Observational teamwork assessment for surgery, OTAS) [23]. Initially developed by the Surgical department of the Imperial College of London, this evaluation system was then refined. Both systems have shown have good inter-observer reproducibility. In a prospective study, Undre et al. evaluated teams involved in 50 surgical operations with OTAS [24]. This study not only evaluated the overall level for the team in terms of NTS, but also was able to identify specific points requiring particular attention. The value of evaluation scales is also to be able to measure the progress made by a team over time.

**Principle components of NTS**

**Situational awareness**

Situational awareness refers to the capacity to analyze information coming from the environment (patient, time, team, monitoring) but also to anticipate events that might or are about to occur [25].

In surgical steps that require intense concentration on the surgical technique, the surgeon can sometimes not perceive information or signals provided by other members of the team. If the information is critical, this “involuntary blindness” can be the source of adverse events. This risk must be understood by all members of the team and justifies the repetition of these important messages. To enhance the comprehension, auditory distractions (music, discussions unrelated to the surgery) must be eliminated, as is the case when pilots are in a critical portions of their flight, called the “sterile cockpit” phase [26].

All new information should be perceived and analyzed, by anticipating the potential risks, before deciding whether the gesture should be continued or not. Discussion with other surgeons or anesthesiologists to evaluate all potential options is essential to decrease the risk of misinterpretation of the situation. The capacity of momentarily halting the procedure in order to re-analyze the situation and integrate the new information is the hallmark of surgeons with good NTS.

**Decision making**

There are several different pathways possible to lead to such a decision. The mechanisms underlying intra-operative decision-making have been studied and briefly described [27]. During any such analytic decision, different options are gathered and the advantages and disadvantages of each compared one by one. This process calls for a particular effort, experience and devoted time. The literature seems to indicate that about one half of surgeons use this modality during surgery [28,29]. Another method is when a decision relies on a rule: this event calls for that action. Even though simple and reproducible, this approach is not adaptable to all situations.

Decision-making that relies on recognition of the situation is the most widely used by experts and is effective in stress-related situations where a rapid decision is necessary [30]. Experts are capable of recognizing situations they have already seen and then to make a decision based on their experience, without having to analyze what is going on.

Final decisions can be made in a creative or inventive fashion. This is usually used as a last recourse, because outcomes are uncertain.

<table>
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<th>Table 2  Evaluation steps for NOTSS and ANTS.</th>
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<tr>
<td><strong>Non-Technical Skills for Surgeons (NOTSS) [19]</strong></td>
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<tr>
<td><strong>Type of non-technical skills</strong></td>
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<td>Situational awareness</td>
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**S133**
In the NOTSS system, the decision-making section highlights the identification of different options, making them known and executing them.

Communication and teamwork

Communication is the cornerstone of teamwork [31]. Several studies have shown that communication failures are at the origin of serious medical events [4, 32]. Thus, Mazzocco et al. observed a strong relationship between poor communication among team members and an increased number of complications between post-operative days 0 and 30 [5]. Indeed, faulty communication is frequent in the operating room [33].

The goal of communication is to allow different members of a team to have the same perception of a situation and its eventual risks and to exchange information about the different steps of the intervention. Several communication obstacles were listed in a literature review [34]. Obstacles can be « internal », resulting from differences in culture, motivation, personal experience, hierarchy, mood or « external » such as noise, low voices, hearing problems or absence of visual signs. Various recommendations aiming to improve operating room communication have been formulated:

- avoid presuppositions and ambiguities;
- be precise and clear;
- check that information was well received;
- do not hesitate to say that information was not understood;
- deliver information at the right moment.

It is important to underline that improved communication is not only an individual effort but must be conceived on a team-based level.

Leadership

This competency is essential to ensure effective teamwork. One literature review clearly showed that the definition of leadership varied according to the systems used to evaluate NTS, but it was not possible to identify which leadership characteristics were determining factors in the success of an operation [35]. The NOTSS marker classification declines three pillars for leadership:

- define and maintain standards;
- encourage the other team members;
- manage stress and pressure.

The OTAS method includes adhesion to good practice standards, time management, utilization of all resources, feedback and authority [24].

Factors influencing NTS

Fatigue and stress are two elements that can affect NTS, independently of any technical mastery issues. Maintaining an optimal level of NTS implies understanding what they mean. Sleep deprivation, even minimal, can alter one’s cognitive capacities, similar to moderate alcohol consumption [36]. Reducing the time load facilitates reduction of errors due to inattention [37]. Nevertheless, the impact of fatigue remains under-estimated according to one inquiry revealing that 70% of surgeons interrogated considered that fatigue did not affect the technical gesture [38].

With regard to stress, a literature review showed that onset of stress was mainly related to the use of laparoscopic surgery, bleeding or time pressures [39]. A more recent study found that surgeons were exposed to stress chronically and not acutely, related to constant anxiety of a possible complication [40]. Management of this constant anxiety improves over time with experience.

Impact on the onset of adverse events

The influence of various training or awareness heightening programs for surgical teams to NTS has been evaluated. To analyze the results of these studies, one has to understand the terminology. One speaks of a crew in situations where each individual is interchangeable with another person and capable of performing the same task (notion of equivalent actor). In this setting, the configuration of the group is not the same from one day to another and security is assured by strictly following the established procedures as in the aviation industry. Conversely, one speaks of a team when a group of professionals know each other and are used to working together. In this case, security is assured not only by respecting the procedural rules but also by the understanding the actors have of each other. This understanding has advantages (fluidity of actions, anticipation) but also disadvantages (the unspoken, unaccomplished expectations or misunderstandings...). In the domain of health care, the situation is variable with, in some cases, teams that are stable and used to working together, while in other cases, a crew must be mobilized to care for the patients [41]. A large retrospective American study showed that team training (surgeon, anesthesiologist, nurse anesthesiologist, nurse) was associated with decreased surgical mortality [42]. The results of this study suggested that training in NTS should not be conceived on an individual level but should involve the entire team. A Dutch randomized study that included 74 teams showed that prior training of the entire team in a simulation unit improved performances when confronted with two emergency obstetrical scenarios [43]. A recent review of the literature found that “‘team training’ was the main topic of an increasing number of publications [44].

The synthesis of these studies clearly shows the positive impact of this strategy. Moreover, it would seem that timely grouped training combined with collective long-term strategies provide the best results.

What are the objectives to obtain in terms of NTS?

The reform of medical studies in France includes NTS training for residents in surgery, but no details are available with regard to the contents or the goals of the educational program [45]. Traditionally, surgical culture favors individual performances [46]. Thus, it is probable that training of young surgeons in NTS could change this culture, in which a successful operation will be seen as the result of true team effort.

Even though defining the precise goals of NTS is not the objective of this article, several points seem important. The very fact of defining NTS and heightening the awareness of their importance to surgeons during their education is the first step.

Installing a culture of safety by underscoring the dual verification of critical information and standardized communication during the key moments of an operation on one
hand, and feedback and analysis of adverse events, on the other.

Identifying « bad behaviors » or inadapted attitudes

Revisiting the notion of hierarchy. The notion of « senior » versus « junior » hierarchy is solidly anchored in hospital culture, and particularly in surgery. This situation contrasts sharply with the aeronautical profession where criticism or calling into question of the commander by the co-pilot is encouraged, even though the final decision remains under the reins of the leader.

The attitude of the active « follower », that is, someone who intervenes in the development, verification and progression of events decreases the risk of forgetting something and improves situational awareness.

How should NTS be taught and evaluated?

In the absence of any clearly defined gold standard, any description of the optimal approach would be difficult. How to react when an acute and unexpected problem arises can be interpreted in different ways and several opinions exist as to the way to respond. This is why the scaling systems requires acceptance of a certain degree of incertitude and flexibility in their interpretation as well as reliance on surgical experience [21,22].

Several educational modalities have been shown to be effective. These include formal courses, demonstrative videos, and simulations. Each approach having its own precise goal, it seems that the best results are obtained by a combination of several of them [18]. The goal of formal courses is to explain the different NTS and their importance, the videos stimulate learner awareness of the drawbacks of NTS, while simulation guides the learner to train and improve his or her skills in conditions that are close to clinical practice. One example of a training program for teamwork in the United States is called Team STEPPS (The Team Strategies and Tools to Enhance Performance and Patient Safety) and can serve as a working basis [47]. High fidelity simulation is also an interesting pedagogical tool to learn NTS [48].

Several studies have reported that technical skills were correlated with NTS [49,50]. Leadership qualities contribute to help improve exposure and facilitate the surgical gesture while mastering a technique allows the operator to maintain an optimal level of NTS not to have to concentrate only on the gesture.

These studies suggest that learning and evaluation of NTS should be associated with technical skills. This also signifies that simulation should include technical gestures that have a particular degree of difficulty or must be performed under a particular constraint, in order to replicate real life on one hand, and, on the other, to limit the Hawthorne effect (better outcome for participants motivated because they are being observed). Each scenario usually includes pedagogic technical and non-technical objectives.

Several scenarios soliciting NTS exist already and have been tested by simulation [19]. They imply diverse situations: late arrival of one of the members of the team, material failure, personal problems of one member of the team, major bleeding. Generally speaking, a high-fidelity simulation includes a briefing, then a scenario with a team that is immersed in a high-fidelity environment (for example an operating room with a mannequin). The scenario is then transmitted directly to another room with other learners. In the next step, there is a common debriefing between the trainer and all the learners who engage in a reflective analysis of the technical and NTS relative to the scenario. This debriefing is an essential step in the training process. Likewise, teaching the teachers is indispensable [48,51]. These simulation sessions allow the trainee to fully understand the concept of inter-professionality and its importance by involving all members of the team implicated in the operating room: surgeon, scrub and circulating nurse, anesthesiologist, nurse anesthetist… all taking care of the same patient.

There are two evaluation modalities: one is called penalization or summative (the goal is to obtain a grade, a diploma) and the other formative evaluation (the goal is to improve the skills of the learners). Each training program has to define their evaluation modality. Currently the favored model is the formative evaluation; data with regard to the capacity of the simulation program to identify and grade weaknesses remains a topic for debate.

A literature review has shown that self-evaluation of skills is not reliable. Optimal evaluation requires an external reviewer [52]. Moreover, the results obtained using evaluation grids are more reproducible between two expert surgeons than between expert and novice [33]. The previously described evaluation grids for NTS and teamwork (MOTECH...) can be used to evaluate NTS but they require preliminary training.

Conclusion

Interest in NTS is increasing, attesting to the awareness that the practice of surgery requires not just technical savoir-faire and clinical knowledge. Thanks to the experience acquired in the air transportation industry or other industries potentially at risk in terms of NTS, we now have a clear definition of NTS, applicable to the operating room by the surgical team. Evaluation grids have been validated for NTS and can serve as support for pedagogical projects. All the tools necessary for teaching NTS are available. Training in NTS is a new element in the training pathway of French surgeons, and for which the question of the best modality and means necessary for this training remains open.

Disclosure of interest

The authors declare that they have no competing interest.

References


