Non-technical skills in robotic surgery and impact on near-miss events: a multi-center study

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Abstract

Background Robotic surgery requires a set of non-technical skills (NTS), because of the complex environment. We aim to study relationship between NTS and near-miss events in robotic surgery.

Methods This is an observational study in five French centers. Three robotic procedures were observed and filmed by one of expert trainers in NTS. They established and scored a non-technical skills in robotic surgery (NTSRS) score, that included eight items, each scored from 1 to 5, to assess the whole surgical teams. The surgical teams also self-assessed their work. The number of near-miss events was recorded and classified as minor, or major but no harm incidents, independently by two surgeons. Correlations were Spearman coefficients.

Results Of the 26 procedures included, 15 were prostatectomy (58%), 9 nephrectomy (35%), and 2 pyeloplasty (7.7%). Half of procedures ($n = 13$) were performed by surgeons with extensive RS experience (more than 150 procedures). Per procedure, there was a median (quartiles) of 9 (7; 11) near-miss events. There was 1 (0; 2) major near-miss events, with no harm. The median NTSRS score was 18 (14; 21), out of 40. The number of near-miss events was strongly correlated with the NTSRS score ($r = -0.92$, $p < 0.001$) but was not correlated with the surgeon's experience. The surgeons for fifteen (58%) procedures, and the bed-side surgeons for 11 (42%) procedures, felt that there was no need for an improvement in the quality of their NTS. None of the surgeons gave a negative self-evaluation for any procedure; in three procedures (12%), the bed-side surgeons self-assessed negatively, on ergonomics.

Conclusion Occurrence of near-miss events was reduced in teams managing NTS. Specific NTS surgical team training is essential for robotic surgery as it may have a significant impact on risk management.

Keywords Assessment, Live surgery, Near-miss events, Non-technical skills, Robotic surgery, Training

Non-technical skills are known to be essential in surgery. We aimed to study their impact on risk management in robotic surgery, due to its specific spatial configuration by assessing non-technical skills of surgical teams and occurrence of near-miss events.

Robotic surgery takes place in a technically complex environment, where team members are separated and visual communication, which is 80% of informations exchanged in non-robotic surgery, is totally inoperative [1, 2]. In addition, verbal communication is impaired, due to the distance between team members. This new robotic surgery paradigm

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requires interactions inside the team, through a set of non-technical skills (NTS): decision-making and situational awareness, social interactions (communication, cooperation) and personal factors as leadership (Fig. 1). These skills have already demonstrated their importance in surgery; they have a significant impact on surgical results and if not mastered, they may lead to an increase in peri-operative morbidity and mortality. Gawande et al. found that 43% of all surgical errors were related to problems in communication and teamwork [3]. Robotic surgery demands significant adaptations to the standard operating room environment including team interactions, good organization and ergonomics, stress and disruptors management [4] (Fig. 1).

Poorly organized teamwork can lead to misunderstandings, poor decision-making, loss of time, technical problems, or errors. These malfunctions are intraoperative adverse events which are defined as "something that was not intended by the surgeon, nor desired by a set of rules or an external observer, or that led the task outside acceptable limits" [5]. Non-technical errors may be associated with intraoperative adverse events and also may influence clinical outcomes [6, 7].

To assist the standardization of intraoperative reporting, the EAES (European Association for Endoscopic Surgery) designed an adverse event classification [8]. This system categorizes intraoperative events with the goal of reproducing industrial practice where it has long been acknowledged that near-miss events form the base of a pyramid with serious incidents typically preceded by numerous low impact [9].

Near-miss events are defined as occurrence of a risk, or an action or omission, that increase likelihood of negative consequence and under slightly changed circumstances could result in an injury or adverse effect on patient outcome.

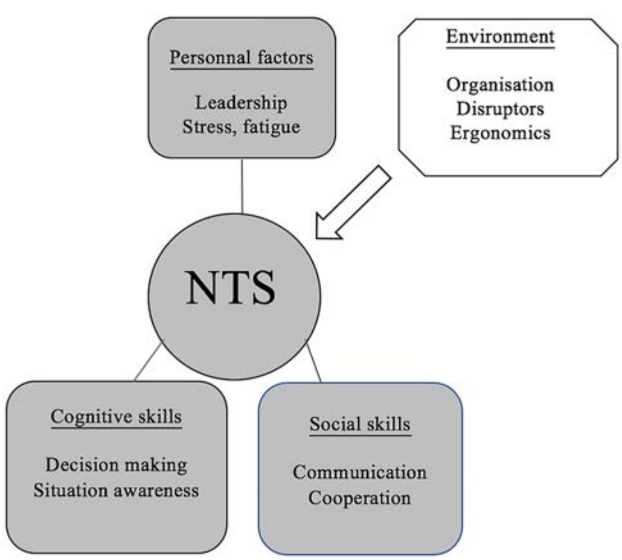

Fig. 1 Non-technical skills (NTS)

These near misses correspond to grade 1 and 2 of the EAES classification of intraoperative adverse events in laparoscopic surgery [8].

Only few studies have evaluated impact of NTS in robotic surgery, whereas this is a configuration where NTS are probably the most decisive [10, 11]. Some studies have shown a link between improvement of NTS and better technical realization in simulation [12–14], but none have studied the relationship between NTS and occurrence of intraoperative near-miss events in live robotic surgery.

We aimed to assess NTS of surgical teams in robotic surgery and their relationship with occurrence of near-miss events in the operating room.

Materials and methods

This is a multi-center prospective observational study of robotic-assisted surgery, conducted over one year period, in five French urological surgery departments: Toulouse University Hospital, Nancy University Hospital, Gentilly Polyclinic in Nancy, Montpellier University Hospital, and Robert Schuman Hospital in Metz.

To collect data objectively, we commissioned 2 experts in NTS from STAN (Surgical Telemanipulation Advanced Notechs) Institute. STAN Institute is a private company composed by French Air Force Instructors experts in human factors, organizational behavior and NTS, trained by IRBA, the French Armed Biomedical Research Institute. Those professionals master the Medical Crew Resource Management© an adaptation of Crew Resource Management courses developed by aviation and adapted to healthcare [15]. Experts were informed on different procedures observed and had a good knowledge of robotic surgery and in assessing surgeons, as they are trainers for the international robotic surgery university degree program in Nancy, France.

Procedures were observed and filmed by one of the expert trainers. Video recordings were taken by a wide angle camera positioned so that the surgeon at console and the team at bedside can be viewed, with audio capture by microphones. Patients were not filmed during procedures and we did not collect their personal data or clinical outcomes.

Before each procedure, the expert noted: date, location and type of procedure, a census of the entire team (surgeon, bed side surgeon, scrubbed nurse, circulating nurse, anesthesiologist, anesthetist nurse), experience of the surgeon (number of procedures performed, total number of procedures in robotic surgery, training in robotic surgery, prior awareness of NTS), experience of the bed-side surgeon (number of robotic surgery assisted, duration of practice as bed-side in robotic surgery).

He recorded and time-stamped each event not intended or which led the task outside acceptable limits, and its nature.

He also noted if there was a pre-operative briefing, the completed WHO checklist and a debriefing.

During live observation, the expert completed the Non-Technical Skills in Robotic Surgery (NTSRS) score (Table 1).

Tool development: the NTSRS score is a composite score, derived from different tools that were developed to measure NTS of surgeons [16–21]. It was developed by the STAN Institute expert trainers, in collaboration with three surgeons: two surgeon-educators, experts in robotic surgery, and a senior surgical trainee. The selection and definition of the eight nontechnical skill items to be included in this new rating tool was based on existing evidence-based rating systems and frameworks of nontechnical skills in the operating room (communication, cooperation, decision-making, leadership and situational awareness), adding three areas that were judged specific to robotic surgery: organization, ergonomics of the operating room, and stress and disruptors management. Those three areas were classified as the "environment" dimension and were identified by all STAN Institute experts as essential to assess non-technical skills of surgical teams in robotic surgery. They were missing in all the reference tools [4, 22].

Previous to the study, the NTSRS score was blind tested by the experts in simulated operating rooms.

For each procedure, the expert rated the eight items in the score based on a Likert scale from 1 (very poor) to 5 (excellent).

The total NTSRS score is the sum of the results obtained from the three environment and the five skills items (Table 1).

At the end of procedure, the expert asked separately for self-assessment of the surgeon, the bed-side surgeon and the scrubbed nurse about: ergonomics, quality of communication, cooperation, leadership, situational awareness and maintenance of safety. Each item was rated with a Likert scale from 1 (very poor) to 5 (excellent). Notes 1 and 2 corresponded to a negative self-assessment, 3 to a neutral impression, 4 and 5 to a positive impression.

Based on the experts observations and event recordings, completed with analyzes of video recordings, two surgeons (a surgeon-educator expert in robotic surgery, and a senior surgical trainee well educated to the different procedures) independently counted and classified near-miss events using observational clinical human reliability analysis (OCHRA) [23, 24]. They classified near-miss events as grade 1 (minor error, no damage or corrective action required, security control was maintained) and grade 2 (major error, event with no harm) (Table 2). Each procedure was blinded and analyzed by the two separate surgeons. Surgeons were not involved into procedures. Before the study, they were trained to NTS and to assess errors in robotic surgery.

Their inter-observer reliability was evaluated by the intraclass correlation coefficient [25]. A coefficient greater than 0.8 corresponded to a good reliability [26].

Approval by the institutional ethic committee of Nancy University Hospital was obtained, and all surgical teams were observed and filmed after they provided informed consent.

Statistics

Numerical parameters were described by median (quartiles), qualitative parameters as frequency and percentage. We evaluated the relationship between numerical parameters using the Spearman correlation coefficient. According

Table 1 The non-technical skills robotic surgery (NTSRS) score

The NTSRS score			
Dimension	Minimum–Maximum score	Element	Behaviours
Environment	3–15	Organization	Preparation of adequate equipment, checklist at the beginning of the intervention, qualified and trained personnel available
		Ergonomics	Installation of the robot and the console, layout of the room
		Disruptors	Identifying and managing stress and distraction, maintaining cognitive skills
Skills	5–25	Safe communication	Appropriate and effective verbal communication, presence of feedback
		Situation awareness	Awareness of the patient's condition, difficulties and roles of the team, anticipation of problems
		Cooperation	Interaction with bed-side surgeon, with the nursing team, with the anesthetist team
		Leadership	Delegation and coordination of tasks to his team, supports his team, does not transmit stress
		Decision-making	Decision on technical or human issues, considers options, argues choices
Total score	8–40	Scoring: (1) Very poor (2) poor (3) acceptable (4) good (5) excellent	

Table 2 The near-miss events classification

Near-miss events grade	Intraoperative near-miss events classification	Example error events
Grade 1	Minor error, inconsequential, no damage or corrective action required, maintain of security control	Applying excessive force, concentration lapses, poor instrument selection or insertion, incorrect order of steps, unplugged cables, tissue avulsion, wrong clip application, continues procedure with stain on the endoscope, minor loss of time, robot arm conflicts
Grade 2	Major inconsequential error with unsupported safety or consequential event with no harm, requiring corrective action but no change in postoperative care	Loss of instruments of the field of vision with sudden and insistent movements, minor bleeding, brutal loss of pneumoperitoneum, wrong coagulation parameters, wrong plane dissection, accidental trocar extraction, missing compress

Table 3 Procedure characteristics

	n (%) of procedures
Experience of surgeons	
> 150 procedures in robotic surgery	13 (50%)
20–150 procedures in robotic surgery	11 (42%)
< 20 procedures in robotic surgery	2 (8%)
Presence of checklist, briefing or debriefing	
Complete checklist	1 (4%)
Partial checklist	16 (62%)
Briefing	12 (46%)
Debriefing	2 (8%)

to Cohen [27], the correlation was considered strong if the absolute value of the correlation coefficient was greater than 0.5. Numerical parameters were compared between groups by a Wilcoxon test. Analyzes were performed using SAS software, version 9.4 (SAS Institute Inc., Cary, NC, USA). The level of significance was set at 5%.

Results

Procedure characteristics

Of the 27 procedures observed between September 2016 and September 2017, one was not included in the study for early laparotomy (due to abdominal adhesions). There was 15 procedures observed by one expert and 11 by the other one.

Procedure characteristics are given in Table 3.

NTSRS score

The median NTSRS score was 18 (14; 21), out of a maximum of 40 (Table 4). The lower score was 10 out of 40, and the higher score was 25 out of 40. 42% ($n = 11$) of teams obtained a NTSRS score higher than 20 out of 40.

In the domain of environment, experts observed poor organization and poor disruptors management (scores < 3 out of 5) in 73% ($n = 19$) of procedures. In 88% ($n = 23$), experts noted poor ergonomics because of wrong layout of the console or the robot.

Safe communication was good (score > 3 out of 5) in one procedure, and was assessed 'very poor' in 61% ($n = 16$) of procedures.

Table 4 Number of near-miss events per procedure and the Non-Technical Skills Robotic Surgery (NTSRS) score for the 26 procedures observed

	Median (quartiles)	Minimum–maximum
Number of near-miss events per procedure		
Total	9 (7;11)	3–20
Grade 1 near-misses	7 (7;10)	3–14
Grade 2 near-misses	1 (0;2)	0–7
Non-Technical Skills Robotic Surgery (NTSRS) Score		
Environment		
Ergonomics	2 (2;2)	1–3
Organization	2 (2;3)	1–3
Distractors	2 (1;3)	1–3
Environment score /15	6 (5;7)	3–8
Skills		
Communication	1 (1;2)	1–4
Situation awareness	2 (2;3)	1–4
Decision-making	3 (2;3)	1–5
Cooperation	3 (2;4)	1–4
Leadership	3 (2;4)	1–5
Skills score/25	13 (9;15)	6–19
Total Score/40	18 (14;21)	10–25

Experts found that situation awareness were poor in 69% ($n=18$) because of lack of anticipation and not sharing the situation awareness within the team.

Leadership, decision-making and cooperation were assessed acceptable, good or excellent (score > or = 3 out of 5) in respectively 18 (69%), 15 (58%), and 13 procedures (50%).

There was a statistically significant correlation between the environmental dimension and the skill dimension of the NTSRS score (correlation coefficient, $r=0.59$, $p=0.002$).

Near-miss events

For the 26 observed procedures, a median of 9 (quartiles: 7; 11) near-miss events per procedure was observed (Table 4); 38% ($n=10$) of the procedures had more than nine near-miss events and more than two grade 2 near-misses. The intra-class correlation coefficient for the number of grade 1 near-miss events was 0.87, 95% CI [0.75; 0.94] and 0.80 [0.61; 0.90] for grade 2 near-miss events. When there was fewer than 10 near-miss events, the number of grade 2 near misses was more than 1 in only one case. If there were more than 9 near-miss events, there was fewer than two grade 2 near-miss events in only one procedure.

Relationship between NTSRS scores and number of near-miss events

The number of near-miss events was strongly and negatively correlated with the NTSRS score ($r=-0.92$, $p<0.001$) (Table 5), with strong correlations for both the numbers of grade 1 and 2 events. Near-miss events were correlated with environment score ($r=-0.72$, $p<0.001$) and skills score ($r=-0.84$, $p<0.001$) and both near-misses grade 1 and 2 were correlated with each dimension of NTSRS score.

Relationship with surgeon's experience

Surgeons had a median of 10 years of experience in surgery (quartiles, 5; 14), and 5 years (4; 6) in robotic surgery. There was little correlation between the number of near-miss events per procedure and the surgeon's experience (Table 5); further, the surgeon's experience was not related with the NTSRS score, except in the area of decision-making where there was a moderate correlation with number of procedures in robotic surgery ($r=0.45$, $p<0.05$) and years of experience in robotic surgery ($r=0.4$, $p<0.05$) (Supplement 1).

Table 5 Factors associated with the number of near-miss events, in 26 robotic surgery procedures

	Total number of near-miss events		Number of grade 1 near-miss events		Number of grade 2 near-miss events	
	r[1]	*p* value	r	*p* value	r	*p* value
Non-technical skills in robotic surgery score						
Total score	− 0.92	< 0.001	− 0.80	< 0.001	− 0.88	< 0.001
Environment score	− 0.72	< 0.001	− 0.66	< 0.001	− 0.72	< 0.001
Skills score	− 0.84	< 0.001	− 0.78	< 0.001	− 0.77	< 0.001
	Total number of near-miss events		Number of grade 1 near-miss events		Number of grade 2 near-miss events	
	r	*p* value	*r*	*p* value	*r*	*p* value
Surgeon's experience						
Number of years of surgery procedures	− 0.09	0.653	− 0.06	0.762	− 0.06	0.781
Number of robotic surgery procedures	− 0.21	0.298	− 0.16	0.428	− 0.19	0.367
Number of years of robotic surgery	− 0.16	0.430	− 0.14	0.477	− 0.15	0.483
	Total number of near-miss events		Number of grade 1 near-miss events		Number of grade 2 near-miss events	
	Median (q1;q3) [2]	*p* value	Median (q1;q3)	*p* value	Median (q1;q3)	*p* value
Pre-operative checklist						
Not done ($n=9$)	11 (8;14)	0.143	10 (7;11)	0.171	1 (1;3)	0.122
Done ($n=17$)	8 (7;10)		7 (6;8)		0 (0;2)	

[1]Spearman correlation coefficient

[2]Median (quartiles) of the numbers of near-miss events

Impressions of teams

The surgeons and the bed-side surgeons thought there was no need for improvements to the quality of their NTS for 15 (58%) and 11 (42%) of the procedures, respectively.

There was no negative self-assessment of surgeons on any of the procedures in any areas. For three procedures (12%), bed-side surgeons self-assessed negatively on ergonomics (Table 6). 13 assessments were missing for scrubbed nurses. They thought there was need for improvement of their NTS in 8 procedures. Negative self-assessment for ergonomics was given in two procedures and for communication also for two procedures.

Table 6 Self-assessment of surgeons and their teams (bed-side surgeons and scrubbed nurses) on their non-technical skills in 26 robotic surgery procedures

	Self-assessment of non-technical skills (n (%))		
	Negative	Neutral	Positive
Surgeon's assessments ($n=26$)			
Ergonomics	0	5 (19%)	21 (81%)
Communication	0	1 (3.9%)	25 (96%)
Decision-making	0	0	26 (100%)
Cooperation	0	0	26 (100%)
Situation awareness	0	1 (3.9%)	25 (96%)
Leadership	0	1 (3.9%)	25 (96%)
Safety	0	1 (3.9%)	25 (96%)
Bed-side surgeon's assessments ($n=26$)			
Ergonomics	3 (12%)	6 (24%)	17 (65%)
Communication	0	3 (12%)	23 (88%)
Decision-making	0	2 (7.7%)	24 (92%)
Cooperation	0	2 (7.7%)	24 (92%)
Situation awareness	0	1 (3.8%)	25 (96%)
Leadership	0	2 (7.7%)	24 (92%)
Safety	0	4 (15%)	22 (85%)
Scrubbed nurses assessments ($n=13$)			
Ergonomics	2 (15%)	3 (23%)	8 (61%)
Communication	2 (15%)	2 (15%)	9 (69%)
Decision-making	0	0	13
Cooperation	0	0	13
Situation awareness	0	0	13
Leadership	0	1 (8%)	12 (92%)
Safety	0	1(8%)	12 (92%)

Discussion

Link between NTS and near-miss events

This study shows a strong negative correlation ($r=-0.92$, $p<0.001$) between NTS and number of near-miss events in robotic surgery: the higher the NTSRS score, the fewer near-miss events. NTSRS score was strongly correlated with both near-misses grade 1 ($r=-0.8$, $p<0.001$) and grade 2 ($r=-0.88$, $p>0.001$). This is the first study which proves impact of NTS on near-misses, specifically for robotic surgery. Our study shows how essentials are NTS to reduce near-miss events in robotic surgery.

In the literature, there is an improvement in technical performance when NTS are mastered [28]. Schiff et al. found an increase in blood loss and operating time in case of communication failures between the surgeon and his team or when there was a high level of noise in the operating room [29].

In our series, we did not observe any harmful intra operative adverse events and no information on patient outcome was available; consequently, the relevance of the identified events for patient outcome could not be ascertained. However, near-misses analysis represents a novel surrogate assessment method for intraoperative technical performance [30, 31]. Analyzes of clinical outcome could be the subject of further studies.

Despite the few procedures observed, we found strong correlations, which let us think that by increasing our workforce, we should strengthen our results.

NTSRS score

NTSRS scores were quite low, half of teams obtained scores lower than 18 out of 40 and the higher NTSRS score was 25 out of 40. Teams obtain acceptable or good scores in the areas of leadership, decision-making and cooperation as experts observed good teams interactions, caring atmosphere, goodwill of surgeon, and appropriate decisions made at the console or the bedside in respectively 69%, 58% and 50% of the procedures.

Whereas in situation awareness and safe communication areas, experts noted poor behaviors as there were hazardous or not effective communication, and lack of feedback.

Experts observed poor organization and disruptors management as there were issues with preparation of equipment, wrong console or robot settings, or failure to complete the checklist and the presence of disruptors, with difficulties to maintain cognitive skills and distraction from the task performed.

A study to attempt validating the NTSRS score should be done. Reliability and reproducibility analyzes of our score are necessary. Although, this is a multi-center study with structures with different organizations (private and public) and the assessment was successfully done each time. The score was also blind tested by the experts before the study and seems to show good reproducibility but no statistical analysis have been done and this is one of the limitation of our study.

Raison et al. recently proposed a new NTS assessment tool: the Interpersonal and Cognitive Assessment for Robotic Surgery (ICARS) system [32], that has been validated and shown to be reproducible for robotic surgery. It includes an environmental dimension and also ergonomics, disruptors and checklist but the study was published after our study period.

We could think principal bias of our study relates to the Hawthorne effect with on-site presence of the assessor and recording devices in operating room. This could improve or deteriorate general surgical teamwork and NTSRS score. However, scores being quite low, we might think that its presence was forgotten once the surgical team was plunged into procedure.

NTS training and bed-side surgeon's role

Although the importance of NTS is recognized, these skills are rarely taught and evaluated during medical training and even though they have been shown to improve patient safety [33].

Yule et al. concluded that dedicated training for NTS helped improve team members NTS and timeliness in managing troubles [34]. NTS training is appropriate for all levels and training juniors alongside senior is probably the best way [35]. It concerns the whole surgical team. Recently, the robotic surgery section of the European Association of Urology proposed a standardized robotic surgery training curriculum, that includes a non-technical dimension [36, 37].

Al-Jundi et al. found that 81% of surgical team members considered training in these NTS to be as important as learning technical skills. Despite this, junior surgeons were the group, who considered NTS not to be so important [38]. However, the bed-side surgeon has a primary role within the surgical team [39, 40] and experts observed surgeons aware of NTS working with a bed-side surgeon who was not aware or not trained in robotic surgery and NTS: safe communication, shared situation awareness, and cooperation were deteriorated.

The benefit of training in robotic surgery through simulation has already been demonstrated for technical and non-technical skills [41–43] Bootcamps or simulation workshops in multidisciplinary teams are a good way to improve both the technical and non-technical skills of junior surgeons [35, 44–46] and should be integrated with robotic surgery training to improve safety.

NTS and experience

In our study, no correlation was found between surgeon's experience and the NTSRS score, except in the area of decision-making. That does not mean experience is not related with NTS acquisition but we should distinguish between experience and specific training in NTS.

A study by Gostlow et al. found that NTS scores initially increased quickly with experience until reaching a peak after the end of junior training and then decreased linearly over time, particularly in the areas of leadership and cooperation [47].

A recent literature review pointed out that curriculum trained surgeons achieved outcomes rates at least comparable to those of expert surgeons and emphasized the importance of tools for evaluating NTS and the implementation of standardized and validated curricula [48].

Teams impressions

Most of surgical teams assessed themselves very positively on all of their skills. Only few bed-side surgeons criticized on ergonomics, which seems far from experts evaluation. We did not analyze correlation between experts scores and self-assessments. However, teams, whether the surgeon, the bed-side, or the scrubbed nurse, self-assessed very positively, while score assessed by the experts were low. For example, in the safe communication area, surgeons and bed-side surgeons self-assessed themselves positively (>3 out of 5) in 96% and 88% of procedures while expert's score was more than 3 out of 5 in only one (3.8%) procedure and median score was 1 out of 5 (1; 2). In the ergonomics area, experts noted negative scores in 88% of procedures, whereas surgeons, bed-side surgeons and scrubbed nurses self-assessed negatively in respectively 0, 15% and 12% of procedures.

It could be because no intraoperative adverse event occurred during the study that teams felt there is no need for improvement, or because they are not aware of the importance of NTS. Furthermore, while there is a general caring atmosphere in the operating room, maybe team members don't want to give personal negative review as they are afraid of uncertain privacy. In medicine, we often overrate our skills and surgical teams might work on it.

Finally, a Likert scale with general skills is maybe not appropriate for self-assessments and perhaps we should use more specific and relevant questions.

It would be of interest to study whether there is a link between surgeon's leadership and his team's cooperation.

STAN Institute's review

In operating rooms, safe communication is generally weak. However, the observers have detected that surgical teams use a standardized communication for extraction of foreign objects from the patient ("needle extracted", "compress is out",…). They noticed that communication is not always effective and efficient for all kind of request (for example when changing of pneumoperitoneum pressure or preparing equipment). Teams speak a lot but communicate not particularly.

The observers have remarked that surgeon's leadership is essential and his goodwill with his team increases cooperation.

Due to their own training and experience, the surgeon and the bed-side surgeon have a good self-situation awareness. Because of the lack of communication, this situation awareness is not shared with the surgical team and could create a root of near-miss events. With safe verbal communication (transmitter sends a request- receiver collates the message, acts and then gives feedback to the transmitter) situational awareness is increasing within the team.

According to the experts, there are a lot of disruptors in robotic operating rooms (phone calls, colleagues entering and leaving the room, some speaking with the surgeon or with the team, change of a team member) which cause interference in safe communication and influence the leadership and the decision-making.

Teams could also implement briefing which is another security standard procedure. It is done sometimes when surgery is expected to be difficult but remains brief. However, it allows the whole team to be plugged into the procedure and increases situational awareness. No debriefing was observed though it aims to improve team performance. However, these two measures increase the quality of teamwork and the feeling of security in operating theaters [49, 50].

Conclusion

High NTSRS score is strongly associated with low number of near-miss events. Thus, improving NTS in robotic surgery may lead to reduce the occurrence of near-misses and could have an impact on risk management. Robotic surgery requires technical deftness and additional mastery of NTS appears to be decisive to raise awareness of the occurrence of errors. We need further studies to prove the role of NTS on clinical outcomes in robotic surgery.

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Compliance with ethical standards

Disclosures Drs Anthony Manuguerra, Nicolas Hubert, Charles Mazeaud, Mathieu Roumiguie, Prof. Pascal Eschwege and Jacques Hubert, Miss Julia Salleron report that they have no conflicts of interest or financial ties to disclose.

Informed consent All members of surgical teams gave their consent to be filmed and assessed during procedures.

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