ORIGINAL ARTICLE

A robotic teaching session: separating tool from technique to emphasize a cognitive focused teaching environment

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Abstract

Most robotic curriculum requires simulation on a console prior to operative exposure. This practice does not permit experiencing the physical collisions with the robotic tools, which occurs during surgery. We designed and evaluated an innovative curriculum to address cognitive components and trouble-shoot robotic collisions when the surgeon lacks haptic feedback. We adapted our previous curriculum, designed to teach and document proficiency of robotic docking and instrument exchange, to include robotic collisions. Participants received a 10-min, didactic presentation describing finger grips, internal and external collisions, and instruction on how to trouble-shoot each type. Residents worked in pairs, one at the console and the other at bedside, to complete two simulation exercises. Participants manipulated the robot to determine how best to resolve the situations. Residents completed retrospective post-course surveys and instructors completed a final survey. For comparison, non-participants, PGY-matched surgical trainees, also completed a survey. All participants demonstrated proficiency in docking and instrument exchange. Compared to pre-session, post-session knowledge and confidence improved in five domains reflecting session objectives ($p < 0.05$). Participants could list and troubleshoot collisions more than the non-participant matched peers ($p < 0.05$). Instructors supported the additional collision components, but noted learners needed more time. Two of three non-participants expressed interest in a teaching session to address these components. Collisions occur using robotic technology and rarely get addressed in surgical training. We describe an opportunity for surgeons to trouble-shoot robotic collisions in a safe, simulated environment. This easily transferable curriculum represents one of the first industry-independent robotic teaching sessions for surgical trainees.

Keywords Surgical education · Robotic surgery · Resident training · Integrating robotic technology

Introduction

Surgical training employs the apprenticeship model which allows ongoing organizational learning to produce skilled individual trainees and maintain a continuous production of new experts. Organizational learning occurs within the surgical field continuously via formal and informal instruction [1]. Efforts to improve medical and surgical education have used organizational learning to drive change—new curricula continues to emerge through "integrating new constructs into existing cognitive structures" [2]. To elucidate the most efficient and effective training methods, we must thoughtfully evaluate the ongoing approaches to surgical teaching.

The growth of robotic technology within surgical practice has created a need for robotic curricula. While various approaches have been documented in the literature, no standardized approach exists. Surgical educators have expressed concerns of an emerging training gap that could develop from this disruptive technology [3]. Most surgical robotic curricula require simulation prior to operative exposure [4]. However, some cognitive features of robotic technology cannot be experienced on current simulators resulting in one's initial exposure occurring in the operative setting. As such, many tasks required by the bedside assistant during robotic cases must be taught in the operating room due to inaccessibility of the robotic equipment. To address these features, institutions may host a separate teaching session in

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the operating room in addition to requiring practice on the daVinci simulator (Sunnyvale, CA) [4]. Review of current general surgery resident robotic curricula reveals that these sessions frequently address the bedside assistant's responsibilities, namely, docking and instrument exchange.

However, to our knowledge, there is no formal instruction for learners on how to manage instrument collisions. Instrument collisions are restricted movement due to instrument interaction and can occur at multiple locations throughout the operative environment. They can occur at the surgeon's console (with collision of the surgeon's hands), external to the patient at the operative bedside (collision of external robotic joints) or inside the patient (collision of instruments within the body cavity). Instrument collisions can arise at any point during an operation and require prompt recognition, localization, and management to avoid prolonged delays in the operative procedure [5].

Collisions at the surgical console are recreated with the daVinci simulator, so our course created opportunities to experience the other two types of collisions. External collisions may not be visible from the surgeon's console, in which case, the bedside assistant must recognize and localize, where the collision has occurred. Frequently, the solution to these external interactions requires adjustment of the sterile equipment, actions performed by the bedside assistant. At academic centers, surgical residents often fill this role. Internal collisions, however, cannot be visualized at the bedside and must be recognized, localized, and addressed at the surgeon's console. Therefore, recognition and correction of collisions are a necessary skill utilized throughout the progression of resident responsibility in robotic operations.

To address these additional cognitive components encountered in the robotic operative setting, we redesigned our intraoperative teaching session to include the topic of instrument collisions. The purpose of this study is to describe the collision simulation session and evaluate gains in participant knowledge and skills.

Materials and methods

We describe an evaluation using a participatory approach of a teaching session revised to include new content. The University of California San Francisco (UCSF) Institutional Review Board approved this study as exempt.
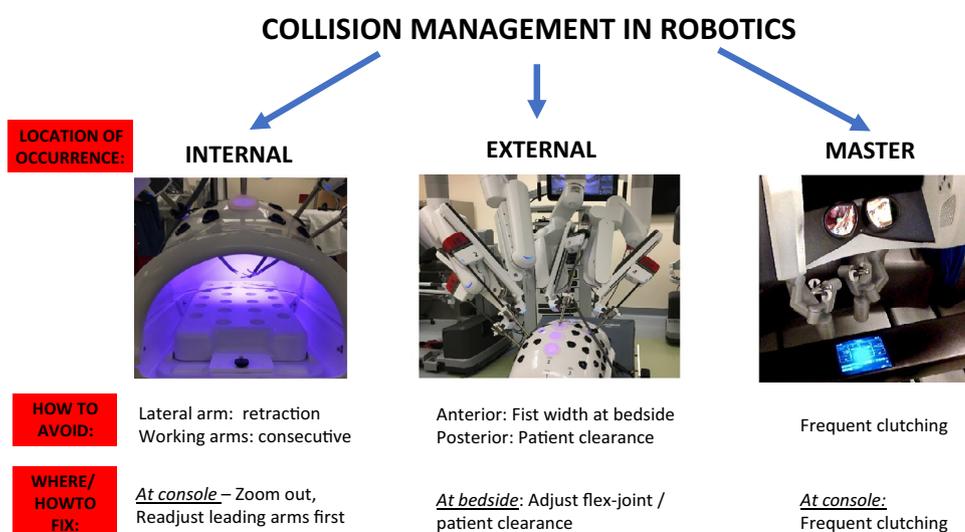
Curriculum

In 2016, we launched a longitudinal robotic curriculum for general surgery residents at the University of California, San Francisco (UCSF). The curriculum introduced surgical residents to various components of robotic surgery in a stepwise fashion during the 5–7 year training program. One of the first structured teaching sessions occurs in the fall of the residents' second post-graduate year (PGY2). Residents gather in the operating room and surgical faculty provide hands-on instruction about robotic docking and instrument exchange. Trainees have the chance to practice these steps before they are asked to illustrate proficiency by performing a series of tasks independently. Recently, the session was revised to include the concept of instrument collisions (Fig. 1), a topic not initially addressed within the longitudinal curriculum.

Participants

All PGY2 general surgery residents ($n = 9$) were required to participate. The PGY2 integrated plastic surgery residents ($n = 3$) were invited, but not required to attend. Three PGY2 urology residents who participate in robotic surgery served as controls.

Fig. 1 Summary slide of collision content for didactic instruction

COLLISION MANAGEMENT IN ROBOTICS

LOCATION OF OCCURRENCE:	INTERNAL	EXTERNAL	MASTER
HOW TO AVOID:	Lateral arm: retraction Working arms: consecutive	Anterior: Fist width at bedside Posterior: Patient clearance	Frequent clutching
WHERE/ HOW TO FIX:	*At console* – Zoom out, Readjust leading arms first	*At bedside*: Adjust flex-joint / patient clearance	*At console:* Frequent clutching

Session

The session was scheduled during the resident's weekly protected learning time. The designated robotic operating room was reserved in advance for a 3-h block. To minimize the faculty to student ratio and to ensure adequate hands-on opportunities, residents participated in two groups in identical consecutive 1.5-h session in the same location on the same day. In addition to the established docking and instrument exchange instruction, participants received a 10-min, didactic presentation describing finger grips, internal and external collisions, and instruction on how to trouble-shoot each type (Fig. 1). Residents then worked in pairs with one at the console and the other at the bedside to complete two exercises that simulated collisions. Participants were required to manipulate the robot at the console to determine how best to resolve the situations.

Evaluation

Table 1 illustrates the multi-modal evaluation design. Participants completed the robotic skills survey (Instrument A) and faculty instructors completed a final survey (Instrument B). For comparison, PGY2 urology trainees who did not participate in this teaching session completed Instrument A online, sent via email, the same week.

Analysis

A retrospective survey asked participants to rate the degree to which they agreed with five statements reflecting knowledge and competence of robotic skills. Using a five-point Likert scale, they were asked to respond with how they felt before the session, and then again, how they felt after the session. Before and after session differences (Instrument A) were compared using paired t tests with $p < 0.05$. Between group differences are given descriptively due to the small n of controls. Given the scarcity of similar teaching sessions, the faculty survey was constructed with open-ended questions specifically to avoid guiding responses and limiting potential answers. Responses on Instrument B were evaluated with content analysis [6].

Results

All seven of the PGY2 general surgery residents and two of the three PGY2 integrated plastic surgery residents participated in the teaching session (89% of total possible participants). All nine participants completed Instrument A at the conclusion of the session. Three faculty instructors ran the sessions and completed Instrument B. All the three of the PGY2 urology residents completed Instrument A.

All nine participants demonstrated proficiency in docking and instrument exchange. Compared to before the session, post-session knowledge and confidence significantly improved in five domains reflecting session objectives (Fig. 2, $p < 0.05$). Residents completing the session appear to be able to list and troubleshoot collisions significantly more than the non-participant matched peers (Fig. 3). Two of three non-participants wished they could have participated in a teaching session to address these components.

Instructor comments supported the addition of the collision components, but all three noted more practice time was needed for residents to thoroughly work through the simulation scenarios.

Discussion

New technologies continue to influence medical and surgical approaches to patient care. Robotic technology's expansion within the surgical field is just one of these examples. Despite value, the process by which new technology becomes integrated into surgical training must occur seamlessly without any compromise to individual patients' care or outcomes. Surgical educators, along with almost all branches of health profession educators, are using various methods of simulation to address these challenges [7–16].

However, any simulation technology has limitations, and the daVinci robotic simulator is no exception. Despite use in nearly all academic institutions with resident robotic training [4], the daVinci simulators cannot address many important skills required for use in the live operating setting. Roles of the bedside assistant are commonly addressed with a separate teaching session, located in the operating room, to review tasks such as docking the robot and instrument exchange. However, instrument collisions, a relatively

Table 1 Evaluation design for assessing the teaching session

Evaluation question	Data source	Data collection instrument	Data collection (time)
What knowledge and skills are gained by trainees through participation in this session?	Participants	(A) Robotic skills survey (Likert scale)	Paper (at session completion)
	Non-participants	(A) Robotic skills survey (Likert scale)	Emailed (same week as session)
	Instructors	(B) Open ended post course survey	Paper (at session completion)

Fig. 2 Participants' confidence with robotic tasks before and after the session
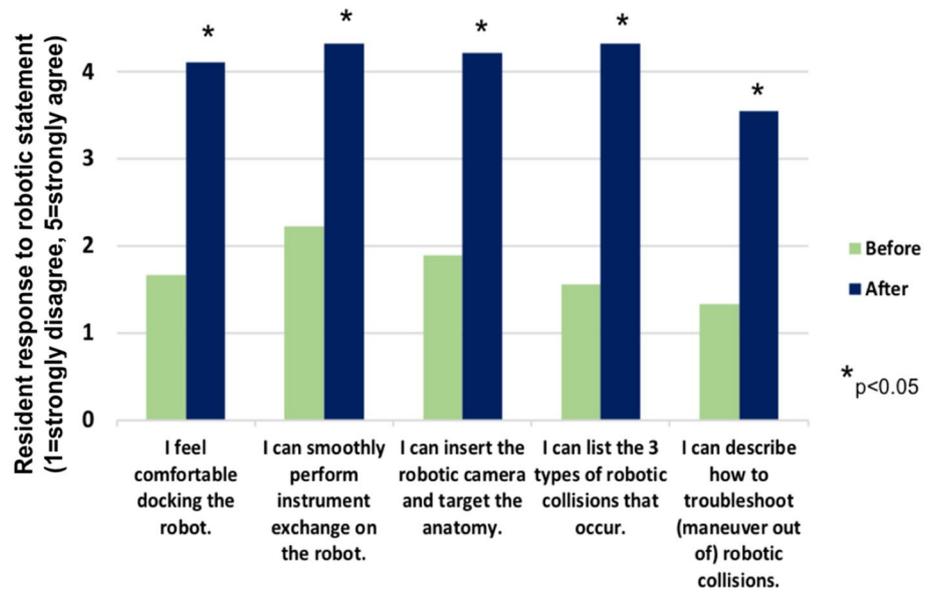
Fig. 3 Confidence with robotic tasks based on participation in the session
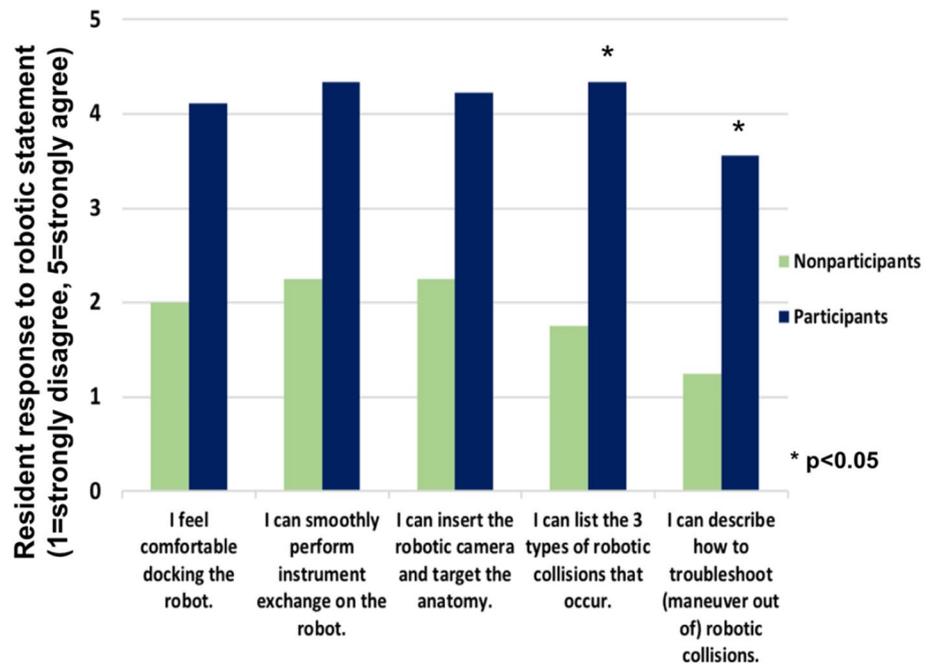
common occurrence in robotic operating rooms, are rarely addressed. After our session which directly addressed these physical and cognitive components, participants expressed greater confidence and improvement in all five domains related to session objectives. Most importantly, participants reported improved collision preparedness as compared to control-matched peers.

The PGY2 urology residents served as a good control group, because they have equal or greater exposure to robotic technology compared to our PGY2 general surgery residents. Urology has used robotic technology at our institution for

over a decade, while its use in general surgery procedures is very recent. Given these differences between the two groups, one would assume that the urology residents would be more confident with these robotic skills than general surgery residents. The results of our study suggest a potential gap in current training models regarding collisions.

This curricular innovation is readily transferrable to any academic institution and requires minimal resources. Required resources include the following: an open operating room with robot, computer for displaying the summary slide (Fig. 1), blue surgical towel (optional for simulation

exercises), robotic instruments, and protected time for trainees and instructors.

There are several limitations to this study. The small sample size decreases the power of the study and the use of a retrospective post-course survey could have created a response bias with exaggerated pre-to-post-course results. In addition, some critics could argue that self-reported confidence in a skill is not the same as technical competence, suggesting that just because trainees feel more confident with managing collisions after the session, they may not actually be technically better at the skill. However, while not demonstrated in this study, other articles report a direct concordance between self-reported confidence and objectively assessed competence of surgical interns [17].

We used a participatory evaluation approach to assess the curriculum, but because of its novelty, no standard of comparison exists. Individual research and personal experience suggests significant value in the proposed course, but buy-in from other surgeons, residents, and educators is required for dissemination of the innovative curriculum. Using this evaluation design, the evidence provided will help other stakeholders to believe in (or give value to) the results produced, a valuable component of the participatory approach. Future work should aim to validate this curriculum independently using a larger group of residents.

Conclusion

This evaluation illustrates successful implementation of a curricular innovation for surgical trainees working with robotic technology. We report creation of a safe, hands-on opportunity for trainees to practice features of robotic technology that cannot be appreciated with current robotic simulators. In addition, this represents one of the first industry-independent robotic training sessions designed by surgeons for surgeons. Results suggest that additional time should be allocated to ensure adequate opportunity for all residents to thoroughly work through the simulation exercises. This extremely feasible, readily transferable, curricular innovation should be recommended to surgical educators and leaders of residency training programs with robotic technology.

Compliance with ethical standards

Conflict of interest All authors (Courtney A Green, MD, Patricia S. O'Sullivan, EdD and Hueylan Chern, MD) declare that they have no conflict of interest.

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