Evaluation and Impact of Workflow Interruptions During Robot-assisted Surgery

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OBJECTIVE To analyze and categorize causes for interruptions during robot-assisted surgery.

METHODS We analyzed 10 robot-assisted prostatectomies that were performed by 3 surgeons from October 2014 to June 2015. Interruptions to surgery were defined in terms of duration, stage of surgery, personnel involved, reasons, and impact of the interruption on the surgical workflow.

RESULTS The main reasons for interruptions included the following: console surgeons switching (29%); preparation of the surgical equipment, such as cleaning or changing the camera (29%) or an instrument (27%); or when a suture, stapler, or clip was needed (12%). The most common interruption duration was 10-29 seconds (47.6%), and the least common interruption duration was greater than 90 seconds (3.6%). Additionally, about 14% of the interruptions were considered avoidable, whereas the remaining 86% of interruptions were necessary for surgery.

CONCLUSION By identifying and analyzing interruptions, we can develop evidence-based strategies to improve operating room efficiency, lower costs, and advance patient safety. UROLOGY 92: 33–37, 2016.

Robot-assisted surgery (RAS) has been associated with improved perioperative outcomes, including less blood loss, quicker recovery, and shorter hospital stay.[1] Nevertheless, the unique surgeon-assistant arrangement, training requirements, and the increased surgical complexity have rendered team interactions more challenging.[2] Accumulation of minor and latent errors can ultimately lead to adverse events and compromise patient safety. Although human error is inevitable, anticipation and prompt management remain vital for optimal patient care.[3-5] Recently, more reports have exposed medical shortcomings and their effect on patient outcomes.[6] Complete analysis of various surgical systems has been recommended to identify the "error-prone" situations within the operating environment.[7]

Teamwork remains indispensable to enhance workflow and minimize interruptions.[2] Interruptions to surgical workflow may be a result of operating room (OR) environment-related factors (equipment and physical layout), teamwork factors (communication, supervisory issues, team experience, and familiarity), in addition to organizational logistics and institutional policies.[4] In this context, characterizing interruptions can guide targeted interventions to eliminate errors and improve overall efficiency. The aims of this study were to understand and categorize procedural interruptions during robot-assisted urological procedures, and to identify potential modifiable factors that can be eliminated to enhance surgical performance.

METHODS

Setting

The "Techno-Fields" project was initiated in 2013 aiming at identifying nontechnical obstacles to optimal performance during RAS (RPCI-I-244113). We retrospectively analyzed 10 recorded videos of robot-assisted radical prostatectomies (RARPs). We identified and analyzed interruption events that occurred during the procedures.

Process

Recording was performed via a digital data collection system comprising three aerial cameras, positioned to maximize coverage of the OR, and up to 8 lapel microphones. The intraoperative console feed was also acquired to provide the operative context and identify procedural interruptions. Prior to recording, consents from surgical team and

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the patient were verified, and the microphones were set up. Recording started after the patient's face was covered and stopped immediately after undocking to maintain patient anonymity.

Following each procedure, team members completed questionnaires on team familiarity and the National Aeronautics and Space Administration Task Load Index (NASA-TLX) (to determine the cognitive load during surgery). Each team was assigned a "Team Familiarity" score based on the duration and number of procedures team members worked together (from 6—least familiarity, to 36—highest familiarity).

A movie editing software, Adobe Premiere Pro CS6, was used to synchronize the audio, video recordings, and the console feed. A video coding software, Noldus Observer XT 12, was then used for analysis. The 4 synchronized videos were viewed simultaneously to characterize each interruption. Videos were reviewed by two different raters, physician assistant (PA) and medical students, and supervised by a Urology fellow.

Methods

Interruptions were defined as the lack of movement of surgical instruments as they appeared on the console feed. Each interruption event was characterized in terms of the start, end, duration, stage of surgery, personnel involved, and topic of interruption. Effect on surgical flow, occurrence of adverse events, and miscommunications and/or repetitions were also noted. Interruption events were classified according to their duration (1-9 seconds, 10-29 seconds, 30-59 seconds, 60-89 seconds, or 90+ seconds), topic (Equipment/Technology; Supervision/Training; Procedure-specific; and Procedure-unrelated) (Table 1). We further classified interruptions into unavoidable (those necessary for progression of surgery) or avoidable interruptions (resulting from miscommunication, could have been avoided with an improved OR setting, or unnecessary and/or nonprocedure related). Because this study was conducted in a teaching institute, interruptions related to surgical teaching and/or training of fellows were considered unavoidable.

Statistical Analysis

Data were summarized using descriptive statistics including means and standard deviations (SD), and represented using bar graphs. Univariable associations were statistically assessed using Wilcoxon rank-sum test or Kruskal-Wallis test for ordinal data, and Pearson chi-square test for categorical variables. Associations between interruptions, Team Familiarity, and NASA-TLX were computed using Spearman correlation. Cohen's kappa coefficient was used to determine inter-rater agreement for qualitative data. All tests were two sided, with statistical significance defined as $P < .05$. All statistical analyses were performed using SAS software (version 9.3, SAS Institute Inc., Cary, NC).

RESULTS

Our study included 10 RARPs performed by a team of 28 members (3 attending urologists, 3 surgical fellows, 3 PAs, 12 circulating nurses, and 7 scrub nurses). The RAS experience of each surgeon is summarized in Supplementary Table S1. The average team familiarity score across the 10 procedures was 30 (range 11-36). Acceptable inter-rater agreement was achieved ($\kappa = 0.76$). The total operative time for the 10 procedures was 1848 minutes, with a total of 252 interruptions identified constituting 163 minutes (9% of total operative time). On average, each procedure was interrupted for 16 minutes (25 interruption events; each lasted for an average of 39 seconds).

The majority of interruptions occurred during prostate removal (65%), followed by the lymph node dissection (21%), and finally urethra-vesical anastomosis (14%). The majority of interruptions (70%) were less than 30 seconds, whereas only 8 events (4%) were longer than 90 seconds (Fig. 1A). Two significant adverse events caused the longest 2 interruptions. A confirmatory biopsy was required in one procedure, whereas another included an intraoperative complication (accidental clipping of the obturator nerve). Mean durations of interruptions by surgery stage were prostate removal (12 minutes; SD = 15), lymph node dissection

Table 1. Classification and description of procedural interruptions

Category	Description	Avoidable*/Unavoidable
Equipment/Technology	Camera related (camera clean or lens change); instruments (addition, removal, or change); suture/stapler/clip application; adjustments of the insufflator	Unavoidable—except where a repetition and/or miscommunication occurred
Supervision/Training	Console switching between the lead surgeon and surgical trainee; teaching	Unavoidable
Procedure-specific	Events necessary for the surgical procedure, including waiting for suctioning, catheter manipulations, a rectal test; and specimen handling (such as lymph node removal or a biopsy)	Unavoidable
Nonprocedure-related	Personal conversations and phone calls, adjustments to console lighting or chair, or other events not pertaining to the procedure	Avoidable

* If any unavoidable event was longer than average or resultant of an adverse event, it was considered avoidable.