The Loud Surgeon Behind the Console: Understanding Team Activities During Robot-Assisted Surgery

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OBJECTIVES: To design a data collection methodology to capture team activities during robot-assisted surgery (RAS) (team communications, surgical flow, and procedural interruptions), and use relevant disciplines of Industrial Engineering and Human Factors Engineering to uncover key issues impeding surgical flow and guide evidence-based strategic changes to enhance surgical performance and improve outcomes.

DESIGN: Field study, to determine the feasibility of the proposed methodology.

SETTING: Recording the operating room (OR) environment during robot-assisted surgeries (RAS). The data collection system included recordings from the console and 3 aerial cameras, in addition to 8 lapel microphones (1 for each OR team member). Questionnaires on team familiarity and cognitive load were collected.

PARTICIPANTS: In all, 37 patients and 89 OR staff members have consented to participate in the study.

RESULTS: Overall, 37 RAS procedures were recorded (130 console hours). A pilot procedure was evaluated in detail. We were able to characterize team communications in terms of flow, mode, topic, and form. Surgical flow was evaluated in terms of duration, location, personnel involved, purpose, and if movements were avoidable or not. Procedural interruptions were characterized according to their duration, cause, mode of communication, and personnel involved.

CONCLUSION: This methodology allowed for the capture of a wide variety of team activities during RAS that would serve as a solid platform to improve nontechnical aspects of RAS. (J Surg Ed 73:504-512.

KEY WORDS: communication, team interactions, robot-assisted surgery, nontechnical skills, flow, interruptions

COMPETENCIES: Practice-Based Learning and Improvement, Interpersonal and Communication Skills, Systems-Based Practice

INTRODUCTION

Robot-assisted surgery (RAS) has changed the traditional arrangement of the surgical team in the operating room (OR), where the console surgeon no longer has physical proximity to the patient and remaining surgical team.[1] This unique surgeon-team arrangement, in addition to the complexity of remotely controlled surgery, changes team actions and interactions in ways that are both critical and challenging. Incorporation of new technology in the OR can bring out new forms of errors and thereby, adversely affect safety and team performance.[2] The Joint Commission identified human factors, communication, and leadership as the most frequent root causes for sentinel events between 2004 and 2014.[3] Factors such as the OR environment (physical layout and personnel congestion), teamwork, communication, and logistics (staffing and scheduling), and institutional policies (training and regulations) are of paramount importance.[4-10] Processes from established and relevant disciplines of Industrial Engineering and Human Factors Engineering are vital to uncover key issues impeding surgical flow and guide evidence-based strategic change to enhance surgical performance and improve outcomes.[11]

There is paucity of literature about team actions in the setting of RAS,[1,12-16] and few studies have tackled this

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subject in the real operative environment.[12,13,15] Although these studies provided insight for interactions during RAS, they were limited by oversimplified coding schemes that overlooked some key aspects of team activities. Surgical adverse events are rare but dangerous; however, few attempts have been made to evaluate environmental factors such as procedural disruptions. A study in which 10 cardiac surgeries were observed by 2 industrial engineers revealed more than 1000 key observations. The study found that 31% of flow disruptions were related to physical layout and 24% interruptions during surgery.[17]

To address this important gap in the literature, our research objective was to design a methodology to allow comprehensive analysis of team activities during RAS. We further sought to determine the feasibility of our methodology for implementation by collecting pilot data from a single procedure and conducting preliminary analysis of 3 key categories as follows: communication events, physical movements, and procedural interruptions.

METHODS

Setup

The "Techno-fields" project initiated in 2013 the Applied Technology Laboratory for Advanced Surgery program at Roswell Park Cancer Institute (Buffalo, NY) aimed at developing evidence-based strategies to heighten performance and safety within the OR environment (RPCI-I 244113). The OR was equipped with digital data collection system, custom tailored by a team of surgeons and engineers. In all, 3 aerial views of the OR environment were recorded with Internet Protocol cameras. The locations of the 3 cameras were chosen to capture all activities in the OR. Camera-1 recorded the OR table and interactions between the right (physician assistant [PA]) and left bedside assistants (scrub nurse), Camera-2 recorded the activity around the console surgeon and the nurse's station, and Camera-3 recorded the left bedside assistant, anesthesia station, and the OR door. Intra-operative recordings of the console feed were also obtained to provide operative context and to observe procedural interruptions (Fig. 1). Up to 8 audio tracks were recorded, where each team member had a lapel microphone connected to an audio interface to facilitate identification and localization of the speaker and speech comprehension.

Consent

OR personnel were consulted and the purpose and methodology were discussed. Their informed consent was valid for a year. Some additional staff consents were obtained just before surgery. RAS procedures were selected for recording only when the patient and all team members assigned for the surgery had given consent. Patients were consented separately before the surgery and their consent was only valid for that surgery. Recording was stopped if a non-consenting staff member was in the room. This consent allowed us to capture all activities during surgeries while maintaining participants' anonymity.

Data Recording Process

After verifying informed consent from the patient and the participating surgical team, microphones were set up. Recording started once the patient's face was covered and timeout ended (to ensure anonymity of patients) and stopped after the undocking of the robot. Recordings were stopped if OR staff who did not consent for the study were temporarily in the room. To control for potential confounding factors such as team familiarity and cognitive load during surgery, team members at the end of each procedure were asked to complete questionnaires on how long they have known each other and the number of procedures they have worked together, in addition to the National Aeronautics and Space Administration Task Load Index (NASA-TLX) questionnaire.[18]

Data Analysis

All recordings were synchronized via a movie editing software (Adobe Premiere Pro CS6), resulting in 4 audiovisual streams per surgery. These were then analyzed in video coding software (Noldus Observer XT 12). Each of these streams included 2 audio tracks mapped in different channels (Fig. 1).

Analysis of a pilot procedure was performed to evaluate if we were clearly able to discern vital team activities that may affect surgical performance and quality patient care, namely, communication, surgical workflow, and procedural interruptions. Observations were made by a Humans Factors PhD, a Human Factors graduate student, and 2 additional trained observers (medical student and a PA student) trained by a Urology fellow.

Team Communication

Our main focus regarding communication was the interaction between the console surgeon and the 2 bedside assistants, referred to as the "key triad." Our coding scheme was adapted from the "Synthesized Communication Coding Scheme for Surgical Teams' interactions."[19] Consequently, each interaction event was characterized in terms of information flow (identifying sender, receiver, time, and duration), mode (verbal vs. nonverbal), topic, statement function (verbal), and form (nonverbal).

Surgical Workflow

The OR was divided into 8 zones (Fig. 2), based on where personnel were typically stationed and the location of supplies and equipment. The ambulatory pattern of each team member was tracked by 2 trained observers by viewing the surgical procedure. Surgical workflow was mapped using link or "spaghetti" diagrams, a traditional Industrial Engineering