ROBOTIC SURGERY AND THE OPERATING ROOM TEAM

Fuji Lai and Eileen Entin
Aptima, Inc.
Woburn, MA

Robotic surgery has the potential to revolutionize the field of surgery and improve patient safety. However, despite the advantages robotic surgery can offer, there are multiple human factors-related issues that may prevent these systems from realizing their full benefit. This study identified some of the salient human factors issues and considerations that need to be addressed for integration of new technologies such as robotic systems into the Operating Room of the future. We conducted in-depth interviews with operating team members and other stakeholders who have experience with robotic surgery to identify workflow, teamwork, training, and other clinical acceptance issues. Addressing these and other human factors issues will help the integration of surgical robotic systems into use for the ultimate goal of improving patient safety and healthcare quality.

INTRODUCTION

Surgical robotics and other innovative technologies for the operating room (OR) hold much promise for revolutionizing the field of surgery and improving patient safety. These systems are being used in various specialties and applications. There are several types of robotic systems in use or in development. In this paper we focus on teleoperated robotic surgery systems. These systems comprise master-slave manipulator systems whereby robotic arms at the patient site are controlled by a surgeon at a control console that is at some distance from the patient. Teleoperated systems can be used to enable minimally invasive endoscopic procedures. In endoscopic procedures surgical tools are inserted through ports into the body cavity. The image of the operative site is fed back through an endoscope inserted through another port. In traditional endoscopic surgery the surgeon stands over the patient manipulating the instrument handles from outside the body, guided by the video endoscopic image in front of him. The use of a robotic assist enables the surgeon to be returned to a more comfortable position, seated at a console in front of a monitor presenting the video feed of the operative site and manipulating a set of handles whose motions are conveyed and translated through computer-assist and robotic end effectors to motions of the instrument tips at the patient site.

Early studies showed that robotic surgery is feasible (Cadiere et al, 2001) and can afford several benefits. These robotic surgery systems simplify existing minimally invasive surgical (MIS) procedures, make difficult MIS operations routine, and make new MIS procedures possible in many surgical specialties. Some of the advantages of robotic surgery over traditional methods include: improved ergonomics, increased dexterity, improved spatial mapping, improved visualization and stereoscopic depth perception, removed fulcrum effect, motion scaling, reduced tremor, faster patient recovery, and the ultimate removal of the barriers of time and space for remote telesurgery when expertise is not local to the patient site (Lanfranco et al, 2004).

Despite the potential advantages, there are multiple human factors-related issues that may be preventing robotic surgery systems from realizing more widespread incorporation into practice. This paper discusses some of the workflow and team related human factors considerations that need to be addressed to help this technology achieve widespread clinical acceptance and attain its full potential benefit to patient safety.

METHODS

In order to identify the salient human factors considerations for integration of robotic and other computer-assisted technologies into the OR of the future we conducted in-depth interviews with a variety of stakeholders identified as key individuals who would be able to offer insight. To understand various perspectives, our sample of 24 participants included 13 end users (eight surgeons, two anesthesiologists, two nurses, and one administrator), seven academic researchers, and four developers. The interviews were conducted on an individual basis, either face to face or via telephone. They ranged in length from half an hour to two hours with an average time of about an hour. No personal identifying information was recorded on the interview materials. We were interested in uncovering specific experiences and in discovering new insights that might inform and help the integration...
RESULTS AND DISCUSSION

Our analysis of the interview data revealed many common recurring themes in the issues and barriers that our interviewees perceived. In this paper we focus on the modifications in the individual team members’ roles and teamwork that robotic surgery introduces.

A New Way of Conducting Surgery—Modified Roles for Every Team Member

The introduction of a robotic system into the OR undoubtedly disrupts the existing workflow. The team for a robotic procedure usually consists of at least two nurses, an anesthesiologist, the operating surgeon, and an assisting surgeon or resident physician. Each of the surgical team members needs to adapt to the introduction of a robotic system into the OR. The new human-system interactions that need to exist are as follows. The operating surgeon is now removed from the patient’s side and is seated at a console. The surgeon needs to create the relationship between the visual information being received at the eyes and the motions carried out at the hands. The anesthesiologist is now at the patient’s side interacting with the patient as well as making sure the robot is not in the way. Also at the patient’s side are the assisting surgeon and the scrub nurse. In addition to the interactions of these individuals with the robotic system, there are new interaction needs in terms of coordination and communication between the team members as well.

Each surgical team member’s role needs to adapt to the introduction of a robotic system into the OR. For the surgeon this involves an entirely new way of conducting surgery including patient selection, port placement, increased perceptual demands particularly due to limited force or haptic feedback, and increased cognitive demands. There are also additional collaboration demands due to the fact that the primary surgeon is now at a distance from the patient’s side and the rest of the team. Because the surgeon is not in the sterile field, there is a need for an assisting surgeon and additional nursing support as well as increased coordination and communication demands. Since the primary surgeon is not able to see the patient directly he/she is now more dependent on the rest of the team members for communicating the status of the patient and robot. In addition surgeons reported a sense of both physical and psychological isolation from the patient due to the fact that they are no longer in the sterile field.

For the anesthesiologist situational complexity and patient protection needs are increased. The robotic system imposes new methods of patient care including making sure the patient is positioned so that there are no pressure points with the robot, placing equipment for easy access, and maintaining access to the patient. The anesthesiologist’s role in maintaining patient protection is increased in that he or she must ensure that no part of the robotic system is hitting the patient, that the robot does not knock out the airway, and that the patient is protected from soft tissue injury. This increased attention to patient protection increases the anesthesiologist’s sense of responsibility for the patient. In addition there may need to be changes to anesthetic management due to increased length of surgery.

From the nurses’ point of view the robot increases the number and difficulty level of the tasks they must perform, from sterilization to setup to tool change to access to the patient. The complexity of the sterilization task is increased in that different parts of the robotic system require different sterilization techniques. The nurses need to know how to set up and drape the robotic system. During the surgical procedure the scrub nurse’s job is more complicated because he or she is now responsible for conducting tool changes on the robot and communicating the status of the change back to the surgeon. Many interviewees noted that the nurse’s role as a protector of the patient is now magnified due to the presence of the robot near the patient. Like the anesthesiologists, nurses may feel an increased sense of responsibility.
and additional burden to make sure that the patient is safe. At the same time, they must spend energy and attention attending to the needs of the robotic system, which can divert their attention from the patient. In addition, specialized training is needed for the nurse who needs to be comfortable with the technology.

Much of the burden of running the system falls on the nurses and technical support staff. In addition, there may need to be specialized engineering support present during cases in order to ensure that the system is working smoothly.

Thus it is clear that there is a need for training of each member of the team for this new way of conducting surgery.

**Team Coordination**

Our interviewees indicated that in addition to the changes to each individual’s tasks, there are changes imposed due to the fact that the robot is now a new surgical team member. As such, there needs to be accommodation and adaptation of the team for this new surgical team member, including new characterization of interactions, decision-making processes, and team coordination strategies. There needs to be mutual understanding by all members of the team of the new tasks—both their own tasks as well as others’ tasks. This implicit understanding would enhance their ability to anticipate. In addition, there needs to be new choreography of movement in order to accommodate physical space constraints.

Many interviewees noted there are important collaboration implications due to the fact that the primary surgeon is no longer at the patient’s side and in close proximity to the rest of the team members. Because he/she is removed from the patient’s side, the surgeon has limited visual information about the patient since he has access only to the scope operative site image. The surgeon is not able to see what is occurring outside this immediate field of view. The surgeon is also not able to communicate easily through physical gestures with the rest of the team. Verbal communication is inhibited by the fact that the surgeon is now immersed in a console. The surgeon is also not able to see the status of the robot. All these factors result in the surgeon being more dependent upon the rest of the team members for communicating status of the patient and robot back to the surgeon, and place increased importance on explicit communication. In addition, since the primary surgeon is no longer in the sterile field more of the burden falls on the team at the patient’s side, in particular, the assisting surgeon, to respond in the event of a complication.

An implication of the increased procedure time is that a robotic case is more likely to run across personnel shifts. As a result, there need to be coordination and communication strategies for handoff from one team to another such that continuity and quality of care is maintained. This is important as handoffs have been identified as critically vulnerable points in the perioperative process when information can be lost or misinformation introduced during the transition (Dierks et al, 2004).

As many interviewees emphasized, teamwork skills will be critical for easing the transition to such new modes of surgery. Teamwork training for robotic surgery teams could be designed to include training in the need for predefined protocols or procedures, monitoring, backup behavior, team orientation, and explicit communication especially in the event of deviation from established protocol.

As noted above, surgical team members must learn how their tasks are related to the tasks performed by other team members, and how that relatedness affects the common goal. The training must foster the understanding of team interdependence and the methods that are available for coordination. There needs to be clear predefined allocation of tasks such that team members are aware of their own tasks as well as the tasks of others.

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Interviewees emphasized the importance of a predefined protocol as well as need for explicit communication in the event of deviation from this predetermined protocol. Explicit communication strategies could be developed for particularly vulnerable phases such as instrument changes. Also, further strategies could be developed for telesurgery where teams would be even further distributed in geographical space, fostering the idea of a “virtual OR” for maintaining the bubble of virtual team situation awareness.

Interviewees emphasized that it is important for the entire team to have access to the same information in order to have the same shared situation awareness of where they are in the procedure as well as what is going on at the operative site. Thus technology aids such as secondary displays in the form of big wall screens capturing case status could allow the rest of the team members to stay abreast of the procedure and be able to anticipate upcoming events.
CONCLUSIONS

The shift to robotic surgery involves a radical culture change. Just as there are many technical development issues to be solved as robotic surgery moves forward, there are also multiple human factors-related issues that may be preventing robotic surgery systems from realizing more widespread incorporation into practice.

Issues include the dearth of long term studies on cost, safety and actual benefits, size of systems making them difficult to fit into overcrowded operating rooms, and need for change in workflow and culture. In this paper we have focused on modifications in the individual team members’ roles and teamwork. Introduction of this system involves changes for the entire team. There must be accommodations made and adaptation of the workflow for this new surgical “team member.” There needs to be new characterization of interactions, decision-making processes, choreography of movements and communications, and integration into work practice/culture that a surgical robot imposes.

Addressing these and other human factors issues will help the integration of surgical robotic systems into the mainstream operating room in the future for the ultimate goal of improving patient safety and healthcare quality.

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REFERENCES

