Communication and Teamwork Failure as a Barrier to Robotic Surgical Safety

Marco A. Zenati M.D., M.Sc., FETCS, Jason K. Maron, M.S.
MRCAS Lab, Department of Cardiothoracic Surgery, BHS and Harvard Medical School
Boston, Massachusetts, USA Contact: Marco_Zenati@hms.harvard.edu

Abstract— Robotic surgery is a high-consequence activity that heavily depends on optimal communication and teamwork. We discuss the current understanding of the role of communication and errors in high-risk surgery, with particular emphasis on conventional and robotic-assisted cardiac surgery.

Keywords— ***robotic cardiac surgery; minimally invasive surgery; communication breakdown; metacognition; teamwork; surgery***

I. Introduction

High-technology medicine, such as robotic cardiac surgery [1], is a complex socio-technical system in which performance depends on individual technical and organizational factors and their interactions; consequently, efforts to improve surgical quality have recently shifted from the individual to the team. In addition, awareness of surgical team quality and its impact on operating room efficiency has considerably increased over the last decade. The difficulty level of team communication increases as the number of health care providers involved with patient care increases and measures to reinforce the quality of communication among team members have been recommended. Unfortunately, team communication failures are widespread in the cardiovascular operating room and result in poor operative performance and unintended injury to patients [2-3]. These communication failures have been shown to be observable, classifiable and predictable. Yet, translation of this knowledge regarding human performance into practical tools for quality and safety improvement has been limited.

II. Team Communication Effectiveness and Surgical Outcomes

Effective teamwork and communication have long been identified as key drivers of quality and safety in many high-risk, high-reliability fields (e.g. aviation, military, etc) and team-based healthcare is no exception. The U.S. Joint Commission on Healthcare Quality and Safety has identified “communication” as the #1 root cause of reported sentinel surgical adverse events in a 10-year period starting in 1995. Adverse events related to surgery account for two thirds of hospital complications, with 75% of errors occurring inside the operating room. Surgical errors cannot be understood separately from the actions of the members of the surgical team: Wiegmann and associates reported that teamwork-related factors alone accounted for roughly 45% of the variance in the errors committed by surgeons during cardiac cases [4]. Teamwork issues involve cases of: (a) mis-communication, (b) lack of coordination, (c) failures in monitoring, and (d) lack of team familiarity. Poor team communication has been linked to poor surgical outcomes in studies from both the United States and Europe [5]. Gawande reported on the dangers of incomplete, nonexistent or erroneous communication in the operating room and found that they were causal factors in 43% of injuries made during surgery [6]. Reports of positive communication with the attending surgeon ($r=-0.38$, $p<0.01$) or resident surgeon ($r=-0.25$, $p=0.08$) from surgical staff have significant negative correlation with the observed/expected surgical morbidity ratio.

The specialty field of cardiac surgery, traditional or robotic-assisted, is a dangerous and complex area of medicine with significant morbidity and mortality. In recent years, cardiac surgery has experienced a growing complexity of its case mix due to increasing patients’ age, co-morbidities and the introduction of advanced robotic technologies [7]. In this setting, achievement and maintenance of excellence is becoming more challenging. Despite a significant improvement of mortality and avoidable complication rates, Wiegmann found that cardiac surgeons make on average 3.5 errors per hour [4]. El-Bardissi studied 31 cardiac surgical cases at the Mayo Clinic and observed a strong correlation ($r=0.67$; $p<0.001$) between the occurrence of technical errors and teamwork failures,

with the majority (51%) of teamwork failures affecting surgeon-technical team interactions [8]. Gurses and associates recently performed a multisite study on patient safety hazards in the cardiovascular operating room and reported, among other significant findings, that cardiac surgeons often did not use names when giving orders, causing confusion between anesthesia and perfusion teams regarding the intended receiver of the order; in addition, recommended communication practices (i.e. repeat backs, callouts, confirmation, structured communication techniques) were rarely used [3].These authors concluded that communication-related hazards (defined as anything that has the potential to cause a preventable adverse patient safety event) are prevalent in the cardiovascular operating room resulting in widespread and substantial risk to patient safety**.**

Surgical safety should not be assessed exclusively in terms of “hard” clinical outcomes (e.g. death, myocardial infarction, bleeding, etc.): in fact, good outcomes may emerge from unsafe processes (that may result in a bad outcome in other situations). A recent study by Dierks and associates, indentified events in the operating room that compromised safety but had gone unnoticed by the providers involved because the outcome was favorable (“outcome bias” in clinical care) [Dierks unpublished 2013]. A more useful terminology for classifying adverse events distinguishes between: (1) System Vulnerability, as the exposure to or opportunity for adverse events; (2) Safety-Compromising Events (“near-misses”), as a variation in the expected course of care that has a negative effect on patient safety and puts the patient at risk for a measurable adverse change in patient status; (3) Adverse Event, a safety-compromising event that progresses to a measurable adverse change in patient status; (4) Contributing factor, conditions or properties that increase the vulnerability of the system, therefore increasing the chance of an adverse event; (5) Compensatory factor, conditions or properties that decrease the vulnerability of the system or reduce the severity of an adverse event.

Team communication in the operating room has been shown to reflect cognitive non-technical skills like situation awareness (SA). SA is defined as “the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future”. As such, SA is one of an array of ‘non-technical’ or ‘behavioral’ skills along with decision making, teamwork and leadership. SA is particularly crucial in cardiac surgery, as situational awareness underpins the ability to make appropriate decisions, communicate the correct information at the right time (e.g. between surgeon and perfusionist) and lead other team members successfully. Good SA can also make a critical difference in task effectiveness by reducing individual errors, improving shared mental models, and enabling team members to capture errors before they adversely affect outcomes [3]. This can make teamwork more successful and rewarding for participants, and safer for patients.

Unfortunately, adverse event analyses in healthcare often reveal failures in SA and diagnostic skills which lead to technical errors. The paradox is that these skills are usually only trained and assessed informally in healthcare. Recently, and in line with other high risk/ high reliability industries such as nuclear power and civil aviation, behavior rating systems for healthcare professionals have been developed for use in real and simulated healthcare learning environments such as NOTSS for surgeons, ANTS for anesthesiologists , SPLINTS for scrub technicians and a more recently developed marker system for emergency physicians [8-10]. These systems all include specific detail regarding SA and provide an opportunity to assess communication behaviors which underlie cognition in terms of ability to: (i) gather, (ii) understand, and (iii) project and anticipate future states. These frameworks allow clinicians and researchers to reflect on these skills in action, intervene to provide learners with strategies to improve their awareness, and recognize situation awareness states of others.

Team situational awareness (TSA) can be measured in terms of situation-related communications events (i.e. speech events that require timely coordination among two or more team members). Effective, closed-loop communication involves the following sequence of actions: (1) sender initiates message; (2) receiver accepts message and provides feedback that it was received; and (3) sender double checks to ensure that message was received as intended. This type of communication has a built-in check to ensure that not only does the communication get to the required person, but that the intended message sent was the same one received. When multiple sources of information as well as multiple recipients are present, such as in the operating room, closed-loop communication can differentiate between effective and ineffective teams.

The communication loop construct (i.e. the full cycle of information flow between the participants in the sequence) was used by Parush and associates to assess susceptibility to communication breakdown: based on their analysis, communication loops that are open, non-directed or with delayed closure, are susceptible to the risk of information loss [11]. These communication loops were quantitatively related to communication indicators of TSA such as questions, replies, and announcements and conceptually should be predictive of delays and efficiency in the operating room.

Translating these principles into modern surgical practice has been accomplished via medical simulation and team training. Yet despite the adoption of non-technical skills training warranting a Class I/B recommendation from Wahr and associates (on the American College of Cardiology Foundation and American Heart Association scale), measurement of how to precisely tailor best practices and sustain a safety culture incorporating values elicited from these skills is not awarded the same confidence [12]. This is partly due to the inherent difficulty of such measurement, but also because the positive transient effects of an experimental intervention tend to wane. Such diminishment is a consequence of the human practitioner. An automated decision-support system, or robot, might be less prone to deprioritize a recommendation or decision rule on grounds of indifference and inconvenience.

III. Situation Awareness with SurGIcal Robots

A critical non-technical skill in Cardiac Surgery is Situation Awareness (SA) [8]. Information sources that allow optimal SA are primarily visual (e.g. adequate surgical exposure of the operating field, visual access to monitors) and acoustic (ability to hear and discriminate critical verbal utterances from other team members). Surgery is a hand-busy, eye-busy activity and the eye gaze of the surgeon is generally focused on the operating field. In case of robotic cardiac surgery, the visual field is even more restricted to the endoscope and can be temporarily compromised by blood splattering on the lens. In addition, the master console of the DaVinci robotic system is located several feet away from the operating table and, even with the aid of a microphone, verbal communication is more difficult than during conventional open cardiac surgery. We conclude that SA is commonly severely compromised during robotic cardiac surgery.

Blum & associates have described a method for phase recognition of procedures using equipment utilization as inputs to predictive hidden Markov models (HMM) [15]; such systems may augment team communication during robotic cardiac surgery when team SA is diminished.

IV. Conclusion

Current research on the breakdown of surgical teams' communication and coordination during surgery indicates an unmet need for systematic acquisition of communication data in a measurable and quantifiable manner as a first step in order to ultimately provide patient safety solutions. To increase the capture of information in the operating room and to enhance SA, Guerlain and associates proposed the introduction of a "black box" recorder, similar to those used in the aviation industry, to assess individual and/or team events for quality improvement [16]. Such technology may help collect the complex data generated in the operating room and identify and understand the human behaviors that occur in the operating room and their relationship to patient safety events. However, none of these concepts has been translated and validated in the cardiovascular operating room. Successful translation of these concepts may improve safety and eliminate a barrier to the adoption of high-technology medicine such as robotic cardiac surgery.

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