

The utility of live video capture to enhance debriefing following transcatheter aortic valve replacement

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ABSTRACT

Background: The surgical and procedural specialties are continually evolving their methods to include more complex and technically difficult cases. These cases can be longer and incorporate multiple teams in a different model of operating room synergy. Patients are frequently older, with comorbidities adding to the complexity of these cases. Recording of this environment has become more feasible recently with advancement in video and audio capture systems often used in the simulation realm. **Aims:** We began using live capture to record a new procedure shortly after starting these cases in our institution. This has provided continued assessment and evaluation of live procedures. The goal of this was to improve human factors and situational challenges by review and debriefing. **Setting and Design:** B-Line Medical's LiveCapture video system was used to record successive transcatheter aortic valve replacement (TAVR) procedures in our cardiac catheterization/laboratory. An illustrative case is used to discuss analysis and debriefing of the case using this system. **Results and Conclusions:** An illustrative case is presented that resulted in long-term changes to our approach of these cases. The video capture documented rare events during one of our TAVR procedures. Analysis and debriefing led to definitive changes in our practice. While there are hurdles to the use of this technology in every institution, the role for the ongoing use of video capture, analysis, and debriefing may play an important role in the future of patient safety and human factors analysis in the operating environment.

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INTRODUCTION

Newer surgical techniques such as robotic, endovascular, and percutaneous procedures continue to expand in their application and evolve in quality and precision. This has allowed their application to expand to multiple surgical subspecialties as well as to interventional locations outside the typical operating room environment. This expansion has brought new physical, technical, and environmental demands to the hospital teams asked to support these new endeavors. Transcatheter aortic valve replacement (TAVR) is an example of a relatively new procedure (Food and Drug

Administration approval in the United States in 2011)^[1,2] performed in a procedural

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setting with multiple medical teams working together. In our institution, this procedure is done in our Heart Catheterization Laboratory with teams from interventional cardiology, cardiovascular surgery, echocardiography, and cardiovascular anesthesia sharing a space typically reserved for the cardiology team alone. TAVR is indicated for inoperable or high-risk patients for surgical aortic valve replacement and has demonstrated success in intermediate-risk patients as well (partner 2 trial).^[2] The nature of these high-risk patients increases the technical and organizational demands and challenges of institutions to provide high-quality care with an increasing focus on patient safety.

The integration and communication between teams differ from the traditional hierarchical arrangement in the operating room. This has traditionally been a surgeon-led environment with personnel reporting to the surgeon or, in the cardiology realm, to the lead interventionalist. The operating room structure for the TAVR procedure and many other new hybrid procedures requires integration of multiple specialty teams working together, with “team leaders” from each specialty area. This necessarily leads to an increase in human factors applicable to the procedure and ergonomic demands (human factors/ergonomics). It has long been known that human factors and ergonomics are critical factors in medicine and health-care delivery.^[3-5] There have been a variety of tools developed to aid organizations in improving quality and safety including: TeamSTEPPS,^[6] the Systems Engineering Initiative for Patient Safety model of work system and patient safety,^[5] crew resource management (CRM),^[3] the development of checklists for crisis management in a variety of settings,^[7] and the use of simulation for training and safety.^[8]

Simulation training and CRM are well known to the airline industry. Pilots, cockpit teams, and flight crews, have been trained in CRM in an effort to reduce errors observed in an evaluation of airline accidents in the early 1980’s. CRM has evolved through time to its sixth generation with the continued goals of error/crisis mitigation or management. How can the principles of CRM be applied to the health-care environment? Since the initial reporting of the Institute of Health’s publication on errors in the hospital setting,^[9] the goals of regulatory agencies such as the Joint Commission on Accreditation of Healthcare, Agency for Healthcare Research and Quality, and health-care advisory groups like our own Anesthesia Patient and Safety

Foundation have been able to reduce errors and improve patient safety. Timely preparation and feedback have become characteristics of highly functioning, effective health-care teams. The preprocedure brief or “time out” has been mandated^[10] and a postprocedure debriefing can facilitate improvements in patient safety and care.

Simulation in anesthesia has been advocated as a tool for guided systematic practice in the operating room for procedures and critical thinking in patient care.^[11-17] It can also be used in crisis management for all levels of providers. Medical students and residents can perform tasks and manage patient hemodynamics in a controlled, safe, simulation environment utilizing low- and high-fidelity task trainers or mannequins. A critical part of simulation sessions is also the videotaping and debriefing of the simulation.^[14]

There are a number of available video capture systems for this feedback from a very simple single camera system to one that can incorporate a number of video and audio feeds.^[12,18-21] Our institution utilizes B-Line Medical’s SimCapture in the Simulation Center as well as its LiveCapture solution for *in situ* simulation sessions throughout the hospital. We report the use of our LiveCapture videotaping tool for feedback and debriefing in TAVR cases in our hospital. To the best of our knowledge, we believe this has not been published before-in the TAVR setting.

MATERIALS AND METHODS

Evolution of real-time video capture

We started performing TAVR at our institution with Food and Drug Administration approval of the of the first-generation Sapien valve (Edwards Lifesciences, Irvine, CA, USA). The multi-team staff was identified from the stakeholders for the TAVR procedure. From this, a work group was created and the work group met early and often during the implementation of the program and following the first few cases. The debrief process for cases included the videotape of each procedure. The requirement for live recording in an environment with space restrictions, multiple additional pieces of equipment, and greatly expanded personnel provided logistical challenges. Each team was interested in seeing their performance individually as well as how they blended with the overall team and surgical plan. We elected to incorporate a number of feeds into the B-Line recording. These included sound, two video feeds: (1) A wide angle full table or patient view and (2) the area shared by the cardiovascular surgeon and procedural cardiologist. Additional data

feeds were brought into the B-Line recording included the interventional hemodynamic monitor and the fluoroscopy screen. It was impossible to include all valuable feeds including the transesophageal echocardiography (TEE), the anesthesia screen with multiple inputs, as well as cameras to document everyone's activity (cardiologist performing TEE; anesthesia staff – MD and CRNA; interventional staff; surgical support staff; and bypass personnel on standby).

The institutional requirements for videotaping patients and staff were resolved and to date, several hundred TAVR's have been videotaped. The complexities of designing the system including the cameras, recorders, time-code generation, data stream, processing, data storage, and archiving have been well outlined by Weinger *et al.*^[22] They also discuss more challenging task of hospital acceptance and outline the obstacles of consent, privacy, confidentiality, and medicolegal concerns.^[6,23]

Illustrative case for real-time video recording

TAVR was planned for a 94-year-old woman with severe aortic stenosis (mean gradient 93 mmHg, valve area 0.34 cm²). Her past medical history was significant for hypertension and New York Heart Association (NYHA) Class 3 heart failure. The patient was brought to the catheterization suite with an intravenous arterial line and central line/pulmonary artery catheter. Standard monitors were applied and after an uneventful induction and intubation, the patient went into cardiac arrest. The pulseless electrical activity arrest, subsequent resuscitation, initiation of cardiopulmonary bypass (CPB), and TAVR procedure were captured on the B-Line system.

The coordination of video and audio recordings allowed a specific timeline to be abstracted denoting the time to rhythm recognition and the initiation of advanced cardiac life support, the beginning of cardiopulmonary resuscitation (CPR) [Figure 1], the quality of compressions, the time-to-rhythm recognition, and time-to-drug administration. The required team integration to coordinate tasks and steps for progression in a difficult case are well visualized. Continuous high-quality CPR with minimal disruption was required as there was no immediate return to normal rhythm or spontaneous circulation. Sheaths were subsequently placed percutaneously in the right femoral artery and vein by the cardiovascular surgeon, and CPB was started [Figure 2].

After initiation of bypass, using our standard approach for TAVR, a 26 m Sapiens XT valve was delivered and deployed through the left femoral artery [Figure 3]. TEE confirmed a normally functioning valve with a postdeployment gradient of 9 mmHg and trivial paravalvular regurgitation. The patient was weaned successfully from CPB without further severe hemodynamic derangements. She was taken to the Intensive Care Unit as per our protocol and gradually weaned from sedation and ventilator support. The patient was extubated 7 h postprocedure and discharged from the hospital 6 days later. The patient did very well postoperatively with a marked improvement in her NYHA status at her 90-day postoperative visit.

The stored videotaping of the procedure led to an accurate timeline of the cardiac arrest, resuscitation, initiation of CPB, and valve deployment. This

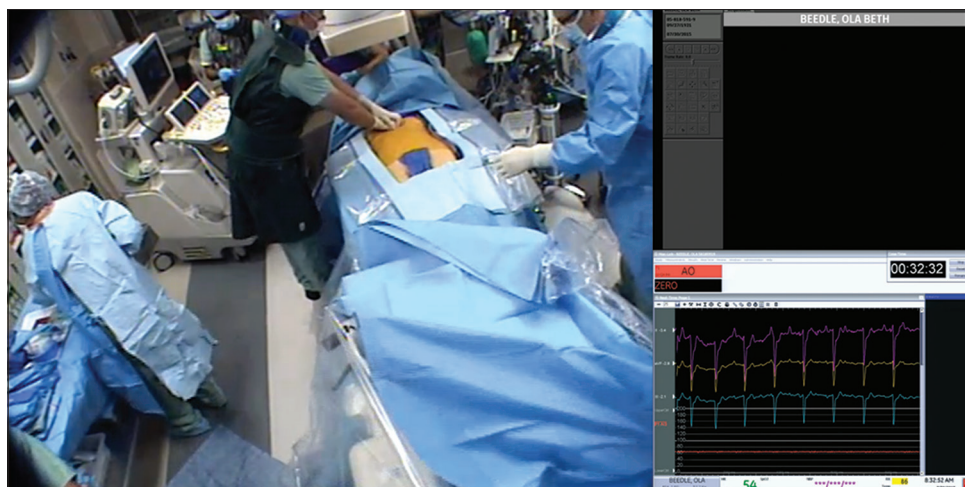


Figure 1: B-Line: Initiation of the code – chest compressions

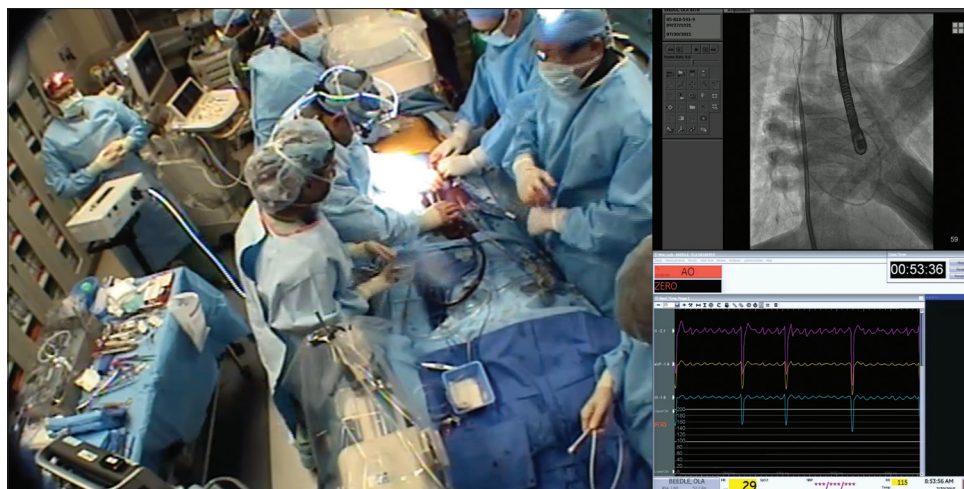


Figure 2: B-Line: Initiation of cardiopulmonary bypass

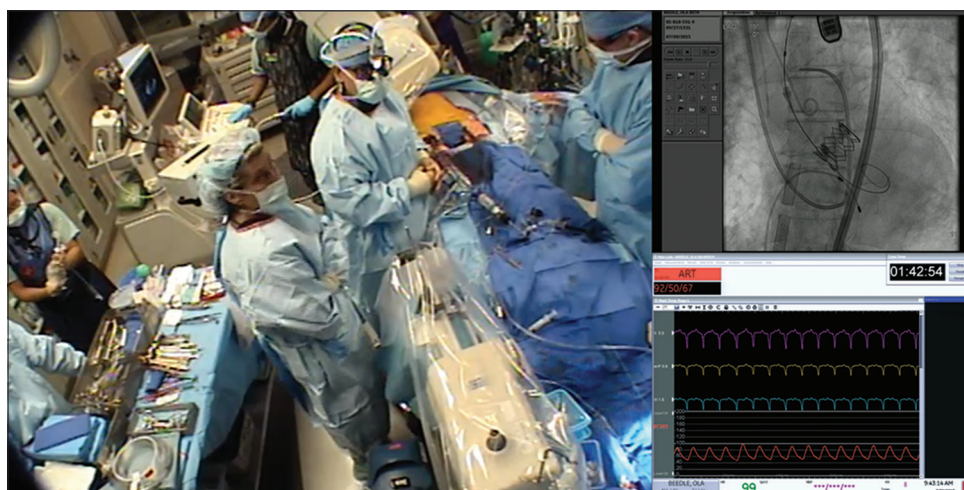


Figure 3: B-Line: Valve deployment on full cardiopulmonary bypass

allowed for an in-depth debriefing of communication, role assumption, situation monitoring, and overall teamwork. Many of these are tenets of the evaluation tools used in TeamSTEPPS.

RESULTS

The complexity of TAVR requires multiple teams to work in a very coordinated manner to care for a patient often too ill to be considered for conventional surgery. Institutions with programs and those developing TAVR programs need to provide “CRM” type assessments to their teams. This can be incorporated in interdisciplinary meetings, the utilization of specific programming such as TeamSTEPPS, or a specific analysis tool or strategy that fits into their program requirements. The ultimate goal of any of these interventions will be to improve patient safety and program outcomes.

After the initial assessment and planning phase before program implementation, our institution has used periodic meetings, preoperative timeouts and briefings, postoperative debriefings, and video and audio recordings to enhance CRM analysis and implementation of safety changes. We have used the illustrative case here to highlight the potential benefits of such an approach. The complexities of developing and implementing a system have been mentioned previously. Weinger *et al.* describe their experience in developing a complete system and using anesthesiology as their test environment, successfully recording, and annotating 270 clinical cases (872 h).^[22]

The addition of video and audiotaping in the operating or procedural suite is not accomplished without challenges. While there has been the successful utilization of homemade systems,^[18] many commercially available

products are geared to simulation in the health-care environment. The B-Line system we incorporated has evolved from the fixed version which is used in our Simulation Center. There, cameras and microphones are fixed in a position felt to provide the most dynamic view of the room and participants. Simulations can be viewed centrally behind one-way glass and annotations of events can be made real-time. Simulation sessions, there are typically divided into an introduction, a simulated case, and a debriefing session. The videotaped case is typically of short duration (10–30 min).

In the Catheterization Laboratory, 6 floors away, significant process changes were made to adapt the recording system to the new environment (B-Line LiveCapture). The portability and mobility of these newer systems are gradually improving making *in situ* recordings more available. Unfortunately, there are no personnel assigned to monitor these cases real-time or to do an immediate review of the recording as in the Simulation Center. In addition, issues with current technology (no on-the-fly animation) create difficulty in annotating the longer recordings made of the TAVR cases. However, review of specific procedures, difficult cases, or unusual events can be done retrospectively as in the case presented.

Video recording has been used in multiple procedural and operating room domains. It has been used to monitor hand contact and bacterial transmission,^[7] communication and situational awareness,^[19] and quality of inspection times and mucosal examination during colonoscopy.^[24] In that same study, copies of the videotapes were made available for third-party review. Intraoperative videotaping has been used to study abdominal surgery^[18] and analyze surgeon leadership during unanticipated events.^[25] As more videotaping is done for simulation, education, team-based assessment and improvement in patient care, more patients, and patient advocates will become aware of this technology. This may spawn new discussions about how and when to use these recordings.

Of importance to this discussion, a bill has been introduced in the State of Wisconsin (2015 Assembly Bill 255) requiring “...hospitals, ambulatory surgical centers, or and other places where surgical procedures are performed (surgical facilities) to offer surgical patients the option to have their surgical procedure videotaped.”

CRM advocates the development of customized and sustainable team-based tools that effectively use the resources available. Video and audio analysis of surgical procedures may provide important information for the analysis of the human and ergonomic factors, communication, and team dynamics affecting each team’s performance. The goal will be to translate this information to customize improvements that enhance patient outcomes and safety.

The analysis of the recording in this case and the subsequent debriefing led to two practice changes for the TAVR teams: (1) Team preoperative briefings to include the identification of very high-risk patients; (2) placement of prophylactic sheaths prior to anesthetic induction for these patients; and (3) the preprocedural timeout was changed to include the immediate readiness of CPB and ECMO.

DISCUSSION

Live video capture or real-time video recording of high-acuity, complex procedures (that are now increasingly common in cardiovascular anesthesia) is a critically important tool from a patient safety and education perspective. As our illustrative case demonstrates, feedback and debriefing following critical incidents either in the operating room, Intensive Care Unit, or catheterization laboratory setting, can facilitate prompt mechanisms of change. This will likely assume far greater importance in the future and may indeed become the standard of care to reduce medical errors in high-reliability organizations like healthcare.

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Conflicts of interest

There are no conflicts of interest.

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TAKE HOME MESSAGES

In this first of its kind of report in world literature, the authors from Mayo clinic beautifully describes the use of live video capture in a case of TAVR. During this aortic valve replacement with multiple team involved, this simulation realm, beautifully, helped the authors achieve their target goal of improving efficiency of human factors and perioperative challenges by reviewing and debriefing during such simulation improves cooperation amongst team mates and helps achieves targets faster in medicine and anaesthesia. So, Simulation is future.