Published in final edited form as:

Jt Comm J Qual Patient Saf. 2016 September ; 42(9): 400–414.

Operating Room–to-ICU Patient Handovers: A Multidisciplinary Human-Centered Design Approach

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Abstract

Background: Patient handovers (handoffs) following surgery have often been characterized by poor teamwork, unclear procedures, unstructured processes, and distractions. A study was conducted to apply a human-centered approach to the redesign of operating room (OR)-to-ICU patient handovers in a broad surgical ICU (SICU) population. This approach entailed (1) the study

of existing practices, (2) the redesign of the handover on the basis of the input of handover participants and evidence in the medical literature, and (3) the study of the effects of this change on processes and communication.

Methods: The Durham [North Carolina] Veterans Affairs Medical Center SICU is an 11-bed mixed surgical specialty unit. To understand the existing process for receiving postoperative patients in the SICU, ethnographic methods—a series of observations, surveys, interviews, and focus groups—were used. The handover process was redesigned to better address providers' work flow, information needs, and expectations, as well as concerns identified in the literature.

Results: Technical and communication flaws were uncovered, and the handover was redesigned to address them. For the 49 preintervention and 49 postintervention handovers, the information transfer score and number of interruptions were not significantly different. However, staff workload and team behaviors scores improved significantly, while the handover duration was not prolonged by the new process. Handover participants were also significantly more satisfied with the new handover method.

Conclusions: An HCD approach led to improvements in the patient handover process from the OR to the ICU in a mixed adult surgical population. Although the specific handover process would unlikely be optimal in another clinical setting if replicated exactly, the HCD foundation behind the redesign process is widely applicable.

Patient handovers (also termed handoffs) following surgery have often been characterized by poor teamwork, unclear procedures, unstructured processes, and distractions.¹ Postoperative handovers of critically ill patients, in particular, are rife with technical and communication errors.^{2,3} This is not surprising, given that the transfer of care to the ICU involves the transport of acutely ill or unstable patients; the transfer of complex monitoring and support equipment from operating room (OR) to mobile and then to local systems; and the sharing of complex patient information among clinicians of different specialties who often have different levels of experience or knowledge.

Several groups have published details of their programs for improving postoperative handovers.²⁻²⁷ Interventions involved various combinations of a protocol to structure tasks and processes, an information transfer checklist to standardize communication, and team training. The methods used to develop them included strategies as diverse as drawing analogies between patient handovers and racing team pit stops,² a Six Sigma approach,³ discussions with clinical staff,^{4,7,12,14,15,21,23,26} a survey of the literature,^{4,8,9,16,25,26} a failure mode and effects analysis and small-scale root cause analyses,⁵ interviews with expert care providers,^{6,12,18,25} and Plan-Do-Study-Act cycles.⁷ With respect to findings, these studies showed improved handover effectiveness (for example, decreased technical errors or information omissions), efficiency (reduced handover duration), safety (fewer interruptions), and perceived teamwork, satisfaction, and handover quality. Two studies failed to significantly reduce high-risk events⁶ and realized errors.⁵ In four additional studies, implementation of a structured handover process improved clinical measures, including a reduction in postoperative complications and an increase in early tracheal extubation,¹⁰ reductions in unplanned extubations and ventilator times,¹¹ reduction in ventilation duration,²⁵ reductions in hemodynamic and respiratory interventions, and fewer

postoperative delays in analgesia and antibiotic administration and in collecting laboratory studies.²¹ Many of these studies focus on one study population—pediatric patients undergoing cardiac surgery.^{2–6,9–11,15} The perioperative and recovery teams caring for this patient population are typically small, consistent, and highly specialized, so the generalizability of these study findings is limited. More recent research has evaluated handovers of adults, but little research^{14,17,18,24,25,27} has been conducted on the mixed, but high-risk, adult surgical population, and it is this patient population that resembles that of many surgical ICUs (SICUs). Furthermore, a majority of these studies provide limited descriptions of their interventions or the methods used to evaluate them.

The goal of our study was to apply a human-centered approach to the redesign of OR-to-ICU patient handovers in a broad surgical ICU population and assess its impact on handover quality. Human-centered design (HCD) is a system and product design philosophy that aspires to enhance human abilities, overcome human limitations, and foster acceptance.²⁸ To achieve these objectives, the system is designed around user characteristics, tasks, and work flows, as opposed to forcing users to change their behavior to accommodate system designs.^{29,30} In HCD, user-centered activities are incorporated throughout the development process, thus allowing users to shape the design of the end product and enhance its usability.^{31,32} The HCD approach has led to significant human-system performance improvements in aviation, military systems, and health care.^{33–36}

We implemented a human-centered approach to the design of postoperative handovers in which we (1) studied existing practices, (2) redesigned the handover based on the input of handover participants and evidence in the medical literature, and (3) studied the effects of this change on processes and communication. Our primary hypothesis was that the redesigned handover process would improve information exchange. We also hypothesized that application of the HCD approach would enhance handover quality by improving teamwork, decreasing staff workload, reducing interruptions, and increasing staff satisfaction, without prolonging handover duration.

Methods

A protocol was submitted to the Durham [North Carolina] Veterans Affairs (VA) Medical Center Institutional Review Board and Research and Development Committees, who determined that their oversight was not required.

Study Setting

The SICU at the Durham VA Medical Center is an 11-bed mixed surgical specialty unit. With continuous on-site coverage by a combination of attending and resident physicians from the VA Medical Center and its academic affiliate, Duke University Hospital, the SICU admitted 1,052 patients in 2012.

Data Collection

The key HCD principle is an explicit understanding of users, their tasks, and the environment.³⁷ To understand the existing (preintervention) process for receiving

postoperative patients in the SICU (described on page 404), we used ethnographic methods—a series of observations, surveys, interviews, and focus groups.

We focused our observations on high-risk patients whom we defined as those with invasive arterial pressure monitoring and/or those who were receiving postoperative mechanical ventilation. Patients were recovering from cardiac, thoracic, neurologic, general, or vascular operations. We observed handovers using a comprehensive checklist that consisted of the following:

An information exchange list (for example, “Did the anesthesia provider discuss intraoperative airway management?”)

- An equipment list (“Was the ventilator ready in the patient’s room before arrival?”)
- A task list (“Were the blood collection tubes labeled?”)
- Team members present
- Team member tasks (“Who connected the ECG [electrocardiograph] cables?”)
- The number of interruptions
- Team behaviors (“Did the receiving team have an opportunity to ask questions?”)
- Time points (time-to-surgery report, total handover duration)

Observations were conducted from March through June 2010. Observers were experienced clinicians who supplemented the checklist with additional descriptive detail (for example, “handover audible only to anesthesia provider; need to leave room for a record-keeping computer; shortage of A-line clamps at the bedside; isolation status not communicated”).

Following observation of each handover, we asked participants to describe what went well during the handover and what could be changed to improve the process (the plus/delta evaluation tool). We also assessed provider workload using the NASA Task Load Index (TLX).³⁸ The NASA TLX and plus/delta surveys were administered to the anesthesia provider and primary SICU nurse immediately following the bedside handover, and to the SICU resident and primary SICU nurse four hours later. Survey times were chosen to represent periods during which workload was expected to be affected by handover quality. The surveyed providers were those who performed most of the work associated with the new patient’s care (before the handover redesign). To obtain an overall workload score ranging from 0 (low) to 100 (high) for each provider at each time point, scores for six workload dimensions—mental, physical, and temporal demand; performance; effort; and frustration—were standardized and weighted based on surveys of providers in each role (the weighting procedure combined the results of the six subscales to reduce variability between responders).³⁸

An organizational behavior [J.D.E.] or human factors [N.S., M.C.W.] expert and a research clinician [A.S.B., S.R.P.] conducted interviews and focus groups. A total of 32 providers were interviewed, including (1) SICU personnel—nurses, physicians, a respiratory therapist,

a ward clerk, and the nurse manager; (2) OR personnel—anesthesiologists, nurse anesthetists, surgeons, a perfusionist, and circulating nurses; (3) other relevant personnel—nurses in the postanesthesia care unit, medical ICU, and coronary care unit (because SICU patients were sometimes routed to these units); and (4) a representative from the bed control committee. Discussions were 30–60 minutes long and spanned such topics as the responsibility for transmitting and receiving information, information prioritization and documentation, leadership during the handover, problems with the current process and potential solutions, and the effect on handover quality of such factors as provider experience and interpersonal relationships.

The interviews and focus groups were recorded, transcribed, and then coded using conventional content analysis, a qualitative method for analyzing text data that is used to describe a phenomenon when existing theory on the topic is limited.³⁹ Coders worked in three clinician and nonclinician dyads to highlight and define key concepts. A human factors expert [N.S.] then integrated the codes created by the teams into a single coding scheme, summarized the codes, and sorted them into categories reflecting related themes. Observation notes and plus/delta survey comments were likewise analyzed and added to the coding scheme.

Applying Human-Centered Design

Using the observation data, we developed a process map that described the baseline handover process (Figure 1a, page 403). Qualitative data—the coding scheme developed using interview and focus group transcripts, observation notes, and survey comments—provided additional insights into existing practices as well as perceived problems and suggestions for resolving them.

We conducted a one-day retreat with key stakeholders from anesthesiology, surgery, intensive care, and nursing, as well as human factors and organizational behavior experts (a key principle of HCD is that the design team include multidisciplinary skills and perspectives³⁷). We used the qualitative and quantitative data to describe the current handover process and to identify problem areas. We then redesigned the process to better align with provider needs and expectations and with evidence gleaned from a review of the literature.¹ As part of the handover standardization, tasks and information delivery were assigned to providers in specific roles (Figure 1b, page 403). Assignments were based largely on observations of which providers had historically performed the tasks and delivered the information, with the goal of introducing change that would have a high likelihood of success. We also created documents and changed processes to support the transfer of information to the SICU both before and after patient arrival.

In line with HCD requirements for an iterative process driven by human-centered evaluation,³⁷ we used in situ high-fidelity patient simulation to model, test, and refine the redesigned handover process. A patient simulator with standard transport equipment and typical invasive monitors was delivered to a SICU patient room by an OR team and handed over to a SICU team. Observers (human factors engineers) and participants then discussed deficiencies in the redesigned process and made suggestions for improvement. Topics for discussion included information content and presentation order, use and format of

supporting documents, task performance sequence, and positions of personnel and equipment in the room. The simulation was repeated following modifications to the process, and problems were again identified and corrected.

Intervention Evaluation

In HCD, the design process is driven by evaluation.³⁷ After the new handover process was introduced and practiced reliably from November 2010 through January 2011, we repeated the observations and survey. Observations were conducted from February through June 2011. A subset of the data was analyzed—those items for which we obtained high-quality data (excluding items for which few data points were available or that observers found difficult to score). For each handover, we calculated the following:

- Information transfer score: The primary outcome measure—information completeness—was reported as the percentage of 20 essential items that were conveyed in the verbal report, such as procedure name, intravenous (IV) lines, anesthetic drugs, and hemodynamic management plan (Appendix 1, available in online article).
- Team behaviors score: A measure based on seven observable behaviors indicative of good teamwork, such as “the receiving team confirmed readiness to receive report” (Appendix 1).
- Total handover duration: From patient arrival in the SICU until the last delivering team member had left the bedside
- Number of interruptions
- Workload: Providers’ NASA TLX scores

In an attempt to assess compliance with the new handover process (as opposed to handover quality), we also measured the following:

- Provider presence: Each handover was given a score of 1 if all four critical providers—the delivering anesthesia provider and surgeon, and the receiving SICU physician and primary nurse—were present for the verbal report. A score of 0 was given if one or more of these providers were not present for the report.
- Task performance: The percentage of tasks completed by the provider to whom they were assigned in the redesigned handover (Figure 1b). These tasks (and assigned providers) were as follows: connecting the noninvasive blood pressure monitor (SICU primary nurse), the arterial blood pressure monitor (anesthesia provider), the pulse oximeter (primary nurse), the ECG monitor (primary nurse), and the central venous pressure monitor (anesthesia provider).

In October–December 2013, three years after establishing the new handover process, we surveyed handover participants—anesthesia providers, surgeons, OR nurses, and SICU nurses, physicians, and respiratory therapists—to evaluate their long-term satisfaction with the changes. Survey respondents were asked to compare the old and new handover processes on a scale of 1 (“the previous handover was much better”) to 5 (“the current handover is much better”), in terms of nine metrics, including ability to prepare for patient arrival,

passing on important information, and getting questions answered. Open-ended comments regarding changes made to the handover process were also solicited.

Statistical Analysis

The Student's two-sample *t*-test was used to compare pre- and postintervention handovers in terms of the information transfer score (primary measure), team behaviors score, workload score, duration, interruptions, and task performance. The provider presence measure was analyzed using a proportion test. The Student's one-sample *t*-test was used to compare the satisfaction survey scores to the expected score of 3 (equivalence of old and new handovers). A *p* value of 0.05 was considered significant.

The Preintervention Versus Postintervention Handovers

Preintervention Handover.—The handover process began with a phone call from the anesthesia provider to the receiving nurse in the SICU approximately 15–30 minutes before the patient's arrival. The content of this conversation was highly variable. While some nurses requested detailed information that could be delivered on arrival at the SICU or obtained via the electronic health record (for example, past medical history), information that is vital for room preparation (for example, isolation precautions) was not consistently provided. The timing of the phone call—very near the end of surgery, often coinciding with emergence or preparation for transport—was perceived by anesthesia providers as disruptive to care at a time of potential patient instability and concentrated activity. The OR circulating nurse made additional calls before arrival—an “off pump call” (for cardiac surgery) and a “rolling call” when the patient left the OR. When these calls were not successfully completed, stress and conflict among participants often disrupted the subsequent patient handover. In addition, SICU providers noted that they were not prepared or available when the patient arrived if a rolling call was not received.

On arrival in the SICU, six or more care providers were often present at handovers, contributing to confusion and room overcrowding. Task performance was often disorganized. In addition, SICU equipment and supplies were missing or faulty in 61% of 49 cases observed, requiring nurses to leave the bedside and disrupt the handover. These and other technical issues are summarized in Appendix 2 (available in online article).

Bedside handover communication was also flawed. Information transfer was inconsistent, and vital information was often omitted. In part, this occurred because providers in different roles believed that different information was important. Nurses rarely stopped their clinical task performance to listen to the verbal report, and some anesthesia providers delivered only a cursory report. These behaviors may have resulted from the fact that they considered the preliminary phone report to be the main report and in face-to-face conversations only discussed information that had changed in the interim. In such cases, however, the other SICU providers learned only about events that occurred since the phone report. Multiple reports were often given to various providers, sometimes more than once. Inaudible reports or reports directed only at certain providers were observed. Participation in handovers was also variable. If the surgeon had left the bedside, a surgical report was simply not given. Key communication problems are listed in Appendix 2.

Postintervention Handover.—The issues evident in the preintervention handover pointed to a need to standardize the transfer of knowledge, equipment, and responsibility for patient care in postoperative handovers. The new process, designed around participant interests, concerns, and work flow, begins with a handwritten preliminary report completed by the anesthesia provider and delivered to the patient’s primary nurse approximately one hour before patient arrival (Figure 2, page 405 [also available online in larger size]). This report provides the nurse with sufficient information to prepare the room, without requiring the anesthesia provider to step away from the surgical patient for a lengthy phone conversation. As such, information is confined to essential elements such as intubation status, lines, infusions, infection precautions, anticipated complexity, responsible OR and anesthesia staff, and estimated time of arrival. Users of the preliminary report—anesthesia providers and SICU nurses—provided feedback on its proposed content. In an iterative design cycle, it was revised and evaluated again by potential users.

On arrival in the SICU, both the delivering and receiving teams complete time-critical tasks, such as attaching the ventilator and transferring monitors to the ICU units, before beginning the verbal handover (Figure 1b). The presence and attention of four providers are required: the delivering anesthesia provider and surgeon, the ICU physician, and the primary ICU nurse. While other providers complete secondary tasks, the smaller group engages in a single, face-to-face conversation in a “sterile cockpit” environment that aims to avoid interruptions and distractions. The SBARQ mnemonic (Situation, Background, Assessment, Recommendations, Questions) was selected to guide this conversation on the basis of a review of the literature and includes, as part of the Assessment phase, a rapid physical survey to identify all lines, tubes, and intravenous infusions. The conversation concludes with designated time for team members to ask and answer questions, and a verbal transfer of responsibility for care. A cognitive aid is available both as a poster in each patient room to serve as a discussion reminder, and as a sheet of paper for the primary nurse to take notes during the verbal handover (Figure 3, page 406). The anesthesia provider was designated as the handover leader, and ICU nurses were empowered to facilitate the process, particularly with new leaders and providers unfamiliar with the new handover.

As stated earlier, we simulated the redesigned process to identify problems and refine procedures and documents. We then implemented the new handover in three phases, which together lasted approximately three months (from November 2010 through January 2011): (1) introduction, (2) “go live,” and (3) sustainment. In the introduction phase, OR and SICU managers, frontline staff champions, and other stakeholders were asked to vet and formally approve the new handover. After adequate support was established, the new process was introduced to the OR and SICU staff via pamphlets, posters in common areas (Appendix 3, available in online article), brief presentations during staff meetings, and direct one-on-one conversations with members of the project team. Four in situ simulation sessions re-creating the handover of a cardiac surgical patient were also conducted to demonstrate the redesigned process and to train staff.

The new handover was fully implemented during a week-long go-live phase in November 2010. Members of the handover project team, department leaders, and frontline champions were present to prospectively generate support and engagement, coach staff through the

change process, identify and overcome barriers, answer questions, and solicit feedback. In the sustainment phase, the level of support and coaching was gradually decreased as the new process gained traction.

Results

Observations

We observed 49 handovers before implementing the new process and 49 handovers after implementation. The results are summarized in Table 1 (page 406). The information transfer score, handover duration, and number of interruptions did not change significantly. However, the team behaviors score improved significantly: A mean 61% of the seven desired behaviors were observed preintervention, as compared with 83% postintervention (one-tailed $t[96] = 1.66, p < 0.001$; Figure 4 [page 407]). In addition, workload significantly decreased from an average TLX score of 34.8 preintervention to 28.4 postintervention (one-tailed $t[96] = 3.18, p = 0.001$).

Compliance Measures

The task performance measure was significantly higher postintervention: 53.6% of tasks were performed by the designated provider preintervention, compared with 78.2% postintervention (one-tailed $t[95] = 1.66, p < 0.001$). The presence of the four critical providers at the handover improved but did not reach significance (from 76.7% of preintervention handovers during which all team members were present to 88.4% postintervention; one-tailed $z = 1.42, p = 0.077$).

Survey

The survey, which was administered in October–December, 2013—three years after implementation of the new handover process—demonstrated significantly higher satisfaction with the new handover (one-tailed $t[55] = 7.91, p < 0.0001$; Figure 5 [page 408]). Survey participants' median score was 4 on a scale of 1 (“the previous handover was much better”) to 5 (“the current handover is much better”). On average, 36 (64%) of 56 participants scored the postintervention handover as “better” or “much better” than the preintervention handover, while only 3 (5%) rated the preintervention handover as “better” or “much better.”

The survey comments were generally positive. A SICU nurse, for example, noted the following:

I often refer to the new handoff format as an example of a well-developed communication tool, based on input from all relevant parties. After this handoff was put into place, transfer became much more efficient and organized. ... The wall chart [cognitive aid] makes it easy to keep all team members on task. We can simply point to the next step in the process. The preliminary report is very helpful because it has a diagram of the patient, along with written info. ... Sometimes simple tools are the best. ...”

Other comments suggested that consistency could be improved, as indicated by those from another SICU nurse:

When the handover is done correctly, the current handover is better for communication and continuity. When the anesthesia sheet is late or not delivered, or if the data are inaccurate, it is difficult for nursing. Also, I have had surgery become impatient while the patient is being hooked up to the monitor. Report is often started before nursing is ready.

Discussion

Problems related to information comprehensiveness and integrity, inefficient or unsafe processes, and poor teamwork have been cited as problem areas in OR-to-ICU patient handovers.^{2,3,5,6,17,24,40–43} We uncovered similar technical and communication flaws, such as lack of prioritization and assignment of responsibility, inconsistent transfer of vital information, multitasking during verbal reports, and crowded, noisy environments. We redesigned the handover guided by HCD, an approach that emphasizes the needs of its participants, and by best practices for this process derived from the literature.¹

Gould and Lewis argue that system design should follow three principles: (1) an understanding of its users and their work; (2) simulation to observe users' interaction with the proposed system; and (3) iterative design (that is, problems identified during testing must be corrected, and the design and testing cycle repeated).⁴⁴ Following these HCD principles, we used observations, surveys, and interviews to characterize the handover participants and task performance associated with patient transfers in our environment. We then designed the new handover on the basis of the work flow and information needs of participants, also accounting for characteristics of the facility and infrastructure. We tested our proposed solution by using high-fidelity simulation to model OR-to-SICU handovers with real providers. We refined the handover process, cognitive aid, and other supporting materials based on our findings, as well as informal and iterative feedback from participants.

HCD has recently been gaining traction in health care. A human-centered approach has been applied successfully to processes such as the design of bar-coded medication administration and the implementation of a nursing shift-change report.^{45,46} As with our initiative, these studies placed an emphasis on the needs and input of frontline staff and on an iterative cycle of testing, feedback, and process refinement.

Our efforts led to a clear improvement in team behaviors and provider workload. Postintervention, more handovers were audible to all team members, and the receiving teams had more opportunities to confirm that they were ready to receive report and to assume responsibility for the patient. In addition, receiving team members left the room less frequently to replace missing supplies or equipment, a finding confirmed by SICU nursing staff, who noted that the preliminary report allowed them to better prepare for patient arrival. Workload also decreased after implementing the new handover, and 18 months after these changes, this finding, as measured in the satisfaction survey, still held true.

Results of the long-term postintervention and initial plus/delta surveys suggest that clinicians were more satisfied with the new structured process. In comparison to the previous handover process, the SICU staff felt better prepared for patient arrival, information

exchange was more effective, and staff workload was reduced. In addition, although simultaneous task performance during the verbal report was discouraged, our redesigned handover did not require more time to complete. This type of multitasking during postoperative handovers is common and has been shown to decrease information retention,⁴³ even though it does not significantly reduce handover duration.⁴⁷ Clinicians have embraced the new handover process, as evidenced by an improvement in task performance by providers to whom they were assigned.

Although we failed in our short-term primary goal of improving the transfer of patient information, our long-term postintervention survey suggests that the most important information was more reliably and consistently conveyed with the new handover process. This finding may be explained in part by informal comments by participating clinicians, which indicated that they found the SBARQ structure awkward. It required anesthesia providers to convey information about the patient's situation, with the surgeons then required to provide information about the situation and background, followed by the anesthesia providers' report of their patient assessment, which, in turn, was followed by the surgeon's assessment and recommendations (Figure 3). This back-and-forth exchange between anesthesia providers and surgeons was perceived as artificial. Other researchers successfully applied the SBAR structure to information transfer in postoperative handovers but did not report similar issues associated with the order of information presentation.^{17,19,22} In our long-term postintervention survey, many handover participants attested to an improved information transfer process, perhaps attributable to their modifying the SBARQ to a structure that allowed for more natural information flow. In the revised format, the surgeon first conveys surgery-related information, and then the anesthesia provider discusses information related to the anesthetic course, both referring to the cognitive aid. The discussion concludes with team questions and answers. Although not initiated by the design team, this change to the handover process demonstrates one of the principles of HCD; namely, an iterative design process that accounts for users' work flows.

The handover process that we designed using an HCD approach still remains in place, and the preliminary report and cognitive aid are still used to guide information transfer. A challenge associated with sustainment of the revised process is teaching the process to new trainees. This has been a source of some frustration for staff, which reflects how the process is now the "new normal" and how staff expect this process to occur the same way every time. Recently, several adjustments to the process have been made to address changing systems and user requirements. First, with the shift to an electronic anesthesia record keeper, the anesthesia provider no longer arrives in the SICU with a handwritten anesthetic record from which to read such information as fluids and drugs administered. Instead, the anesthesia provider typically notes this information upon closing the electronic record keeper in the OR before leaving the room and reports it during the verbal handover. Second, to ensure prompt communication with the patient's family post-surgery, the cognitive aid has been revised with the goals of (1) making the entire team aware of the patient's social support structure, and (2) reminding the surgeon to update the family if he or she has not done so already.

Our handover redesign and subsequent attempt to assess its effects has several limitations. As in most studies of clinical handovers, we were unable to examine the effects of the redesigned process on patient outcomes. However, improved team behaviors, reduced workload, and improved staff satisfaction that we have demonstrated have all been linked to improved quality of care and patient outcomes in other care settings.^{48,49} In addition, our handover redesign involved a single medical center and a specific clinical arena, which raises some concerns about the generalizability of our findings. This report describes an approach to practice improvement that is unique in its human-centered focus. We believe that its generalizability lies in the synergistic blend of HCD and evidence-based guidelines. Although our specific handover process would unlikely be optimal in another clinical setting if duplicated exactly, the HCD foundation behind the redesign process is widely applicable. The methods and tools described in this report serve as examples that other clinical teams can modify to meet the needs of their specific work environments.

Conclusions

Patient transfers from the OR to the surgical ICU are highly complex and are often characterized by unsafe practices. To support the work of clinicians in this environment, we developed a postoperative handover process based on human-centered design principles combined with evidence from relevant literature. Our new process clearly defined roles and task sequences and structured the transfer of information, taking into consideration local work flow, infrastructure, and personnel constraints. This effort improved team behaviors and staff satisfaction and reduced clinical workload, without increasing handover duration. The quality improvement process we have described can be applied widely to the benefit of both patients and clinicians.

Acknowledgments

This work was supported by a VA National Center for Patient Safety grant (Mark, PI). The views expressed in this article are those of the authors and do not necessarily reflect the position or policy of the US Department of Veterans Affairs.

Appendix

Appendix 1.

Information Transfer and Team Behaviors Items for Observations of Operating Room-to-ICU Handovers

Information Transfer Items
Did surgeon/anesthesia provider identify the patient?
Did surgeon/anesthesia provider give the patient's age?
Did surgeon/anesthesia provider give the patient's allergies?
Did surgeon/anesthesia provider report the procedure?
Did surgeon include plan for hemodynamic management?
Did surgeon include plan for pain management?
Did surgeon describe anticipated course, potential problems?

Information Transfer Items	
Did surgeon state “call for” triggers?	
Did anesthesia provider list the patient’s past medical history?	
Did anesthesia provider report the patient’s baseline status?	
Did anesthesia provider report patient’s hemodynamic status?	
Did anesthesia provider state the anesthetic technique?	
Did anesthesia provider state airway management method?	
Did anesthesia provider give details of IV lines?	
Did anesthesia provider give details of invasive lines?	
Did anesthesia provider list the relevant anesthetic drugs?	
Did anesthesia provider give details of intraoperative events?	
Did anesthesia provider give details of IV fluids administered?	
Did anesthesia provider state details of fluids in?	
Did anesthesia provider state details of other fluids out?	
Team Behaviors Items	
Receiving team verbalized assumption of care.	
Was there a need to leave the room for missing supplies/equipment?	
Receiving team verbally confirmed it was OK for delivering team to depart.	
Verbal handover was audible to all team members.	
There was an opportunity for the receiving team to ask questions.	
Receiving team confirmed readiness to receive report.	
Anesthesia and surgery reports were given at the patient’s bedside.	
IV, intravenous.	

Appendix 2.

Technical and Communication Issues in Operating Room-to-ICU Handovers Identified in Interviews, Observations, and Plus/Delta Surveys

Technical Issue	Example
Insufficient time to set up patient room	Waiting for a bed to become available on the floor. ... And then all of a sudden turn the room around as fast as possible to accommodate the OR. [SICU Nurse]
Nurses not always ready to admit patient, sometimes resulting in wait in OR	It would be optimal if when you rolled in they were waiting for you and everybody was there. But that can't happen because there's so many other patients and they have other duties and stuff [to do]. [Anesthesia Attending]
Difficulties during transport, in hallway and SICU	Transport is always tough because you're distracted ... rolling the bed and making sure everybody's organized and the lines are all untangled and you're not tripping on stuff. [Anesthesia Attending]
Tangled IV and monitoring lines	I think a lot of the issues stem from a little disorganization and people's lines are tangled and things are fairly messy. ... [Anesthesia Attending]
Patients arriving with hemodynamic instability, uncontrolled pain, or bleeding	The resident brings the patient to the ICU and hands the patient over. The next thing you know the invasive blood pressure is showing is 70/40. The patient is tachycardic and clearly not doing very well. ...

Technical Issue	Example
	This is an inappropriate handover. He's not resuscitated. [SICU Attending]
Lack of clear allocation of task responsibilities	Often we are all tripping over each other in attempts to organize lines, hook up monitors, etc. Flow may be improved if people had specific tasks they are responsible for. [SICU Nurse]
Missing and malfunctioning equipment and supplies	There is always something broken or not available. [SICU Nurse]
Large number of care providers in patient room, some not essential	Maybe too much help. Too many people doing things around the patient. [Anesthesia Resident]
Handovers are disorganized and not standardized.	When we get there ... there's so much going on, it's noisy, they've got the TV on, there's like 20 different tasks they should be doing and there's always different people and it's just not that organized. [Anesthesia Attending]
Patients not always stable and monitored before start of verbal handover	I want to get in there and see the saturation right away and the blood pressure. Make sure the guy's breathing okay. And a lot of times people are worried about making everything neat and fixing and giving report and nobody's actually looking at the patient. [Anesthesia Attending]
Nurses often complete clinical tasks while listening to report.	... It would probably be best if the nurse who is going to be responsible for the patient has assistance from other nurses. ... so that nurse can sit there and listen to exactly what happened and what the goals are and write down notes for themselves. ... Because sometimes the nurses, while we're talking about what we did, they're getting the patient situated and untangling the lines and wires and things like that. [Surgical Fellow]
Communication Issue	Example
Lack of timely access to computerized patient reports	Sometimes it's a big rush to prepare the room, get the room clean, there were some times you just don't have enough time to do any research on them. [SICU Nurse]
Phone call alerting SICU that patient is leaving the OR is not always made, or not communicated to all SICU team members.	They don't like it when they don't get a rolling call because ... they may be busy doing something else when that patient is coming over to the unit. [OR Circulating Nurse]
Urgent information is not always communicated prior to or immediately upon patient arrival.	Often when they roll in, they don't tell us they're MRSA positive. ... Not a half an hour later, and somebody says, "oh by the way, he's MRSA positive." [SICU Nurse]
Not all team members are present for verbal handover.	No surgical resident or attending came with patient, all report given by anesthesia. [Observer]
Not all team members verify SICU team is ready to begin verbal handover.	Working on monitors so receiving team could not confirm readiness to receive report. [Observer]
Patients are not always explicitly identified.	Patient name never mentioned despite this patient being different than the scheduled patient. [Observer]
Handovers are sometimes inaudible or audible only to some team members.	... They come in and they give them bedside report that they'll usually pull the doctor outside and talk outside so you don't know what's going on with the patient. So it's very, very frustrating from a nurse standpoint. ... I don't know what happened, what he did get, what to expect, what he thinks is going on and that type of thing. ... It just kind of minimizes our importance. [SICU Nurse]
Reports are not always given at bedside.	Getting resident report from surgery out in hall while anesthesia giving report [to nurse] in room. [Observer]
Information sometimes needs to be repeated for team members coming into patient room.	If we could get everybody in one place and have everybody pay attention, then we wouldn't have to repeat things. ... I think redundancy is bad in this situation. [Anesthesia Attending]
Multiple, simultaneous reports are given.	So the anesthesia person is talking to the nurse, and the surgeon's talking to the nurse, and the resident's talking to the surgeon and there's like three or four different conversations and you don't really know if everybody's getting all the info. [Anesthesia Attending]
Inconsistent information content	All the information I get is always good information but it's not always the same information. [SICU Resident]

Technical Issue	Example
Important but atypical information may not be transferred	Some of the vital things maybe they should talk about like say, for instance, some part of the surgery went really bad. ... Nobody transmits that information and everybody thinks everything's just going great. ... Some of the information doesn't get passed on because we're always worried about the fluids, the IVs, and the kind of standards. ... [Anesthesia Attending]
Information delivery is disorganized.	[The anesthesia provider] called that report to the nurse, but there's this resident out there who sometimes looks like a deer in the headlights when the patient gets there. ... They actually haven't gotten that information that the nurse has got, which is a pretty full report. Because sometimes the anesthesia resident ... comes in and says, "Well, I gave you all the stuff on the phone." But the resident didn't get it, just the nurse. [Surgical Attending]
Noise, interruptions, and distractions are common.	Structured handover might be helpful with dedicated time (not being interrupted by others for other patient needs or questions ...). [SICU Resident]
Time for questions is not always provided.	The person who gave me report was very complete in giving me the info I needed. He spoke clear and slow and allowed time for questions and verification. This is not the case for everyone giving report. [SICU Nurse]
Time pressure to finish handovers	When taking sick patients to the ICU there really needs to be appropriate time for adequate handoff without feeling pressured to run back to start another case. [Anesthesia Resident]
Lack of documentation of handovers	They just don't have a chance to jot notes if they need to. ... I would ask the ICU team if they have a particular form that they fill out because I have been in hospitals where they do have those. ... That would probably be helpful. [Surgical Fellow]
Anesthesia charts are sometimes illegible, difficult to understand by non-anesthesia providers, and may be hard to locate.	If it was electronic, it would be easier for them to read. ... In general people that are not anesthesia providers, it's hard for them to decipher that chart. [Anesthesia Attending]
Different experience levels of providers can impede communication and lead to disagreements.	The more I do it, the more I think of what I need to ask them. ... But the first few times ..., it was more being unfamiliar with the operation ... and not necessarily knowing what I needed to ask them specifically. [Junior SICU Resident]
Interpersonal relationships can affect handover quality.	Anesthesia team very rude during handoff. ... It took everything I had not to respond rudely. [SICU Nurse]

OR, operating room; SICU, surgical ICU; IV, intravenous; MRSA, methicillin-resistant *Staphylococcus aureus*.

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Appendix 3. Poster Describing the Redesigned Handover Process

This poster was posted in common areas in the operating room (OR) suite and surgical ICU during the implementation phase.

SBARQ. Situation, Background, Assessment, Recommendations, Questions.

DEPARTMENT OF VETERANS AFFAIRS, DURHAM, N.C.

Preliminary Report Template

Time: _____	Date: _____	OR _____
Anes: _____ RN _____		
Procedure: _____		
Pertinent PMHX: _____		
Airway : Post-op Intubated? ☐ Yes ☐ No		
Expected ICU Course: ☐ Routine ☐ Complex		
Why Complex? _____		
Bleeding Risk: ☐ Actively bleeding ☐ Low ☐ High		
Special Considerations: _____		
Precautions: ☐ Latex ☐ MRSA ☐ HEP ☐ HIV ☐ VRE ☐ Other _____		
ETA: _____		

PAGE ANESTHESIA TECH TO DELIVER TO ICU CHARGE/ADMITTING

Antibiotics: _____ Current Infusions: ☐ Amiodarone ☐ Dopamine ☐ Epinephrine ☐ Insulin ☐ Milrinone ☐ Phenylephrine ☐ Nicardipine ☐ Nitroglycerin ☐ NTG ☐ Vasopressin ☐ Dexmedetomidine ☐ Blood: _____	Time: _____ Operative Lines Card Surgical Intravascular Lines? ☐ ☐
Pt. Name: _____ DOB: _____ SSN: _____	

PIV/Gauge = Peripheral IV Art = Arterial Line IS = Introducer Sheath EPID = Epidural
 TL = Triple Lumen PA Cath = Pulm Artery Catheter ICP = Intracranial Pressure Monitor/Device
 CT = Chest Tubes BP = Balloon Pump ETT = ET Tube OGT/NGT = orogastric tube/nasogastric tube

Figure 2. Preliminary Report

The preliminary report template and operative lines card were developed as part of the handover redesign process. The handwritten preliminary report is completed by the anesthesia provider and delivered to the patient's primary nurse approximately one hour before patient arrival in the surgical ICU.

MRSA, methicillin-resistant *Staphylococcus aureus*; HEP, hepatitis; VRE, vancomycin-resistant Enterococcus; ETA, estimated time of arrival.

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(A) Baseline (Historic) Handover Process and (B) Postredesign Handover Process **Figure 1.**

The (1a) baseline (historic) and (1b) postredesign handover process are shown. The baseline process was highly variable, with some team members not present for parts of the handover, care providers performing different tasks while listening to the verbal reports, and multiple reports delivered and received, with different providers receiving different pieces of information. ECG, electrocardiogram; NIBP, noninvasive blood pressure; ETT, endotracheal; NG, nasogastric.

Preliminary Report

DEPARTMENT OF VETERANS AFFAIRS, DURHAM, N.C.

Preliminary Report Template

Time: _____ Date: _____ OR _____
 Anes: _____ RN _____

Procedure: _____

Pertinent PMHX: _____

Airway : Post-op Intubated? ☐ Yes ☐ No

Expected ICU Course: ☐ Routine ☐ Complex
 Why Complex? _____

Bleeding Risk: ☐ Actively bleeding ☐ Low ☐ High

Special Considerations: _____

Precautions: ☐ Latex ☐ MRSA ☐ HEP ☐ HIV
☐ VRE ☐ Other _____

ETA: _____

PAGE ANESTHESIA TECH TO DELIVER TO ICU CHARGE/ADMITTING

Antibiotics: _____ Time: _____

Current Infusions:
☐ Amiodarone
☐ Dopamine
☐ Epinephrine
☐ Insulin
☐ Milrinone
☐ Phenylephrine
☐ Nicardipine
☐ Nitroglycerin
☐ NTG
☐ Vasopressin
☐ Dexmedetomidine
☐ Blood: _____

Operative Lines Card

Surgical Intravascular Lines? ☐

Pt Name: _____
 DOB: _____
 SSN: _____

PIV/Gauge = Peripheral IV Art = Arterial Line IS = Introducer Sheath EPID = Epidural
 TL = Triple Lumen PA Cath = Pulm Artery Catheter ICP = Intracranial Pressure Monitor/Device
 CT = Chest Tubes BP = Blood Pressure ETT = ET Tube OG/NGT = orogastric tube/nasogastric tube

Figure 2.

The preliminary report template and operative lines card were developed as part of the handover redesign process. The handwritten preliminary report is completed by the anesthesia provider and delivered to the patient's primary nurse approximately one hour before patient arrival in the surgical ICU. MRSA, methicillin-resistant *Staphylococcus aureus*; HEP hepatitis; VRE, vancomycin-resistant *Enterococcus*; ETA, estimated time of arrival.

ICU Bedside Report Cognitive Aid

ICU Bedside Report Cognitive Aid

SITUATION

Anesthesia: ☐ Isolation Precautions
☐ Pt Status Routine vs. Complex
☐ Patient Name and DOB

Surgery: ☐ Diagnosis
☐ Procedure / Technical Details

BACKGROUND (HISTORY)

Anesthesia: ☐ Anesthesia/ Sedation/ Airway
☐ In / Outs (fluids, EBL)
☐ Pertinent Intra-op Events
☐ Pertinent Hx / Home Meds
☐ Allergies
☐ Baseline VS / Functional Status

ASSESSMENT

Anesthesia: ☐ Airway
☐ IV Lines
☐ Infusions
☐ Pacer

Surgery: ☐ Surgical Lines / Special Equip

RECOMMENDATION (PLAN)

Surgery: ☐ Anticipated Course
☐ Hemodynamic management
☐ Pain management
☐ Call back triggers
☐ Potential Problems

QUESTIONS

All: ☐ Questions / Concerns

Anesthesia: ☐ Consensus / Conclude Report

Pt. Name: _____
 DOB: _____
 SSN: _____

Notes:

Figure 3.

The cognitive aid is used by the nursing staff to make notes during the verbal handover. The left half is also reproduced as a large poster above each patient bed. Pt, patient; DOB, date of birth; EBL, estimated blood loss; Hx, history; VS, vital signs; IV, intravenous; Equip, equipment; SSN, social security number.

Team Behaviors Metrics: Percentage of Pre- and Postintervention Handovers During Which Each Behavior Was Observed

Figure 4.

For the seven desired behaviors, a mean of 61% were observed in 49 preintervention handovers, and a mean of 83% were observed in 49 postintervention handovers (one-tailed $t[96] = 1.66$, $p < 0.001$).

Long-Term Postintervention Survey Results

Figure 5.

The survey, which was administered in October–December 2013—three years after implementation of the new handover process—was completed by 56 care providers, whose responses demonstrated significantly higher satisfaction with the new handover (one-tailed $t[55] = 7.91, p < 0.0001$).

Table 1.

Handover Measures, pre- versus postintervention

Measure	Preintervention Mar–Jun 2010 Mean (SD)	Postintervention Feb–Jun 2011 Mean (SD)	<i>p</i> Value
Compliance Measures			
Provider presence (%)	76.74 (42.75)	88.37 (32.44)	0.077
Task performance (%)	53.57 (29.44)	78.19 (21.53)	< 0.001
Quality Measures			
Information transfer score (%)	55.10 (16.31)	56.04 (12.42)	0.375
Team behaviors score (%)	61.14 (23.54)	82.75 (19.04)	< 0.001
Handover duration (minutes)	11.50 (5.02)	10.70 (3.91)	0.267
Number of interruptions	0.76 (1.35)	0.53 (1.4)	0.215
Workload (TLX score) *	34.75 (16.65)	28.38 (17.05)	< 0.001

SD, standard deviation.

* The workload score ranged from 0 (low) to 100 (high).