RESEARCH ARTICLE

Improvement in Patient Transfer Process From the Operating Room to the PICU Using a Lean and Six Sigma–Based Quality Improvement Project

Stephen J. Gleich, MD, Michael E. Nemergut, MD, PhD, Anthony A. Stans, MD, Dawit T. Haile, MD, Scott A. Feigal, RN, Angela L. Heinrich, RN, Christopher L. Bosley, R.R.T-NPS, Sandeep Tripathi, MD

ABSTRACT

BACKGROUND AND OBJECTIVES: Ineffective and inefficient patient transfer processes can increase the chance of medical errors. Improvements in such processes are high-priority local institutional and national patient safety goals. At our institution, nonintubated postoperative pediatric patients are first admitted to the postanesthesia care unit before transfer to the PICU. This quality improvement project was designed to improve the patient transfer process from the operating room (OR) to the PICU.

METHODS: After direct observation of the baseline process, we introduced a structured, direct OR-PICU transfer process for orthopedic spinal fusion patients. We performed value stream mapping of the process to determine error-prone and inefficient areas. We evaluated primary outcome measures of handoff error reduction and the overall efficiency of patient transfer process time. Staff satisfaction was evaluated as a counterbalance measure.

RESULTS: With the introduction of the new direct OR-PICU patient transfer process, the handoff communication error rate improved from 1.9 to 0.3 errors per patient handoff \( (P = .002) \). Inefficiency (patient wait time and non-value-creating activity) was reduced from 90 to 32 minutes. Handoff content was improved with fewer information omissions \( (P < .001) \). Staff satisfaction significantly improved among nearly all PICU providers.

CONCLUSIONS: By using quality improvement methodology to design and implement a new direct OR-PICU transfer process with a structured multidisciplinary verbal handoff, we achieved sustained improvements in patient safety and efficiency. Handoff communication was enhanced, with fewer errors and content omissions. The new process improved efficiency, with high staff satisfaction.
The greatest problem with communication is the illusion that it has been accomplished.

George Bernard Shaw (1856–1950)

The annual cost of measurable medical errors that harm patients is enormous, estimated to be $17.1 billion in 2008.1 A vast majority of medical errors result from faulty systems and ineffective processes rather than poor practices or incompetent practitioners.2 An association between communication failure and preventable medical errors has been suggested in virtually all health care settings.3 Handoffs are among the most vulnerable periods of the care transition. Any error in this process has the potential to lead to multiple subsequent errors. Operating room (OR) to PICU transfers are particularly complex with many individual steps in which effective communication and active team member engagement during the transfer process may reduce error and subsequent patient harm.4 Improving patient handoffs is identified as a patient safety priority for our institution as well as a national patient safety goal. In 2006, the Joint Commission established the implementation of a standardized approach to handoff communications, including an opportunity to ask and respond to questions.5,6 The importance of patient handoffs is also addressed by the Accreditation Council for Graduate Medical Education, which mandates that residency and fellowship programs “must design clinical assignments to minimize the number of transitions in patient care.”7

At our institution, patients transferring from the OR to the PICU were first admitted to the postanesthesia care unit (PACU) for initial evaluation and stabilization. With an intermediary admission to the PACU, we hypothesized that multiple levels of inefficiency existed with numerous opportunities for errors. Handoffs occurred first between the surgical and anesthesia teams and the PACU provider, subsequently between PACU providers, and finally between PACU and PICU providers. The baseline transfer process was complex with multiple transfers and handoffs, as graphically demonstrated in Fig 1. The final handoff process to the PICU was unstructured with no standard policy on the contribution of surgical, anesthesia, PACU, or PICU providers. In addition, the handoff happened separately among nursing, medical, and respiratory therapist staff, leading to the possibility of different information being conveyed. Concomitantly, hospital handoffs and care transitions between patient-care units were identified as hospital-wide areas for improvement via an employee safety survey project in 2013–2014. Consequently, these areas are specifically targeted for local improvement.

An improvement in efficiency and patient safety was sought by streamlining the process of transition of care from the OR to the PICU and eliminating the intermediary PACU admission for nonintubated pediatric orthopedic spine patients. The primary aims of this quality improvement (QI) project were to (1) decrease the number of handoffs by 50%, (2) decrease inefficiency between the OR and PICU by 50%, and (3) decrease handoff errors, including a 50% reduction in omitted and/or incorrect information during patient care handoff from the OR to PICU. The secondary aims of the project included examining the communication patterns across the

![Value stream map: direct observation of the baseline transfer process (OR-PACU-PICU, n = 6 patients). Square, patient transfer events; hexagon, wait time (minutes): time spent while waiting for handoffs (time spent in the PACU during routine recovery patient care counted as wait time); circle, process time (minutes): time to conduct the process of handoff and patient transfer; triangle, handoff content errors (total for all 6 patients).](www.aappublications.org/news)
postoperative pathway and implementing structured measures to decrease risks in communication and handoff failure.

**METHODS**

This study took place at Mayo Clinic Children’s Center, a tertiary academic pediatric medical center with a 16-bed medical/surgical PICU and ~600 annual postoperative admissions. All consecutive pediatric orthopedic spine patients, aged 0–18 years, undergoing posterior spinal fusion for correction of scoliosis were used as the study population during the study period. Only patients who were extubated in the OR before arrival in the PICU were included. As a QI project, this work was classified as exempt and did not require Institutional Review Board approval or informed consent. All ethical guidelines for QI projects were followed.

**Quality Improvement Philosophies: Lean and Six Sigma**

We used Lean and Six Sigma methodology, which are data-driven quality improvement philosophies commonly used in the business and manufacturing arenas. Lean principles are aimed at reducing waste, thus improving efficiency and quality. The goal is to reduce non-value-added activities, such as patient travel or duplicate work. We used value stream mapping (Fig 1) to graphically analyze the baseline process and identify areas of inefficiency. Six Sigma methodology aims to reduce variation and defects through standardized define, measure, analyze, improve, and control steps. In the PICU practice, Six Sigma principles are used to standardize the process and reduce medical errors, including communication handoff errors.

**Initial Analysis: Direct Observation of Baseline Process**

To understand how patient transfer process functioned before intervention, we performed value stream mapping by direct observation of the complete process of care transition from the OR to the PACU and to the PICU from May 1, 2014, through June 30, 2014 (Fig 1). Barriers to effective patient transfer were identified and plotted on an Ishikawa fishbone diagram (Fig 2). Both value-creating and non-value-creating activities were mapped from the start of the process (completion of the OR case) to the conclusion (care transition to the PICU staff). The number of handoffs and the content of each handoff, including which personnel were present at the time of handoff, were recorded via direct observation and documented on a data collection tool (Supplementary Fig 4).

**Additional Retrospective Analysis**

To gather more data on the average “delay” in the OR to PICU transfer, an additional subgroup of orthopedic spine patients from January 1, 2014, through April 30, 2014, was analyzed. For these patients, the time spent in the PACU was retrospectively abstracted from the electronic medical record and analyzed as wait + process time.

**Intervention**

The primary intervention, initiated on October 1, 2014, was the implementation of a direct transfer process from the OR to the PICU. We created a new patient workflow (Supplementary Fig 5) to standardize the process, combining Lean and Six Sigma methodology to reduce inefficiency (patient wait time) and reduce handoff errors. The new process began...
After reservation of a postoperative PICU bed. During surgery, the PICU was updated 1 to 2 hours before procedure completion and again when the patient was leaving the OR upon procedure completion. The patient was transported directly to the PICU by representatives from the anesthesia and surgical teams. While fully monitored on the transport cart, a structured verbal handoff using a handoff paper tool was performed between the OR team and the assembled PICU team. The PICU attending or fellow was designated as the handoff leader to ensure compliance with the structured handoff. One author was always present to audit the new process during the immediate intervention study period.

We implemented a structured handoff tool (Supplementary Fig 6), which was used as a script/checklist for the verbal handoff. The handoff tool was completed by the anesthesia provider before transporting the patient to the PICU.

Before the implementation of the direct to PICU transfer of our study patients, multiple meetings and presentations occurred with stakeholders, including the pediatric orthopedic surgery division, OR nursing group, anesthesia groups, and PICU teams. An educational e-mail and poster were developed and circulated describing the new direct to PICU transfer process. On the day of surgery, we performed brief “just-in-time” training to further educate the anesthesia and PICU staff about the new process and to familiarize the staff with the new handoff communication tool.

**Outcome Measures**

Process measures were defined as follows:

- **Process time (PT):** time (minutes) to conduct the process of handoff and patient transfer.
- **Wait time (WT):** time spent while waiting for handoffs (time spent in the PACU during routine recovery patient care counted as WT).
- **First time quality:** the percentage of time a process step is completed accurately the first time.
- **Number of handoffs and handoff occurrences:** calculation of the number of times a handoff (or care transition without handoff) occurred between providers during the process (recorded via direct observation).
- **Error rate (critical to quality measure):** content and errors in the handoff process calculated by direct observation including OR to PACU handoff, during PACU admission, and PACU to PICU handoff. All communication errors (including wrong procedure reported, inaccurate medication/blood product administration reported, and incomplete information such as absent providers) were counted as numbers and calculated as handoff errors/patient. This metric was compared both pre- and post-intervention.

**Counterbalance Measures**

- **PICU staff satisfaction:** We used PICU staff satisfaction as the primary counterbalance measure. A 10-point satisfaction questionnaire with 7 domains was conducted immediately after the handoff process (Supplementary Fig 7). This survey was a measure of overall satisfaction and perceived value from the PICU staff across all the disciplines and conducted for the registered nurse, respiratory therapist, PICU resident, and the PICU attending physician or fellow separately both pre- and post-implementation.

To assess the sustainability of the new patient transfer process, we retrospectively measured adherence to the new direct transfer process and compared PT + WT between the immediate intervention phase (October 1, 2014–December 31, 2014) and the extended intervention phase (January 1, 2015–December 1, 2015).

**Analysis**

Pre- and post-intervention data were tabulated and analyzed by statistical software (JMP 10.0.0, © SAS Institute Inc., 2012). Student t test was used for comparison, and significant results were defined as \( P < .05 \).

**RESULTS**

**Quality Gaps and Interventions**

After direct observation of the baseline process, 4 major factors causing high rates of handoff errors and delays in patient care were identified, and specific QI methods were used to address each. Multiple and fragmented handoffs were remedied with a single handoff policy (intervention). After implementation, multiple plan-do-study-act cycles were performed to evaluate the obstacles, and specific measures were undertaken to find solutions. Due to initial unfamiliarity with the new process, we found that designating a handoff leader helped guide the process. Inconsistent and erratic handoffs were observed, complicated by frequent distractions, which were improved with workflow models and standardization of the handoff process. Delays in patient care with an intermediary PACU admission were alleviated with our main intervention (direct OR-PICU transfer) using Lean QI methodology and reduction of waste (WT).  

**Value Stream Mapping**

We performed direct observation of the complete baseline transfer process (OR-PACU-PICU, \( n = 6 \)) and intervention (direct OR-PICU, \( n = 4 \)) for pediatric posterior spinal fusion patients. The mean baseline WT was 90 minutes, which decreased to 32 minutes (−58 minutes) after intervention. The PT also decreased from 25.5 to 16.5 minutes (−9 minutes). The FTQ also markedly improved from 0% (ie, there were no patients who made it through the baseline OR-PACU-PICU process without at least 1 handoff error) to 67% after intervention (Table 1). From the expanded retrospective analysis of our electronic medical record, the baseline WT of 27 postoperative patients improved from a median of 110 to 20 minutes for 40 patients in the intervention phase (\( P < .001 \), Fig 3).
handoff, respectively (n = 12 baseline, n = 9 intervention phase). The handoff error rate substantially improved from 1.9 errors per patient-handoff in the baseline phase to 0.3 errors per patient-handoff in the intervention phase (improvement of 1.6 errors per patient-handoff, P = .002).

**Counterbalance Measures**
Survey of staff satisfaction among the multidisciplinary PICU staff was performed for 40 staff in the baseline phase and 42 staff in the intervention phase. PICU staff satisfaction significantly improved after the introduction of the direct OR-PICU transfer process and initiation of a structured handoff process for nursing, respiratory therapy, and the PICU attending physician/fellow group (Table 3).

**Sustainability**
The intervention was sustained with a mean WT + PT of 19.4 minutes for 9 patients in the immediate intervention phase versus 23 minutes for 31 patients in the extended intervention phase (P = .41). Two patients (6%) during the extended intervention phase did not adhere to the new process and had an intermediary admission to the PACU due to bed unavailability in the PICU.

**DISCUSSION**
In this Lean and Six Sigma-based QI project, we demonstrated an improvement in the patient transfer process from the OR to the PICU. We instituted a new, direct OR-PICU transfer process with a structured handoff following examination of areas of error and inefficiency in the baseline process through value stream mapping. We subsequently observed an improvement in efficiency, as measured by a reduction in patient WT. In addition, handoff communication was improved, including the number of handoffs, content, and error rate. This process was implemented with high satisfaction among the multidisciplinary PICU staff.

Our study demonstrated a significant reduction in the number of handoffs by

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**TABLE 1** Value Stream Map Results for Baseline and Intervention Processes

<table>
<thead>
<tr>
<th>Category</th>
<th>Baseline (OR-PACU-PICU), n = 6</th>
<th>Intervention (Direct OR-PICU), n = 4</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>WT (mean ± SD, min)</td>
<td>90 ± 32</td>
<td>32 ± 11</td>
<td>−58</td>
</tr>
<tr>
<td>PT (mean ± SD, min)</td>
<td>25.5 ± 11</td>
<td>16.5 ± 16</td>
<td>−9</td>
</tr>
<tr>
<td>FTQ</td>
<td>0%</td>
<td>67%</td>
<td>+67%</td>
</tr>
</tbody>
</table>

Detailed process steps are shown in Fig 1. FTQ, percentage of time a process step is completed accurately the first time. For this project, the accurate process was defined as “a direct face to face handoff without any errors and all members present”; PT, time (minutes) to conduct the process of handoff and patient transfer; WT, time spent waiting for handoffs (time spent in the PACU during routine recovery patient care counted as WT).

**FIGURE 3** Quantile graph demonstrating reduction in wait times in postoperative patients (from extubation to PICU handoff). WT (electronic medical record): baseline phase (n = 27) and intervention phase (n = 40). IQR, interquartile range (25%–75%).
instituting a direct OR-PICU transfer process. By elimination of the PACU admission, we showed a 400% reduction in the number of handoffs. For each patient handoff, the risk of error increases. In a study of anesthesia providers, each handoff increased the risk of major morbidity or mortality by 8%. Although the PACU has a vital role for adequate recovery of surgical outpatients and patients admitted to the general care floor, our data suggest inefficiency and an increased risk of handoff error with an intermediary PACU stop before PICU admission.

The content of each handoff and the handoff error rate improved after the intervention. Our handoff error rate decreased by 81%, which is comparable to 2 postoperative pediatric cardiac surgical patients demonstrated major distractions, which were improved by the bedside nurse announcing a “sterile cockpit” environment (where nonessential communications are prohibited) and initiating the handover process.15 We introduced a handoff communication tool which was available in the OR for the anesthesia personnel to use during the surgical case and in the PICU for the PICU resident to complete during handoff. The tool additionally functioned as a handoff checklist to reduce the risk of omitted information. Consequently, we observed a significant increase in the handoff content reported, which is analogous to 2 studies of ICU handoffs for postoperative cardiac surgical patients.16,17 By making the tool available to the OR and PICU teams, familiarity was increased and omitted items were quickly recognized, prompting a query to the surgical or anesthesia personnel.

Our multidisciplinary PICU staff was more satisfied with the direct OR-PICU transfer process. We initially expected that a substantial change in the process of handoff and potential greater labor of accepting fresh postoperative patients might decrease overall staff satisfaction. However, we observed an improved satisfaction among almost all providers for all the aspects of the handoffs, which is similar to prior handoff studies.18,19 We acknowledge several limitations in our study. Our methodology involved a direct observation process, which required a substantial amount of personnel resources and time. With no additional funding for this project, our resources were limited and consequently, the number of patients who could be directly observed through the process was small. Despite low numbers of patients who were directly observed, we identified many factors contributing to the ineffective transfer of postoperative pediatric patients to the PICU. In addition, our subject population included a focused group of pediatric orthopedic spine patients. However, our results, particularly the improvement in handoff communication with a structured process, should be generalizable to the greater postoperative pediatric population.

We recognize that certain behaviors of care providers may have been altered because of the Hawthorne effect (observer effect).20 For patients who arrived to the PICU after business hours, there were study personnel, including the PICU attending physician or fellow and charge nurse, who were directly involved in the study of the new process. With enhanced awareness and attention dedicated to the new direct OR-PICU transfer process, our improvement may be exaggerated and may not be sustainable. However, after the immediate intervention phase, we retrospectively analyzed an extended intervention phase, which included 11 additional months (total of 14 months after the first intervention). The improvements were sustained with no difference in times between the 2 intervention periods. Only 2 cases failed to adhere to the new transfer process, both due to immediate PICU bed unavailability from external factors beyond our control. Lastly, we subjectively observed continued satisfaction with the new process and the improved information sharing after concluding the study. With continued “maintenance” education and expansion of the new transfer process to other surgical subspecialties, we anticipate the process and improvements will be

### TABLE 2 Handoff Content Scores for Surgical and Anesthesia Team Personnel and Handoff Error Rate for Baseline and Intervention Processes

<table>
<thead>
<tr>
<th></th>
<th>Baseline (OR-PACU-PICU), n = 12</th>
<th>Intervention (Direct OR-PICU), n = 9</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgical handoff</td>
<td>2.6 ± 4.1</td>
<td>9.5 ± 1.4</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Anesthesia handoff</td>
<td>5.0 ± 4.6</td>
<td>10.0 ± 0.0</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Overall handoff error rate</td>
<td>1.9</td>
<td>0.3</td>
<td>.002</td>
</tr>
</tbody>
</table>

* Errors per patient handoff.

### TABLE 3 Comparison of Average Staff Satisfaction Scores for Baseline and Intervention Processes (Scale of 0–10)

<table>
<thead>
<tr>
<th></th>
<th>Baseline (n = 40)</th>
<th>Intervention (n = 42)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Registered nurse</td>
<td>7.12 ± 2.8</td>
<td>9.5 ± 0.78</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Respiratory therapist</td>
<td>6.2 ± 3.4</td>
<td>9.0 ± 1.6</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Resident</td>
<td>7.8 ± 2.4</td>
<td>8.5 ± 2.0</td>
<td>.180</td>
</tr>
<tr>
<td>Attending physician/fellow</td>
<td>5.3 ± 3.1</td>
<td>9.3 ± 1.4</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>
sustained. Future steps for this QI work include expanding the direct OR-PICU transfer for all pediatric surgical subspecialties with a structured handoff. In addition, other sources of admissions to the PICU, such as the emergency department, should be considered for a single, structured bedside handoff.

We did not include all possible counterbalance measures, including the perceptions of the surgical and anesthesia teams. Future study should also include the impact on the OR schedule and OR turnover time, which may be considerable. Family satisfaction should also be considered.

CONCLUSIONS

By using QI methodology to design and implement a new direct OR-PICU patient transfer process, substantial improvements in overall efficiency, handoff communication, and staff satisfaction were achieved.

REFERENCES


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