The Impact of Standardized Operating Room Process *Versus* Dedicated Team on Outcomes in Pediatric Spinal Deformity Surgery

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Study Design. Retrospective chart review.

Objective. The objective of this study was to identify and compare the effectiveness of a regularized operating room (OR) process *versus* the utilization of a consistent "scoliosis team" for improving outcomes associated with pediatric spinal deformity surgery.

Summary of Background Data. OR standardization has garnered significant attention as a critical strategy for enhancing surgical safety and outcomes. The benefits of OR standardization are significant in complex surgical fields. Previous studies have shown that standardized care protocols can decrease surgical time and costs for spine surgeries. Maintaining a dedicated team can be difficult, but a process can be easily implemented at most institutions.

Materials and Methods. Patients operated on during the study period were divided into two groups based on the type of standardization applied: the dedicated Team group (2018–2022) and the standardized Process group (2023–2024). The dedicated Team group included surgeries performed by a consistent team of OR staff, all following the standardized surgical process. The standardized process divides the surgical procedure into three phases: exposure, screw insertion, and correction. This process reduces the number of trays and instruments required. The Process group was formed in 2023 when new ORs did not maintain a dedicated team.

Results. Surgical time (224 *vs.* 260 min; $P < 0.001$) and LOS (3 *vs.* 4 d; $P < 0.001$) were significantly lower for Process compared with Team. Total morphine consumption (123.0 *vs.* 132.2 mg; $P = 0.028$) and OR costs ($10,819 *vs.* $12,558; $P < 0.001$) were also significantly lower for Process. Thirty-day and 90-day complication rates were not significant between the groups ($P = 0.71$; $P = 0.43$).

Conclusion. A complex procedure like posterior spinal fusion can be standardized in a manner that can invite more staff to participate. Based on the results of this study, a standardized process alone can be beneficial in improving patient outcomes.

Key Words: adolescent idiopathic scoliosis, posterior spinal fusion

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Operating room (OR) standardization has garnered significant attention as a critical strategy for enhancing surgical safety, efficiency, and outcomes. These standardized processes derive concepts from Lean management principles and apply them to health care to reduce waste and improve efficiency.[1,2] The implementation of standardized protocols in the OR aims to minimize variability, reduce errors, decrease costs, and streamline surgical processes, leading to more consistent and predictable surgical results.[1–8] The benefits of OR standardization are especially significant in complex surgical fields; for example, in spine surgeries, standardized care protocols have been shown to decrease complications and improve overall patient outcomes by improving surgical time and efficiency.[2,7,9–11] Surgeon-led standardization ensures that all instruments and surgical steps are familiar to team members through simplification and regularization.[3]

Sarwahi *et al.*[3] previously examined the effects of standardization on posterior spinal fusions (PSF) for adolescent idiopathic scoliosis (AIS). In their study, standardization consisted of two parts: (1) simplification and systematization of the procedure and (2) assembling a dedicated team.[3] They found that process standardization with a dedicated surgical team can reduce surgical time, estimated blood loss (EBL), and infection rates.[3] Muhly *et al.*[2] also found lower surgical time and costs following implementation of a dedicated team for PSF procedures. It can be difficult to assemble a dedicated scoliosis team, but a standardized process can be easier to implement for most institutions.[3,12,13] Process standardization alone has been shown to shorten OR time through a coordinated multidisciplinary effort.[13] This study aims to compare outcomes from PSF procedures performed under a standardized OR process alone with those conducted by a dedicated team.

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MATERIALS AND METHODS

This IRB-approved study reviewed pediatric patients aged 10 to 18 years who underwent PSF for AIS between 2020 and 2024 at two tertiary care hospitals within the same health system. All procedures were performed by pediatric orthopedic surgeons with a minimum of 10 years of experience. Patients with neuromuscular, syndromic, and congenital scoliosis diagnoses were excluded from the study.

Patients operated on during the study period were divided into two groups based on the type of standardization applied: the dedicated Team group (2020–2022) and the standardized Process group (2023–2024). The dedicated Team group included surgeries performed by a consistent team of five anesthesiologists, three OR technicians, three nurses, and three neurophysiologists, all following the standardized surgical process. In 2023, a new operating complex opened at a separate location within the same health system. This involved a new location with new management where a larger OR staff pool learned and utilized the surgeon-led standardized process. Starting in 2023, the new ORs did not maintain a dedicated team, leading to the formation of the Process group.

Standardized Process

The standardized process was meticulously implemented to ensure consistency in surgical procedures regardless of team composition. This process involved establishing uniform protocols for each stage of the surgical pathway (Fig. 1):

- *Preoperative*: The standardized preoperative protocols included comprehensive patient assessments, advanced imaging studies, and detailed surgical planning to ensure thorough and consistent preparation for surgery. Patients underwent evaluations that involved shared decision-making and obtaining informed consent, ensuring that both patients and families were well-informed about the surgical procedure and expected outcomes.
- *Intraoperative*: Intraoperative standardization focused on simplifying and streamlining the surgical process. The number of trays required were reduced, thereby facilitating easier setup and handling. The weight was limited to a maximum of 11 kg per tray. The surgical procedure was divided into three well-defined phases: exposure, screw insertion, and deformity correction. Each phase was associated with specific trays and tools, which helped in maintaining consistency and efficiency during the surgery. For exposure, two cerebellar self-retainers, two Beckman-Adson retractors, and two Cobb elevators were employed. Screw insertion instruments include burr, pedicle finder, ball tip feeler, osteotome, and mallet. Screw size was standardized at 6.5 mm×40 mm for T10 and below, 6.5 mm×35 mm for T3 to T9, and 6.5 mm×30 mm for T1 and T2. This allows surgical technologists to save time by loading the screws in advance. Screw insertion is started in lumbar spine and progresses cephalad, with alternating reduction and standard uniplanar screws. The left side screws are inserted first, followed by the right side. The

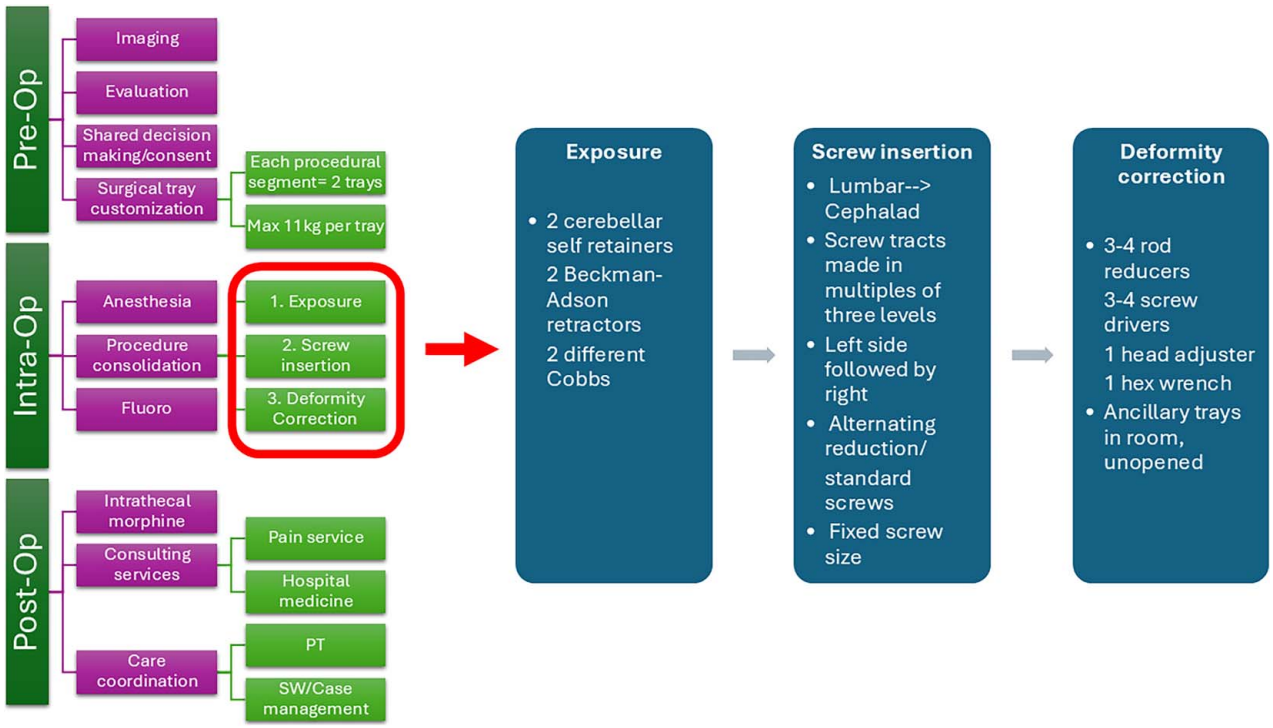

Figure 1. The standardized surgical process involves the preoperative, intraoperative, and postoperative courses of the surgical pathway.

deformity correction tray has three to four rod reducers, three screw drivers, one head adjuster, and one hex wrench. Anesthesia protocols include standardized induction, maintenance, muscle relaxation, and blood conservation strategies, such as the use of tranexamic acid and hypotensive anesthesia. Fluoroscopy is used at the start of instrumentation to confirm levels.

- *Postoperative*: Postoperative standardization includes a protocol that focused on rapid recovery and pain management. The protocol incorporates the use of microdose intrathecal morphine (1.5 μg/kg) for pain control, eliminating the need for patient-controlled analgesia (PCA) pumps. Discharge preparation included multidisciplinary collaboration involving physical therapy to ensure a smooth transition to postoperative recovery and expedite safe discharge.

Dedicated Team

The dedicated team, operational from 2020 to 2022, was comprised of a consistent group of five anesthesiologists, three OR technicians, three nurses, and three neurophysiologists. Each member of this team consistently participated in the surgeries utilizing the same standardized surgical process as described above. The presence of a dedicated team aimed to leverage the benefits of experienced and well-coordinated team dynamics.

Data Collection

Demographic and clinical data were collected retrospectively. Demographic variables include age, gender, and body mass index (BMI). Radiographic variables include preoperative and postoperative Cobb angles and levels fused. Intraoperative details such as estimated blood loss (EBL), morphine consumption, surgical time, and time in OR were documented. Surgical time was documented from time out to surgery end. Time in OR was measured from when the patient enters the OR to exit from the OR. Postoperative outcomes included the length of hospital stay (LOS), morphine use at various intervals, narcotic refills, and complication rates at 30 and 90 days.

Statistical Analysis

Data is presented using medians and interquartile ranges (IQR) for continuous variables and analyzed using the Wilcoxon rank-sum test. Categorical variables were presented as frequencies and percentages and analyzed using χ^2 or Fisher exact tests. The minimal clinically important difference (MCID) for Cobb angle in spinal deformity patients is 5°. All P values were two-tailed, with $P < 0.05$ considered significant. An independent biostatistician performed all statistical analyses using SAS software version 9.4 (SAS Institute Inc., Cary, NC).

RESULTS

Demographics

There were 327 AIS patients in this study. A total of 145 patients were in the standardized Process group, and 182 were in the Team group. The median age (Process: 15.6 yr *vs.* Team: 16.1 yr; $P = 0.17$), gender distribution and BMI (Process: 21.0 kg/m^2 *vs.* Team: 21.5 kg/m^2; $P = 0.60$) were not statistically significant between the groups (Table 1).

Radiographic Variables

Both groups had similar preoperative Cobb angles (Process: 51.3° *vs.* Team: 50.3°; $P = 0.59$) and levels fused (Process: 13 *vs.* Team: 13; $P = 0.64$). However, the postoperative Cobb angles were significantly lower in the Process group compared with the Team group (Process: 14.2° *vs.* Team: 18.7°; $P = 0.002$). Percent Cobb correction was also significantly higher in the Process group (73.5%) compared with the Team group (63.7%; $P < 0.001$). However, the difference seen in the postoperative Cobb angles is considered clinically insignificant as the MCID for Cobb angles is 5° (Table 1).

Hospital Course and Surgical Outcomes

Surgical time was significantly shorter in the Process group compared with the Team group (Process: 224 minutes *vs.* Team: 264 minutes; $P < 0.001$) (Tables 2–4). Time in OR was also significantly shorter in the Process group (Process: 346 min *vs.* Team: 401 min; $P < 0.001$). In addition, LOS was significantly shorter in the Process group compared with the Team group (Process: 3 d *vs.* Team: 4 d; $P < 0.001$). EBL was also significantly lower between the groups (Process: 350 mL *vs.* Team: 450 mL; $P = 0.020$) (Table 2).

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Morphine consumption was significantly lower for Process compared with Team intraoperatively (Process: 35.2 mg *vs.* Team: 50.0 mg; $P < 0.001$) and 0 to 24 hours postoperatively (Process: 42.7 mg *vs.* Team: 56.3 mg; $P < 0.001$). Total morphine consumption was found to be significantly lower in the Process group compared with the Team group (Process: 123.0 mg *vs.* Team: 139.1 mg;

TABLE 1. Comparison of Demographic and Radiographic Variables Between Standard Process and Standard Team Patients that Underwent Posterior Spinal Fusion

	Process (n = 145)	Team (n = 182)	*P*
Age (yr)	15.6 (14.2, 17.1)	16.1 (14.3, 17.7)	0.173
BMI (kg/m^2)	21.0 (18.8, 26.2)	21.5 (18.7, 24.1)	0.601
Female, n (%)	84 (57.9%)	124 (68.1%)	0.057
Preop Cobb (°)	51.3 (42.0, 64.9)	50.3 (42.0, 58.1)	0.589
Postop Cobb (°)	14.2 (6.9, 21.7)	18.7 (10.7, 26.1)	**0.002**
Cobb correction (%)	73.5 (62.3, 83.2)	63.7 (52.6, 75.4)	**< 0.001**
Levels fused	13 (12, 13)	13 (11, 13)	0.643
Fixation points	25 (22, 26)	24 (22, 25)	0.082

Data are presented as median and interquartile range. The minimal clinically important difference (MCID) for postoperative Cobb angles is 5°. Statistical values with $P < 0.05$ are considered statistically significant and bolded.

P-values were obtained from Wilcoxon rank-sum tests for continuous variables and χ^2 tests for categorical variables.

TABLE 2. Comparison of Hospital Course and Surgical Outcomes Between Standard Team and Standard Process Patients that Underwent Posterior Spinal Fusion

	Process (n = 145)	Team (n = 182)	*P*
EBL (mL)	350 (250, 600)	450 (300, 600)	**0.020**
Surgery time (min)	224 (199, 250)	264 (230, 298)	**< 0.001**
Time in OR (min)	346 (313, 385)	401 (364, 445)	**< 0.001**
LOS (d)	3 (3, 4)	4 (4, 5)	**< 0.001**
Total transfusion, n (%)	25 (17.2%)	51 (28.0%)	**0.022**
Intraoperative morphine use	35.2 (25.0, 50.4)	50.0 (33.2, 62.4)	**< 0.001**
0–24 h morphine use	42.7 (26.9, 66.0)	56.3 (38.0, 88.0)	**< 0.001**
24–48 h morphine use	40.5 (30.0, 55.9)	45.0 (26.2, 60.0)	0.670
Total morphine consumption	123.0 (85.9, 161.2)	139.1 (105.0, 194.0)	**0.004**
Hospital stay costs ($)	24600 (24600, 32800)	32800 (32800, 41000)	**< 0.001**
Operating room costs ($)	10819 (9612, 12075)	12751 (11109, 14393)	**< 0.001**
30-d complication	6 (4.1%)	7 (3.9%)	0.909
90-d complication	3 (2.1%)	4 (2.2%)	1.0
Narcotic refill	30 (21.7%)	26 (14.7%)	0.104
OOB			0.197
0	52 (37.7%)	70 (40.9%)	
1	68 (49.3%)	65 (38.0%)	
2	14 (10.1%)	28 (16.4%)	
3	2 (1.5%)	6 (3.5%)	
4	2 (1.5%)	2 (1.2%)	

Data are presented as median and interquartile range. Statistical values with $P < 0.05$ are considered statistically significant and bolded.

P-values were obtained from Wilcoxon rank-sum tests for continuous variables and χ^2 or Fisher exact tests for categorical variables.

$P = 0.004$). The rate of narcotic refills, however, was not significant (Process: 20.6% *vs.* Team: 14.3%; $P = 0.104$). Transfusion rates were significantly lower in the Process group (Process: 17.2% *vs.* Team: 28.0%; $P = 0.022$). Time to out-of-bed activity was not significant between the groups ($P = 0.197$) (Table 2).

Operating room costs were significantly lower for the Process group (Process: \$10,819 *vs.* Team: \$12,751; $P < 0.001$). Hospital stay costs were also significantly lower for the Process group (Process: \$24,600 *vs.* Team: \$32,800; $P < 0.001$) (Table 2).

Thirty-day complication rates were not statistically significant between the groups (Process: 4.1% *vs.* Team: 3.9%; $P = 0.71$). Six patients in the Process group and 7 patients in the Team group had 30-day complications, which are detailed in Table 3. There were 3 (2.1%) 90-day complications in the Process group and 4 (2.2%) 90-day complications in the Team group which were not significant ($P = 1.0$) (Table 4).

TABLE 3. Comparison of Postoperative Complications Within 30 Days Between Process and Team Groups

Process (n = 145)	Team (n = 182)	*P*
6 (4.1%)	*7 (3.9%)*	0.71
4 irrigation and debridement	3 superior mesenteric artery syndromes	
1 fever with return to ED	2 infections requiring return to ED	
1 bowel perforation	1 intraoperative anaphylactic reaction	
	1 rod dislodgement requiring revision	

$P < 0.05$ is considered significant.

TABLE 4. Comparison of Postoperative Complications Within 90 Days Between Process and Team Groups

Process (n = 145)	Team (n = 182)	*P*
3 (2.1%)	*4 (2.2%)*	0.94
3 irrigation and debridement	3 irrigation and debridement	
	1 return to ED for severe back and abdominal pain	

$P < 0.05$ is considered significant.

DISCUSSION

Surgeon-led standardization seeks to simplify the surgical process to reduce wasteful practices and produce successful outcomes in the surgical setting.[1,11,13,14] In this method of standardization, the process is created according to the individual surgeon's natural workflow, tailoring to their approach.[3] Process standardization can improve communication and team integration in the OR, increasing safety and efficiency in terms of maximizing resource utilization while minimizing patient complications, surgery cancellations, and overrunning surgical case time.[4,15] These have the secondary benefits of cost savings and improved patient, surgeon, and staff satisfaction.[15] There were three main findings in this study: (a) length of stay, surgical time, estimated blood loss, transfusion rates, and opioid consumption were improved in the Process group compared with the Team group, indicating increased efficiency; (b) hospital costs were significantly lower in the Process group; and (c) the increase in efficiency seen with the Process group led to similar complication rates and did not compromise patient safety outcomes. These results demonstrate that the standardized process offers a more feasible and efficient alternative compared with a dedicated team.

Standardization seeks to simplify the surgical process by reducing wasteful practices akin to lean management principles.[1] Standardization can impact the preoperative, intraoperative, and postoperative courses. Preoperative standardization involves having all patients undergo lab testing, magnetic resonance imaging (MRI), and additional testing such as pulmonary function tests (PFT).[3,16,17] This leads to avoidance of surgery cancellation which can otherwise occur.[16] In our study, standardization had the greatest impact on the intraoperative and postoperative course. Postoperatively, a rapid recovery protocol, which was utilized in both groups, can decrease the length of stay, allow for earlier mobilization, and decrease opioid consumption.[3,8,18] Intraoperative standardization at our institution involves limiting the number of trays to only 5 to 7, with each weighing a maximum of 11 kg. This has led to cost savings as the number of instruments required are far fewer than in the past. This also leads to better inventory management and efficient sterilization as the trays can be processed quickly

by the autoclave unit and be made available the following day. It also allows more participation by female staff members who otherwise avoid lifting heavy trays.[3] Limiting the weight of the trays also decreases the risk of back injuries, tendonitis, and wrist sprains in OR staff.

Simplification of the surgical steps involves standardizing implant insertion, including the screw size, pattern, and order of insertion. The instruments used for each procedure have also been standardized into three stages, facilitating easier setup. Using a set size and number of screws allows for the surgical technologist to load the screws in advance, reducing waiting time. While the surgeon is making screw tracts, the surgical team is loading the screws for the next several levels. This translates to decreased surgical time and additional benefits such as decreased blood loss and lower chance of infection as the wound is open for a shorter amount of time.[7,19,20] While this process is utilized in both groups, the Process group had shorter median surgical time compared with the Team group, indicating that a set team itself is not required to achieve improved outcomes. Shorter surgical time can lead to lower intraoperative morphine consumption, as demonstrated by this study. This study also demonstrated decreased total morphine consumption in the Process group, including in the postoperative period. Tartar *et al.*[21] found that longer surgeries can involve more extensive tissue manipulation and muscle retraction, leading to higher pain control requirements postoperatively—this can explain the higher opioid consumption seen in the Team group. Shorter surgical time with lower pain control requirements also facilitates earlier discharge, as seen with the shorter LOS in the Process group and corroborates the findings seen in Fletcher *et al.*'s[22] study, which found a correlation between surgical time and LOS. Shorter LOS along with shorter surgical time has led to significant savings on hospital costs in our study. This is similar to the findings seen in Flynn *et al.*,[7] where shorter surgical time contributed to decreases in costs with the use of a dedicated team and standardized process. Sanders *et al.*[11] also previously found a 22% decrease in hospital costs with an accelerated discharge protocol after PSF. The utilization of fewer trays and instruments may also contribute to reduced costs in the Process group.[1] Despite these improvements in efficiency, there was no significant difference in complication rates between the two groups, indicating that the standardized process did not compromise patient safety outcomes.

Although team standardization can often be practiced, it is not readily accessible for many institutions due to several factors, including personnel and resource allocation.[3,12] Previous studies that examine improving OR efficiency have limited the number of surgeons and OR staff involved which restricts process changes to only ORs that have this standardized team.[2,3,7,13] Assembling and maintaining a standardized team is faced with challenges such as scheduling conflicts and staffing shortages, leading to instability of the team itself.[3,12] In our case, the opening of new operating theaters at a separate location within the same health system meant that the dedicated team could no longer be supplied by OR management at this new location. Sarwahi *et al.*[3] previously found that a standardized surgical process with streamlined steps is transferrable between institutions. At our new location, we maintained the standardized surgical process to be utilized by a new set of nurses and OR technicians. This standardized PSF process has been transferred between hospitals, with improvements in outcomes, indicating that these improvements are reproducible.[3] Harders *et al.*[13] implemented a coordinated multidisciplinary process redesign to reduce nonoperative time; like our study, they had the explicit goal to not limit staff members, ensuring that their process standardization could be taught to the majority of the OR staff. By demystifying and simplifying this complex scoliosis procedure, we can open the door for more staff to integrate and learn the process, expanding our pool of available talent.[1,3,13] The present study supports the notion that by focusing on surgeon-led process standardization, hospitals can achieve similar, if not better patient outcomes than from a dedicated team alone.

The limitations of this study include some possible confounding variables such as variations in surgeon experience. The study also focuses primarily on short-term patient outcomes where further research might be needed in observing long-term outcomes. Furthermore, this study only consisted of AIS patients. Future studies can examine the effects of a standardized process on nonidiopathic scoliosis patients undergoing PSF.

This is the first study to compare the effectiveness of a standardized surgical process and a dedicated surgical team in pediatric spinal deformity surgery. A complex procedure like PSF can be standardized and simplified in a manner that can invite more staff to participate. Based on the results of this study, a standardized process can be beneficial in improving patient outcomes without increasing complication rates.

➢ Key Points

- ❑ A surgeon-led standardized process involves uniform preoperative, intraoperative, and postoperative protocols to increase efficiency in pediatric spinal deformity surgery.
- ❑ A standardized process can simplify a complex procedure like posterior spinal fusion, allowing more OR staff to participate and is more feasible to implement than a dedicated scoliosis team.
- ❑ The utilization of a standardized process alone significantly reduces surgical time, LOS, morphine consumption, and hospital costs compared with the use of a dedicated team.
- ❑ Complication rates were similar between the groups, indicating that the standardized process did not compromise patient safety outcomes.

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