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CASE SERIES

Is it feasible to implement a rapid recovery pathway for adolescent idiopathic scoliosis patients undergoing posterior spinal instrumentation and fusion in a single-payer universal health care system?

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Abstract

Purpose The purpose of this project was to determine if it is feasible to implement a rapid recovery pathway (RRP) for the surgical treatment of adolescent idiopathic scoliosis (AIS) within a single-payer universal healthcare system while simultaneously decreasing length of stay (LOS) without increasing post-operative complications.

Methods A retrospective analysis was completed for all patients who underwent posterior spinal fusion for AIS at a tertiary children's hospital in Canada between March 2010 and February 2019, with date of implementation of the RRP being March 1st, 2015. Patient demographic information was collected along with a variety of outcome variables including: LOS, wound complication, infection, 30-day return to the OR, 30-day emergency department visit, and 30-day hospital readmission. An interrupted time series analysis was utilized to determine if any benefits were associated with the implementation of the RRP.

Results A total of 244 patients were identified, with 113 patients in the conventional pathway and 131 in the RRP. No significant differences in demographic features or post-operative complications were found between the two cohorts ($p > 0.05$). Using a robust linear time series model, LOS was found to be significantly shorter in the RRP group, with the average LOS being 5.2 [95% IQR 4.3–6.1] days in the conventional group and 3.4 [95% IQR 3.3–3.5] days in the RRP group ($p < 0.05$).

Conclusion This study shows that it is possible to implement a RRP for the surgical treatment of AIS within a single-payer universal healthcare system. Use of the pathway can effectively reduce hospital LOS without increasing the risk of developing a post-operative complication. This has the upside potential to reduce healthcare and family costs.

Level of evidence Therapeutic III.

Keywords Rapid recovery pathway · Scoliosis

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Introduction

Posterior spinal instrumentation and fusion (PSIF) is one of the most invasive pediatric orthopaedic surgical procedures and has, in past, included an admission to an intensive care unit (ICU) and a prolonged hospital stay of at least 5 days [1]. The procedure is also one of the most costly, with routine surgical treatments having an associated cost between $75,000 and $100,000 in the United States [2]. Prolonged hospital stay also increases the risk of developing a post-operative complication [2]. With 0.5–5% of adolescents being diagnosed with some form of scoliosis and 5000 patients a year receiving operative management in North America for this condition, length of stay (LOS) after surgery has come into focus as an area for improvement and there is large incentive to develop a catered rapid recovery protocol for this population [1, 3–5].

Rapid recovery pathways (RRP) have recently been introduced in the United States for AIS patients undergoing PSIF to reduce hospital LOS. Previous studies evaluating the effectiveness of RRPs following PSIF have shown that, following the implementation of the RRP, LOS decreased without a concomitant increase in adverse events [6–9]. However, a current limitation to the generalizability of these works is that all have been conducted within the United States and no translational work has been performed to determine if this type of pathway would work in a publicly funded, single-payer, healthcare system. Studies which have compared the differences in orthopaedic procedures in the United States and Canada have found that the LOS is significantly longer in Canada [10–13]. A few of these studies have also found that there are more post-operative complications in Canada compared to the United States for the same procedure [11, 13].

To determine if these standardized protocol findings would translate to a publicly funded, single-payer, healthcare system, such as in Canada, a RRP for PSIF in AIS patients was developed and subsequently deployed on March 1st, 2015 at a single tertiary children's hospital. The primary objective of this study was to determine if implementing a RRP in single-payer healthcare system could decrease hospital LOS without increasing post-operative complications, as it has shown to do in the United States.

Methods

A single children's tertiary referral centre located in Canada was used in this study. Following institutional ethics board approval, a retrospective review was undertaken for all patients who underwent spinal fusion surgery between March 1st, 2010 and February 28th, 2019. The first cohort made up the conventional pathway group and consisted of all the cases between March 1st, 2010 and February 28th, 2015. The second cohort made up the RRP group and consisted of all the cases between March 1st, 2015 and February 28th, 2019. Patients were excluded from analysis if they had previous spinal surgery or an underlying neuromuscular cause to their scoliosis. However, those with a syndromic or congenital cause to their scoliosis were included if they did not have any underlying comorbidity that would alter their peri- or post-surgical course. There were four participating, fellowship trained, pediatric orthopedic surgeons, all with specialized interest in spine. Their years of experience ranged from 5 to 30, although most of the cases were done by the senior surgeons. Additionally, the surgeons frequently worked collaboratively in teams and the surgical tactics were similar including: multimodal neuromonitoring, tranexamic acid, traction and/or Ponte osteotomies, and all-screw constructs in both the conventional and RRP cohorts.

A lean process was utilized to develop the RRP for AIS patients undergoing PSIF. Lean processes in healthcare settings consist of the thorough evaluation of the task, the operators, and the outcomes to improve patient care [14]. Based on discussion from the lean process meetings, the surgical management of AIS was broken down into five sections: the pre-operative section, the surgical day section, the POD 1 section, POD 2 section, and POD 3 section. A detailed comparison of the conventional pathway and RRP is presented in Table 1. Highlights of the RRP analgesia protocol specified that all patients received a single, weight-based dose of intrathecal morphine in the operating room. Post-operatively, patients were prescribed around the clock scheduled dosing of acetaminophen and a NSAID that continued until discharge. In addition, patient-controlled analgesia (PCA) in bolus mode only (no basal) was started in the PACU and continued until the afternoon of POD2, after the patients had successfully ambulated. They were then switched to oral opioids as needed in addition to the continued foundational analgesia.

Patient charts for the two groups were reviewed for pertinent pre-operative, operative, and post-operative features. Pre-operative features included demographic information (age and sex) and pre-operative Cobb angle. Operative features included Cobb angle correction and intraoperative blood loss. Finally, post-operative features included day of discontinuation of PCA and Foley catheter as well as when standing and walking were initiated.

The primary outcome for this study was the comparison of hospital LOS between the two pathways. Hospital LOS was defined as the time from admission to hospital on the day of surgery (standardized at 8:00:00 h for every patient)

Table 1 Comparison of the 'conventional group' and 'rapid recovery pathway group' pre- and post-operative management

	Conventional group	Rapid recovery pathway group
Tour of hospital and discussion of post-operative expectations	Not applicable	~2 weeks pre-operative
24 h ICU admission	POD 0	Not applicable
Standing at bedside	POD 2–3	POD 1
Walking in hallway	POD 3–4	POD 2
PCA discontinuation	POD 2–3	POD 2
Foley catheter discontinuation	POD 2–3	POD 2
Mobilization with physiotherapy	POD 2–4	Not applicable, mobilized under supervision of nursing staff
Discharge	Following successful bowel movement and cleared by physiotherapy	POD 3

to the time of discharge from hospital. Secondary outcome variables were complications related to the hospital stay or procedure. These included any wound complication, any 30-day return to the operating room (OR), any 30-day visit to the emergency department (ED), or any 30-day readmission to the hospital.

Statistical analysis

Differences between pre-operative, operative, and post-operative characteristics before and after implementation of the RRP were assessed using Student *t* tests or Wilcoxon tests, as appropriate. Chi-square tests were used for categorical data, with the Fisher exact test being used when the expected value was lower than 5. Medians were used for variables with skewed distributions and confidence intervals to evaluate magnitude of differences. To compare hospital LOS between groups, an interrupted time series analysis was used to model change in relation to the implementation of the RRP. Due to the various changes in practice during the implementation process, a period of 90 days before and after the initiation of the RRP (March 1st, 2015) was removed from the model building. Since several outlying observations were evident, even after the log transformation was applied, a robust linear regression approach was used. Significance was set at a two-sided p value of 0.05.

Results

There was a total of 271 operations for AIS between March 2010 and February 2019. Of the 271 cases, 18 cases were excluded as they had included an anterior release before the PSIF, seven cases were removed as they underwent vertebral body tethering, one case was removed as the patient underwent concomitant thoracoplasty, and one case was removed as there was an intraoperative complication and the procedure was aborted. This left 244 participants undergoing PSIF for AIS, with 113 following the conventional pathway cohort and 131 in the RRP cohort. Within the conventional pathway, 7 had a congenital or syndromic cause to their scoliosis compared to 12 in the RRP.

The pre-operative, operative, and post-operative characteristics of these groups are compared in Table 2. The average pre-operative curve in the RRP group was larger compared to the conventional group (mean of 67.5° ± 13.3° vs 62.3° ± 10.8°), a difference of 5.2° (95% CI 2.2, 8.3; $p < 0.001$). The average curve correction was greater for the RRP group compared to the conventional group (mean 45.8° ± 13.8° vs 38.2° ± 12.1°), a difference of 7.6° (95% CI 4.3, 10.9; $p < 0.001$). The average estimated blood loss (EBL) was less in the RRP group as compared to the conventional group (mean EBL of 806 ± 418 cc vs 994 ± 606 cc, mean percentage of estimated blood volume 22.2% vs 27.4%). a difference of − 188 cc (95% CI − 324, − 53; $p = 0.01$). Post-operatively, compared to the conventional group, the RRP group showed earlier discontinuation of the PCA (median 51.7 IQR 50.5–53.8 h vs 62.0, IQR 53.0–74.0 h), a difference of − 10.3 h (95% CI − 17.9, − 2.8; $p < 0.001$); earlier discontinuation of the Foley catheter (mean of 1.9 ± 0.33 days vs 2.4 ± 0.64 days), a difference of − 0.5 days (95% CI − 0.6, − 0.3; $p < 0.001$); earlier standing at bedside (mean of 1.0 ± 0.088 days vs 1.9 ± 0.62 days), a difference of − 0.9 days (95% CI − 1.0, − 0.7; $p < 0.001$); earlier ambulation (mean of 1.9 ± 0.31 days vs 3.0 ± 0.91 days), a difference of − 1.1 days (95% CI − 1.3, − 1.0; $p < 0.001$); and were discharged sooner (median 3.4 IQR 3.3–3.5 days vs 5.2 IQR 4.3–6.4 days), a difference of − 1.8 days (95% CI − 1.9, − 1.7; $p < 0.001$).

Incidence of complications is presented in Fig. 1. There existed no difference in the rate of wound complications, 30-day return to the OR, 30-day visit to the ED, or 30-day hospital readmission between the cohorts ($p > 0.05$). For wound complications, 100% (3/3) were due to drainage of the surgical site requiring antibiotics in the conventional group, whereas, in the RRP group 50% (2/4) were due to

Table 2 Comparison of the pre-operative, operative, and post-operative features in the conventional pathway group and rapid recovery pathway group

	Conventional pathway ($n=113$)	Rapid recovery pathway ($n=131$)	p value
Pre-operative			
Age (years)	15.2 ± 2.0	15.3 ± 1.9	0.772
Sex (% female)	77.0%	78.6%	0.452
Body mass index (kg/m^2)	20.8 ± 4.3	21.3 ± 4.6	0.436
Curve magnitude (°)	62.3 ± 10.8	67.5 ± 13.3	< 0.001
Operative			
Levels fused	11 ± 1.8	11 ± 1.9	0.491
Curve correction (°)	38.2 ± 12.1	45.8 ± 13.8	< 0.001
Estimated blood loss (cc/%EBV)	993/27.4% ± 60	806/22.2% ± 418	0.0067
Post-operative			
PCA discontinuation (h)	62.0 (53.0, 74.0)	51.7 (50.5, 53.8)	< 0.001
Foley discontinuation (days)	2.4 ± 0.6	1.9 ± 0.3	< 0.001
Standing initiated (days)	1.9 ± 0.6	1.0 ± 0.09	< 0.001
Walking initiated (days)	3.0 ± 0.9	1.9 ± 0.3	< 0.001
Hospital LOS (days)	5.2 (4.3, 6.1)	3.4 (3.3, 3.5)	< 0.001

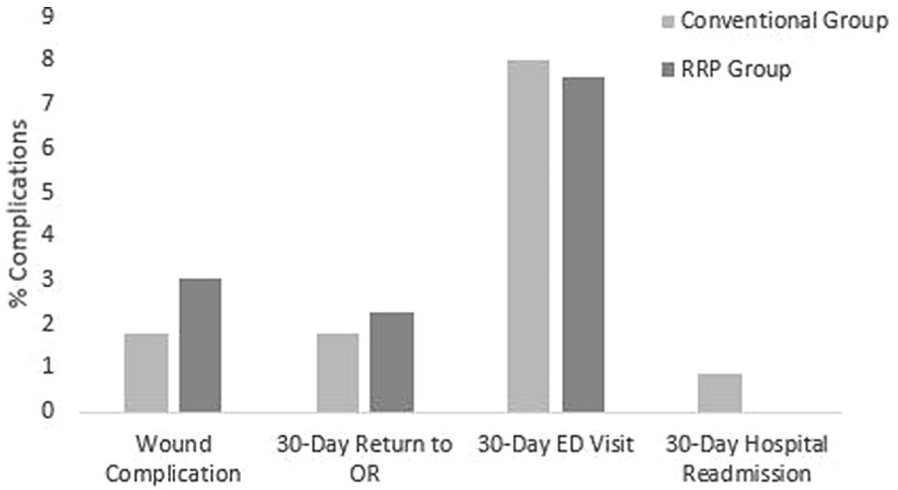

Fig. 1 Comparison of the percent complications between the conventional pathway group and rapid recovery group

surgical site drainage requiring antibiotics and 50% (2/4) due to wound dehiscence. Screw misplacement and/or screw removal was the only reason for 30-day return to the OR in the conventional group (100%, 2/2) and in the RRP group return to OR was due to screw misplacement and/or removal (66.6%, 2/3) or due to deep wound infection requiring irrigation and debridement (33.3%, 1/3). 30-day visit to the ED was due to pain (55.6%, 5/9), constipation (11.1%, 1/9), and other (33.3%, 3/9) in the conventional group, whereas, in the RRP group, 30-day ED visit was due to constipation (40.0%, 4/10), syncope (20.0%, 2/10), pain (10.0%, 1/10), or other (30.0%, 3/10).

Two interrupted time series models were used to assess the change in LOS following the implementation of the RRP. First, an ordinary linear regression model on log-transformed LOS was utilized which demonstrated a modest decrease in LOS following the intervention (13.9% [95% CI, 2.4–24.1]) (Fig. 2a). Next, a robust estimation method was used to mitigate several outlying observations. This demonstrated a larger decrease in LOS following implementation of the RRP (27.2%, [95% CI, 23.2–30.9]) (Fig. 2b) when compared to the ordinary linear regression model.

Discussion

Previously, the post-operative course for AIS patients following PSIF was solely focused on meeting appropriate discharge criteria, with the medical team taking little to no active role in the patient's in-hospital recovery. By standardizing the recovery protocol with RRP, it ensures that consistent post-operative outcomes are achieved and allows

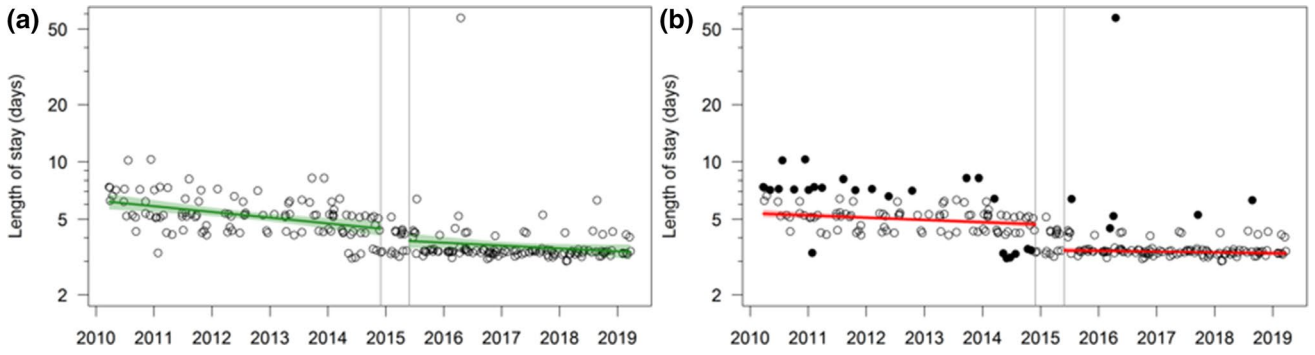

Fig. 2 **a** Ordinary linear regression model for log-transformed LOS and **b** robust linear regression model for log-transformed LOS. Shaded 95% confidence bands around the fitted curves are also shown. Vertical bars indicate the period 90 days before and after initiation of the RRP. Observations represented by filled circles indicate data points that have been automatically downweighted (to less than 5% of their weight) by the robust model

for the earlier detection of complications. The goal of this study was to determine if implementation of RRP for AIS patients undergoing PSIF in a single-payer universal healthcare system could similarly decrease LOS without increasing post-operative complications as seen in previous work in the United States.

There are several obstacles unique to the single-payer system which make implementation of RRP more challenging. In Canada, there is reduced financial incentive for patients to be discharged [13]. It is has been demonstrated previously that LOS is longer in Canada compared to the United States for a variety of orthopaedic procedures [10–13]. Also, there are fewer resources available to quicken the recovery for in-patients in Canada than in the United States, which can prolong discharge [11, 13]. Funding for specialized teams including nurse practitioners and therapists is limited by constrained hospital budgets. At the same time, acceptance or endorsement from nursing and allied health staff is more difficult when the institutional culture for efficiency is not as developed as is currently seen in many centers in the United States. This sentiment can subsequently be reflected by families who would prefer to spend more time in hospital as they are usually unaware of the increased morbidity associated with a prolonged or unnecessary stay.

Our study showed that hospital LOS decreased by 27.2% (median decrease of 1.8 days) and confirms that the use of RRP can be successful in single-payer systems. This reduction is similar to that seen for RRPs for AIS surgery in the United States [6–9]. Fletcher et al. [6] was one of the first to study the benefits of a RRP for scoliosis surgery and they found a decrease in LOS from 4.21 to 2.71 days. The implementation of a RRP is seen to be sustainable, with Oetgen et al. [8] finding that there were no changes in LOS, following the initial decrease, in each 6 month period examined for 2.5 years following the RRP implementation. Though not assessed directly in this study, it can be assumed that the protocol was maintained due to the almost horizontal slope of the LOS seen in the robust linear model following the implementation of our RRP (Fig. 2b). This consistency was facilitated by use of a lean process model which ensures constant review of the outcome of interest and the endorsement by all staff involved in the patient's care [14].

Sanders et al., demonstrated that in the 1 year and 5 month period following the implementation of the RRP there was a savings of $475,000, or around $5000 per patient. This decrease in post-operative costs was a result of the decrease in hospital LOS and decreased return to the OR in this group [9]. Though the Sanders study is limited by the shorter follow-up of the RRP group, the decrease in associated costs probably relates to our study as well. Canadian adult ICU beds are associated with an average cost of $4186 per day versus $1492 per day for a regular ward bed [15]. By decreasing hospital LOS and eliminating the post-operative ICU admission, it can be assumed that similar cost savings would be seen in our cohort. Finally, since our centre serves a large catchment area, another consideration would be the decrease in costs incurred by families required to take time off-work and stay in hotels during their child's hospital stay.

The rates of wound complications, 30-day return to the OR, 30-day ED visit and 30-day hospital readmission did not differ significantly between the two groups. The overall complication rate in this study was similar to that seen in previous studies implementing a RRP following PSIF in AIS patients [6, 7, 9]. When compared to more general studies examining the rates of complications following PSIF for AIS, this study showed similar rates of wound complications and slightly decreased rates of reoperation, though the higher reoperation rate observed in one of the studies listed may be due to the inclusion of both early and late complications [16–19]. The reason for ED visit differed between the conventional and RRP groups. The most common reason for return to the ED in the conventional

group was due to poorly managed pain (5/9), whereas only 1 patient visited the ED for pain control in the RRP group. This may be the result of improved focus on better post-operative pain control following the implementation of the RRP. Greater emphasis on pain education before discharge in the RRP group was undertaken and patients were also encouraged to call the acute pain service nurse practitioner if they had any questions. The most common presenting complaint to the ED in the RRP group was constipation (4/10) compared to only one patient in the conventional group, although this difference was not significant.

There are several limitations to this study. The main limitation is that retrospective review of the data limits the ability to determine which element of the RRP was most associated with the reduction in hospital LOS. This is meliorated through the use of an interrupted time series analysis, a method which has not been previously used in studies examining the effects of a RRP for PSIF in AIS patients, as it accounts for any previous trends before the intervention [6, 7, 9, 20]. Another limitation is the failure to capture patient and patient family data regarding their subjective experience and whether implementation of the RRP decreased associated costs to the family. This represents a future direction of this work, as it would be important to understand the differences in family comfort when providing an earlier discharge.

In conclusion, the use of this RRP in Canada demonstrated similar decreases in hospital LOS to those seen in cohorts in the United States. There was also earlier initiation of standing, walking, PCA discontinuation, and Foley catheter removal without any changes in the rates of post-operative complications. These findings confirm the feasibility and utility of implementing a standardized recovery protocol for AIS patients undergoing PSIF in a single-payer universal healthcare system. Future work should focus on elucidating patient and family satisfaction as well as exact cost saving benefits experienced by both the healthcare system and patients' families following the implementation of RRP.

Author contributions ZD: methodology, formal analysis and investigation, writing—original draft preparation, writing—review and editing, approval of final version, and accountability. NB: methodology, formal analysis and investigation, writing—review and editing, approval of final version, and accountability. KS: conceptualization, methodology, writing—review and editing, approval of final version, and accountability. DM: conceptualization, formal analysis and investigation, writing—review and editing, approval of final version, and accountability. PM: conceptualization, methodology, writing—review and editing, approval of final version, and accountability. AT: methodology, writing—review and editing, approval of final version, and accountability. JJ: conceptualization, methodology, formal analysis and investigation, writing—original draft preparation, writing—review and editing, approval of final version, and accountability.

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Compliance with ethical standards

Conflict of interests Dr Kevin Smit reports grants from Zimmer Biomet that do not involve this research project. No other conflicts to disclose.

Ethical approval This retrospective chart review study involving human participants was in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The Ethical Research Board of University of Ottawa approved this study.

References

1. Martin CT, Pugely AJ, Gao Y (2014) Increasing hospital charges for adolescent idiopathic scoliosis in the United States. Spine 39(20):1676–1682
2. Boylan MR, Riesling AM, Chu A, Paulino CB, Feldman DS (2019) Costs and complications of increased length of stay following adolescent idiopathic scoliosis surgery. J Pediatr Orthop 28:27–21
3. Harris AB, Gottlich C, Puvanesarajah V, Marrache M, Raad M, Petrusky O, Skolasky R, Njoku D, Sponseller PD, Jain A (2020) Factors associated with extended length of stay in patients undergoing posterior spinal fusion for adolescent idiopathic scoliosis. Spine Deformity 8:187–193
4. Konieczny MR, Senyurt H, Krauspe R (2013) Epidemiology of adolescent idiopathic scoliosis. J Child Orthop 7:3–9
5. Yoshihara H, Paulino C, Yoneoka D (2018) Predictors of increased hospital length of stay in adolescent idiopathic scoliosis patients undergoing posterior spinal fusion: analysis of national database. Spine Deformity 6:226–230
6. Fletcher ND, Andras LM, Lazarus DE, Owen RJ, Geddes BS, Cao J, Skaggs DL, Oswald TS, Bruce RW (2017) Use of a novel pathway for early discharge was associated with a 48% shorter length of stay after posterior spinal fusion for adolescent idiopathic scoliosis. J Pediatr Orthop 37(2):92–97
7. Gornitzky AL, Flynn JM, Muhly WT, Sankar WN (2016) A rapid recovery pathway for adolescent idiopathic scoliosis that improves pain control and reduces time to inpatient recovery after posterior spinal fusion. Spine Deformity 4:288–295
8. Oetgen ME, Martin BD, Gordish-Dressman H, Cronin J, Pestieau SR (2018) Effectiveness and sustainability of a standardized care pathway developed with use of lean process mapping for the treatment of patients undergoing posterior spinal fusion for adolescent idiopathic scoliosis. J Bone Joint Surg 100:1864–1870
9. Sanders AE, Andras LM, Sousa T, Kissinger C, Cucchiaro G, Skaggs DL (2016) Accelerated discharge protocol for posterior spinal fusion patients with adolescent idiopathic scoliosis decreases hospital postoperative charges 22%. Spine Deformity 42(2):92–97
10. Antoniou J, Martineau PA, Filion KB, Haider S, Zukor DJ, Huk OL, Pilote L, Eisenberg MJ (2004) In-hospital cost of total hip arthroplasty in Canada and the United States. J Bone J Surg 86(11):2436–2439
11. Beaupre LA, Wai EK, Hoover DR, Noveck H, Roffey DM, Cook DR, Magaziner JS, Carson JL (2018) A comparison of outcomes between Canada and the United States in patients recovering from

hip fracture repair: secondary analysis of the FOCUS trial. Int J Qual Health Care 30(2):97–103
12. Cram P, Lix LM, Bohm E, Yan L, Roos L, Matelski J, Gandhi R, Landon B, Leslie WD (2019) Hip fracture care in Manitoba Canada and New York State, United States: an analysis of administrative data. CMAJ Open 7(1):E55–E62
13. Hart A, Bergeron SG, Epure L, Huk O, Zukor D, Antoniou J (2015) Comparison of US and Canadian perioperative outcomes and hospital efficiency after total hip and knee arthroplasty. JAMA Surg 150(10):990–998
14. Sethi R, Yanamadala V, Burton DC, Bess RS (2017) Using lean process improvement to enhance safety and value in orthopaedic surgery: the case of spine surgery. J Am Academ Orthop Surg 25:e244–e250
15. Canadian Institute for Health Information (2016) Care in Canadian ICUs. Ottawa, ON: CIHI
16. Bartley CE, Yaszay B, Bastrom TP, Shah SA, Lonner BS, Asghar J, Miyanji F, Samdani A, Newton PO (2017) Perioperative and delayed major complications following surgical treatment of adolescent idiopathic scoliosis. J Bone Joint Surg 99:1206–1212
17. Carreon LY, Puno RM, Lenke LG, Richards BS, Sucato DJ, Emans JB, Erickson MA (2007) Non-neurological complications following surgery for adolescent idiopathic scoliosis. J Bone Joint Surg 89:2427–2432
18. Coe JD, Arlet A, Donaldson W, Berven S, Hanson DS, Mudiyam R, Perra JH, Shaffrey CI (2006) Complications in spinal fusion for adolescent idiopathic scoliosis in the new millennium. A report of the Scoliosis Research Society Morbidity and Mortality Committee. Spine 3:345–349
19. Mignemi M, Tran D, Ramo B, Richards BS (2018) Repeat surgical interventions following "definitive" instrumentation and fusion for idiopathic scoliosis: 25-year update. Spine Deformity 6:409–416
20. Stambough JB, Nunley RM, Curry M, Steger-May K, Clohisy JC (2015) Rapid recovery protocols for primary total hip arthroplasty can safely reduce length of stay without increasing readmissions. J Arthroplasty 30(4):521–526