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CASE SERIES

Implementation of an enhanced recovery pathway in Australia after posterior spinal fusion for adolescent idiopathic scoliosis delivers improved outcomes

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Abstract

Purpose Traditionally, spinal surgery for Adolescent Idiopathic Scoliosis (AIS) has seen long hospital length of stay (LOS) and slow mobility progression. Postoperative enhanced recovery pathways (ERP) for this population in North America and Asia have successfully reduced LOS and hospital costs without increasing complications. This study assessed if ERP introduced in an Australian center achieves similar results.

Methods A pre–post intervention study compared a historical AIS cohort having a posterior spinal fusion (PSF) who received conventional care (CC) (2013–2014) with prospectively assessed ERP recipients (2016–2018) separated by 1-year implementation period. Patient characteristics, surgical details, postoperative analgesia, mobilization, LOS and complication outcomes were collected.

Results The 32 CC and 61 ERP recipients had similar demographics. ERP recipients had 44% decreased LOS (mean LOS 3.5 ± 0.9 days vs. CC 6.3 ± 0.9 days, $p < 0.001$) as all ERP milestones were achieved sooner including transition to oral analgesia (MD −2 days, 95% CI 1.8–2.3), oral intake (MD −2.3 days, 95% CI 2.0–2.6) and mobilization, with fewer physiotherapy sessions (5.2 vs 8, $p < 0.001$). Postoperative in-hospital costs were 50.2% less for ERP vs CC (AUD $8234 vs $16,545). Due to small sample size, no differences between the groups were detectable for complications (4.9% vs 6.3%) or readmission (1.6% vs 3.1%).

Conclusion An ERP for AIS after PSF in this Australian center improved functional recovery reducing LOS and by associated postoperative inpatient costs. Other Australian hospitals should consider an ERP for this population with larger-scale audit to assess impact upon complications.

Level of evidence III.

Keywords Scoliosis · Posterior spinal fusion · Accelerated discharge · Hospital stay · Financial impact · Postoperative

Introduction

Adolescent idiopathic scoliosis (AIS) is a structural, lateral curvature and rotation of the spine with no clear underlying cause occurring in children aged over 10 years [1]. Worldwide, AIS is estimated to affect between 0.47 and 5.2% of children [2]. The treatment of choice for AIS with a Cobb angle > 50 degrees is spinal fusion surgery [3]. Traditionally spinal fusion surgery resulted in long hospitalization of approximately 5–6 days and a slow progression in mobilization [1, 4, 5]. A recent systematic review of 19 studies of Enhanced Recovery Pathways (ERP) in various adult spinal operations have shown decreased postoperative pain scores (in 3 of 13 studies), opioid consumption (4 studies), hospital

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length of stay (LOS) (7 studies) and direct/indirect or total costs (8 studies) [6].

An ERP described in 2014 for use after pediatric spinal surgery for AIS involved earlier mobilization, faster transition to oral pain medication, and no requirement of bowel movement prior to discharge [7]. Comparison of ERP implementation (one campus) with conventional care (CC) (at a second campus of a United States of America (USA) hospital) demonstrated reduced hospital LOS and costs with no difference in the low incidence of complications ($n = 279$). Since this publication, several North American [2, 8–12] and one Asian [13] institution have implemented a similar pathway, with 80% of patients with AIS who underwent PSF with an ERP reporting the time of discharge was appropriate [12] and high satisfaction [10].

An ERP (based on [7]) was introduced at our tertiary pediatric hospital in 2016 for posterior spinal fusion (PSF) in AIS. To our knowledge, this is the first use of an ERP within the Australian healthcare setting. The study aimed to determine whether an ERP would also effectively shorten functional recovery (LOS and time to achievement of milestones) and reduce hospital costs in an Australian institution.

Methods

Study design

A pre–post intervention study compared data for a retrospective historic AIS cohort having PSF over 2 years (2013–2014) who received CC with prospectively assessed ERP recipients over 2 years (February 2016–January 2018), after a 1-year implementation period. Patients aged between 10 and 18 years were included. Exclusion criteria were patients with non-idiopathic etiology, a significant past medical history such as developmental delay, autism spectrum disorder, cancer, prior spinal surgery (anterior or staged surgical procedures) or those with intraoperative complications such as loss of motor signals indicating a need for a longer and more intensive postoperative care. The most recent historical CC group prior to the washout period was used to reduce confounding factors not related to the pathway.

Conventional care (CC)

Prior to ERP implementation, CC involved transitioning analgesic medication from intravenous (IV) to oral medication on postoperative day (POD) 3, sitting out of bed and walking with physical therapy (PT) POD2 or POD3, eating of solid food once bowel sounds heard (approximately POD3 or POD4) and removal of the indwelling catheter (IDC) once the patient is mobilizing to the bathroom (POD3 or POD4). Discharge criteria included drinking adequately and tolerating some solid food, passing urine without difficulty and having opened bowels, adequate pain control with analgesic medication and deemed safe from PT and occupational therapy (OT). All patients were given a written patient information leaflet at a preadmission review on what to expect postoperatively. Patients were discharged with home analgesia including regular Paracetamol, a weaning regimen of controlled release Oxycodone/Naloxone (TARGIN®; Mundipharma Pty Ltd, Sydney, Australia) twice a day, immediate release Oxycodone 4 hourly as needed, occasionally Tramadol and/or Gabapentin and rarely a non-steroidal anti-inflammatory drug (NSAIDS). The medication plan was written at discharge and was weaned over 2–3 weeks with phone follow-up by the Children's Pain Management Service (CPMS), with Paracetamol the last medication to be weaned.

Enhanced recovery pathway (ERP)

The ERP was formulated in consultation with the spinal surgeons, scoliosis coordinator, scoliosis anesthesiologists/CPMS, PT, surgical ward nurses and OT. A formalized clinical pathway for staff was created with education sessions for each involved discipline to ensure the pathway was completed consistently. The ERP involves transitioning from IV to oral medication POD1, sitting out of bed and mobilizing with the PT POD1, removal of IDC the evening of POD1 and eating solid food as soon as tolerated. The discharge criteria were similar to CC except for the requirement to only pass flatus and not a bowel movement prior to discharge. The patient information leaflet given to the patient and family pre-surgery was revised highlighting ERP goals and a laminated resource was created outlining the daily expectations of the ERP pathway which was placed on their hospital room wall for reference during admission. Patients were discharged home with the same medication and weaning plan as the CC patients. An overview of the ERP by POD is shown in Supplement 1.

Data collection and outcomes

The first author (SET) collected historical CC data retrospectively from hard-copy medical chart review with prospective data collection of the ERP recipients during their hospital admission. Data included demographic information, pre-surgery Cobb angle and surgical details (number of vertebra fused, pedicle screws placed and anesthetic duration). Postoperative data included the day patient controlled analgesia (PCA) use ceased, IDC was removed, simple solid foods intake commenced, first time sitting out of bed and walking, number of PT and OT sessions, and hospital LOS.

Complications were included to 6 months postoperatively only, as complications after this time were unlikely to be due to the care pathway or LOS. Complications were categorized based on severity and etiology as described in Table 1 with the addition of hospital readmission related to the spinal surgery.

Hospital costs (mean in-hospital costs per admission; Australian dollars [AUD$]) were obtained from the institution's Decision Support Unit. Since the ERP did not impact preoperative or intraoperative care, only postoperative costs (nursing (not inclusive of food and board), medical (orthopedics only) and allied health) were compared. No costs after the patients were discharged or those associated with complications were considered.

The primary outcome was LOS. The secondary outcomes were times to achievement of milestones, number of PT and OT sessions, postoperative hospital costs per admission and complications.

Statistical analysis

Chi-square test was used to compare categorical variables and two-sample *t* test was used to compare mean values for the two care pathways. As the number of complications and readmissions were small, no statistical analysis was completed. Statistical analyses were performed using Stata (v16; StataCorp, College Station, Texas, USA).

Results

Thirty eight AIS patients underwent a PSF in January 2013–December 2014. Five patients were excluded due to staged procedures and one due to neurological complications resulting in data for thirty two CC recipients. Eighty one AIS patients underwent PSF and received ERP February 2016–January 2018. Six were excluded due to staged procedures, nine were excluded due to significant past medical history and 5 were excluded due to neurological precautions, resulting in data collection for 61 ERP recipients. There was no clinically meaningful difference between CC and the ERP groups in terms of sex, pre-surgery Cobb angle, pedicle screws or anesthetic duration. Age and number of vertebrae fused differed statistically ($p < 0.05$), however not in a clinically meaningful way (Table 2).

All care milestones were met earlier by the ERP versus CC recipients (Fig. 1), with clinical and statistical significance (Table 3). Consequently, the hospital LOS was shorter by 44%—mean difference of 2.8 days (Table 3). Of the 61 patients in the ERP, 1 was discharged home on POD 2 (1/61; 1.6%), 42 went home on POD3 (42/61; 68.9%), 11 went home POD 4 (11/61; 18%), 3 went home POD5 (3/61; 4.9%), 3 went home POD 6 (3/61; 4.9%) and 1 went home POD 7 (1/61; 1.6%) (Fig. 2). The number of PT sessions was reduced, while OT sessions remained similar between the two groups (Table 3).

Table 1 Postoperative complication category and definition (adapted from [7])

Complication	Definition
Type 1—wound: conservative	Postsurgical wound complications treated expectantly or with antibiotics with no surgical intervention
Type 2—wound: surgical	Postsurgical wound infection that required surgical debridement or drainage
Type 3—revision	Repeat operation for non-infectious reasons
Type 4—medical	Medical complications related to their spinal surgery that required a prolonged or atypical postoperative course such as urinary infection or pulmonary complication
Readmission to hospital	For reasons relating to anesthesia for posterior spinal fusion or post-surgical complication (and not other medical indications)

Table 2 Patient demographics and surgery characteristics

	Conventional care	Enhanced recovery pathway	*p* value
Number of patients	32	61	
Sex (*n* [% female])	27 (84%)	51 (84%)	0.92
Age (years)*	15.4 ± 1.5	14 ± 1.6	< 0.001
Pre surgery cobb angle (degree)*	59.7° ± 9.1	62° ± 10.0	0.28
Vertebrae fused (*n*)*	9.4 ± 1.8	10.2 ± 1.7	0.04
Pedicle screws (*n*)*	14.3 ± 3.1	15 ± 2.9	0.28
Length of anesthetic (min)*	268.4 ± 45.3	261.7 ± 45.1	0.50

*Data presented as mean ± standard deviation

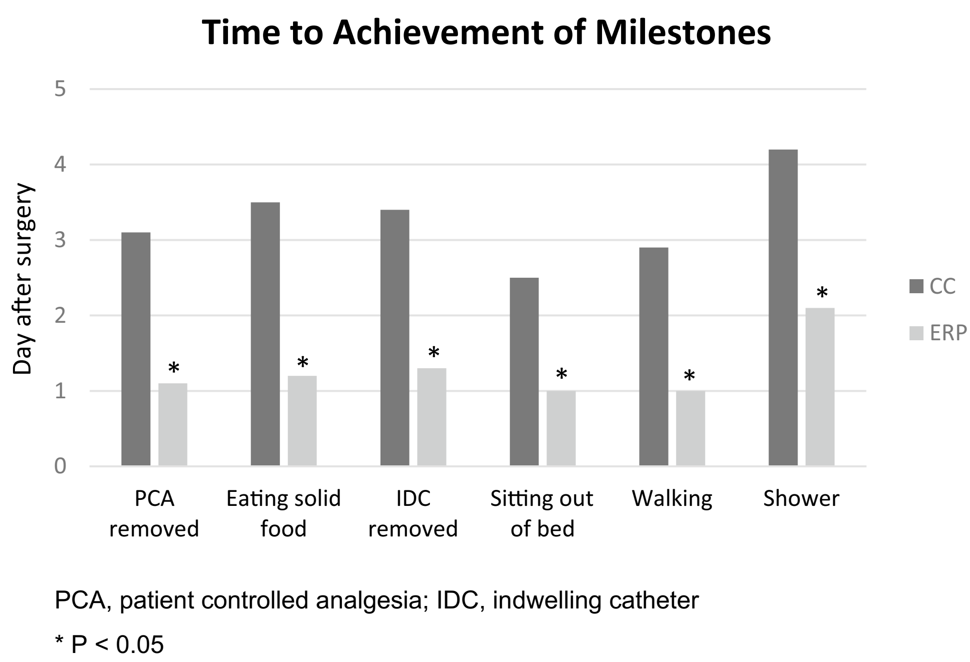

Fig. 1 Time to achievement of milestones

Table 3 Time to achievement of milestones, number of physical therapy and occupational therapy treatment sessions and hospital length of stay

	Conventional care $n=32$	Enhanced recovery pathway $n=61$	Mean difference (95% CI)	*p* value
Achievement of pathway milestones				
PCA ceased (days)	3.1 ± 0.8	1.1 ± 0.4	2.0 (1.8–2.3)	< 0.001
Solid food intake (days)	3.5 ± 0.9	1.2 ± 0.4	2.3 (2.0–2.6)	< 0.001
IDC removed (days)	3.4 ± 1.2	1.3 ± 0.5	2.1 (1.7–2.5)	< 0.001
Sitting out of bed (days)	2.5 ± 0.7	1.0 ± 0.2	1.5 (1.3–1.7)	< 0.001
Walking (days)	2.9 ± 0.9	1.0 ± 0.2	1.9 (1.7–2.1)	< 0.001
Shower (days)	4.2 ± 0.5	2.1 ± 0.5	2.1 (1.9–2.3)	< 0.001
Physical therapy treatments (*n*)	8.0 ± 1.5	5.2 ± 1.2	2.8 (2.2–3.4)	< 0.001
Occupational therapy treatments (*n*)	1.7 ± 0.6	1.5 ± 0.9	0.2 (− 0.15 to 0.55)	0.26
Hospital length of stay (days)	6.3 ± 0.9	3.5 ± 0.9	2.8 (2.4–3.2)	< 0.001

Data presented mean ± standard deviation

CI confidence interval, *IDC* indwelling catheter, *PCA* patient controlled analgesia

No clinically meaningful difference was seen between the groups for complications or readmissions (Table 4). In terms of complications, two ERP patients received oral antibiotics (Type 1—wound: conservative); while one was readmitted and received a spinal wound washout/debridement and IV antibiotics (Type 2—wound: surgical). The CC cohort had two patients with complications; one patient (while still admitted) underwent revision surgery on POD5, for loss of fixation of the L4 pedicle screw (Type 3—revision); one patient was readmitted to hospital due to vomiting (Type 4—medical). A further patient had an L5 sensory loss occur at 6 weeks postoperatively; however, this resolved without medical intervention or hospital readmission and, therefore, was not included.

Postoperative costs were significantly less for those on the ERP compared to the CC per admission (Table 5).

Discussion

Implementation of an ERP for AIS patients after PSF at this Australian center decreased time to functional recovery with decrease in hospital LOS, earlier milestone achievement

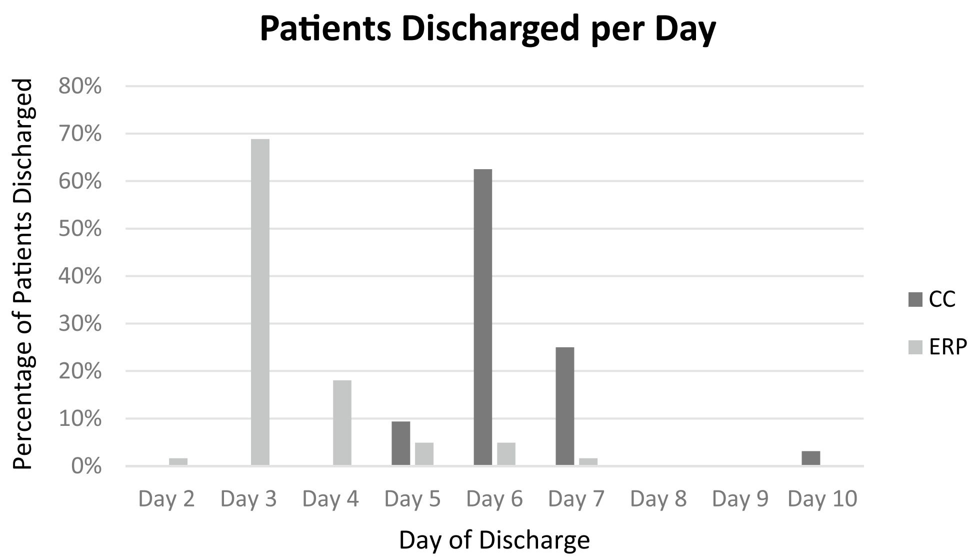

Fig. 2 Percentage of patients discharged per postoperative day

Table 4 Complications (including readmission requirement)

	Conventional care $n=32$	Enhanced recovery pathway $n=61$
Type 1—wound: conservative (*n*, %)	0	2 (3.3%)
Type 2—wound: surgical (*n*, %)	0	1 (1.6%)*
Type 3—revision (*n*, %)	1 (3.1%)	0
Type 4—medical (*n*, %)	1 (3.1%)*	0
Total complications	2 (6.3%)	3 (4.9%)
Readmission (*n*, %)	1 (3.1%)	1 (1.6%)

Data presented as frequency and percentage

*Readmission

during inpatient stay, and associated decrease in postoperative ward costs and number of PT sessions completed.

The reduction in LOS from 6.3 to 3.5 days (44%) in this study is comparable to those for ERPs in USA hospitals with reduction in LOS from 4.3 to 2.9 days (48%) [14], from 5.7 to 4 days (4.2%) [8] and 5 to 3.5 days (30%) [9] and achieving a similar LOS as the 3.6 days in the Asian ERP prospective only audit [13]. Regarding in-hospital milestones, previous slightly larger studies report significant decreases for their ERP pathway versus CC in time to removal of PCA and IDC ($n=138$) [9], epidural/PCA and IDC and also time to sitting, though no significant change in time to regular diet or to walking ($n=190$) [10]. The current study demonstrated decreased time to achievement of all milestones including PCA and IDC removal, and commencement of eating solid food, sitting out of bed, walking and showering. With regards to allied health intervention, there was no impact on the small number of OT sessions but significant decrease in number of PT sessions, as patients' mobilization progressed quicker with earlier attainment of their therapy goals and therefore reduced need for rehabilitation sessions. One prior study had observed a significant decrease in time to PT discharge by a mean of 12 h [10]. However, another study reported an increase in rehabilitation costs attributed to an increase in number of therapy sessions despite significant impact on LOS [2].

With regard to complication and readmission rates, the literature varies in the cut-off times used for these outcomes. In the current study, there were no clinically meaningful differences over a 6-month postoperative period between the

Table 5 Mean postoperative hospital cost per admission (AUD$)

	Conventional care	Enhanced recovery pathway	% decrease
Ward medical (orthopedic) ($)	10,849.5	4662.0	57
Ward nursing ($)	4579.4	2805.0	38.8
Ward allied health ($)	1116.5	767.0	31.3
Combined ward medical (orthopedic), nursing and allied health ($)	16,545.4	8234.0	50.2

Data presented mean

CC and ERP groups. Other studies comparing CC to ERP after PSF have also found no significant difference in wound (3.6 vs. 3.3%, $n=284$ [11], 2.2 vs 1.1%, $n=150$ [14]) and overall complications rates (major: 6 vs 3.3%, $n=80$ [2]), or readmission (30 days: 5 vs 3%, $n=138$ [9]; 6 months: 1.5 vs. 4.4% $n=284$ [15]). While, two studies found a decrease in total complications with an ERP (over 1–12 months [3 phase study]:12 vs 1 vs 3%, $n=190$[10]; 6 months 20 vs. 7.6%, $n=150$ [14]).

The financial implications of an ERP use are an important consideration for sustainable healthcare. Again the prior literature varies in the assessment of financial impact with 33% decrease in inpatient room and board hospital costs [7], 22% decrease in postoperative hospital charges [11] versus 9% decrease in total average costs per episode of care [2]. This latter study's inpatient cost (nursing and hospital room and board) decreased by 18.8%, however, was countered by a 14.3% increase in rehabilitation costs. A further study has assessed cost differences over 0–90 days postoperatively which emphasizes facility costs as being the greatest contributor [15]. Implementation of the ERP in this current study saw a 50.2% decrease in combined postoperative ward costs per admission (inclusive of postoperative nursing, ward medical (orthopedics) and ward allied health costs) and would be greater if inclusive of food and board costs. No other analysis to date has included consideration of the financial benefits of early discharge on increasing hospital bed availability and, therefore, may underestimate the true financial benefit of the ERP. While, a full assessment of the economic impact should incorporate the financial costs of complications and readmission.

Estimated blood loss (EBL) during surgery was unable to be analyzed for the CC cohort due to the data being recorded differently across the years. One prior study found no significant differences in EBL between groups [14], while another observed a statistically but not clinically significant decrease in operative time and intraoperative EBL in the ERP group which is not readily related to an accelerated postoperative program but transfusion costs are relevant in cost calculations [11].

Pain levels after PSF can be severe and difficult to manage [16] and may be expected to increase in the setting of earlier mobilization with an ERP. Studies have again had variable results for this outcome. One study saw a small but significant increase in average daily pain scores in the ERP group on POD2, POD3 and on the day of discharge [11]. While, three studies were positive where the use of multi-modal pain protocol and early mobilization was not associated with an increase in self-reported pain for the ERP (3 phase $n=332$ [8] and $n=190$ [10]) and self-reported daily pain scores were significantly improved on POD 0, POD 1 and POD 2 in ERP vs CC recipients ($n=138$ [9]). Pain report was not included as an outcome for this study as this was poorly documented in the historic data for the CC cohort. The relevance of analysis of subjective pain score report when expectations are set, analgesic medication is being administered, functional goals are being met and patients (and parents) are satisfied is debatable. The data has more relevance when paired with analgesic (including opioid) intake as demonstrated in a study with lowering over time of both pain scores and opioid intake (by ~ 0.2 mg/kg on POD 1 and POD 2 and maintained over 1.5 years post ERP introduction) [17]. An important influence is also the change over time where staff expectations have been reset and the ERP benefits embraced, where patients are supported, encouraged and congratulated by all staff including nursing, allied, medical and pain service (the latter visiting twice daily to support the patient with individualized adjustment of their analgesic regime to assist with adequate pain control).

This study has several limitations. It is a pre–post intervention study with a historic cohort and like other studies, there is a discrepancy between group size but in contrast with other studies, the CC cohort is smaller. This has been influenced by a surgical practice shift towards completing a PSF over an anterior spinal fusion (ASF) for AIS. Despite the care pathways occurring at different times, the groups were similar in the majority of characteristics and there were no clinically meaningful differences. As already highlighted, the overall sample size is small and, thus, the main issue, which this study shares with prior studies, is being underpowered to detect a clinically relevant difference in the case of rare adverse events.

Conclusion

As is the case with the Northern American experience, implementation of an ERP for AIS after a PSF in the Australian healthcare setting improves functional recovery with a decrease in hospital LOS and time to achievement of milestones. The use of this accelerated care pathway also assists with sustainable healthcare by decreasing postoperative hospital costs. Other centers should consider the use of an ERP for this patient population and larger-scale (ideally multicenter) audit should be performed to assess the sustainability and also impact upon postoperative complications and hospital readmission (which could then be factored into further cost–benefit analysis).

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s43390-021-00340-4.

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Author contributions SET, GMP, SPP, DMP, MBJ: (1) made substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data; or the creation of new software used in the work; (2) drafted the work or revised it critically for important intellectual content; (3) approved the version to be published; (4) agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Availability of data and material The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Code availability Not applicable.

Declarations

Conflict of interest The authors have no conflicts of interest to declare that are relevant to the content of this article.

Ethical approval This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Human Research Ethics Committee of The Royal Children's Hospital, Melbourne (Ethics approval number: HREC 36015).

Consent to participate Not applicable.

Consent to publication Not applicable.

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