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RESEARCH ARTICLE

A Retrospective, Multicentre Comparison of Continuous Epidural Analgesia and Patient-Controlled Analgesia Following Posterior Spinal Instrumented Fusion for Adolescent Idiopathic Scoliosis

Maisha M Jamali [1,2]; J. Paige Little [1]; Kris Lundine [5]; Gregory E Moloney [3]; Donna M Peachey [5]; Maree T Izatt [1,2]; Adam F Parr [2]; Robert D Labrom [1,2]; Dimitrios Vagenas [4]; Geoffrey N Askin [1,2]

[1] Biomechanics and Spine Research Group, Queensland University of Technology at the Centre for Children's Health Research, Brisbane, Australia
[2] Orthopaedics Department, Queensland Children's Hospital, Brisbane, Australia
[3] Anaesthetics Department, Queensland Children's Hospital, Brisbane, Australia
[4] Research Methods Group, Faculty of Health, Queensland University of Technology
[5] The Royal Children's Hospital, Melbourne, Australia

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ABSTRACT

Introduction: The Queensland Children's Hospital (QCH) in Brisbane, Australia offers continuous epidural analgesia as standard postoperative care for adolescent idiopathic scoliosis following posterior spinal instrumented fusion. Intravenous patient-controlled analgesia, is a well-established alternative for managing postoperative pain. Both modalities are associated with side effects. Epidurals are linked to transient neurological changes, while patient controlled analgesia is associated with opioid induced complications. To compare continuous epidural analgesia to patient controlled analgesia, data from Queensland Children's Hospital and the Royal Children's Hospital (RCH) (where patient controlled analgesia is standard for postoperative analgesia), was analyzed. The primary objective was to assess safety and side-effects of both methods by assessing objective postoperative outcomes.

Methods: A retrospective chart review was conducted at Queensland Children's Hospital from 06/01/2020 to 19/12/2022 and at Royal Children's Hospital from 07/01/2020 to 13/12/2022. The study included 203 patients, with 120 patients from Royal Children's Hospital and 83 from Queensland Children's Hospital. Mean ages were 14.64 +/- 1.54 and 14.92 +/- 1.71 respectively (P=0.28). Mean cobb scores were 70.55 +/- 17.83 and 66.70 +/- 10.59 respectively (P=0.06). Data analysis involved student's t-test and Chi-squared analysis using SPSS software.

Results: Patient demographics were comparable, however Queensland Children's Hospital patients had more levels fused (P<0.01). Queensland Children's Hospital patients experienced lower rates of sedation and discharge without a bowel motion (P<0.01). Temporary neurological complications were exclusive to QCH patients (26 cases), however all cases resolved without further complications. Rates of respiratory depression, postoperative nausea and vomiting, readmissions and deep surgical infections were similar (P>0.05). At RCH, 51.67% of patients mobilized with physiotherapy assistance of POD1, compared to 54.22% at QCH. Mean discharge time for Royal Children's Hospital and Queensland Children's Hospital was 3.45+/-1.15 and 5.36+/-1.69 days respectively (P<0.01). Both centres had 6 unplanned readmissions (P=0.49).

Conclusion: Both continuous epidural and patient-controlled analgesia are safe and effective following posterior spinal fusion for adolescent idiopathic scoliosis, though they differ in complication profiles. Epidurals are linked to transient neurological effects, while PCA is associated with opioid-related sedation and respiratory depression. Differences in recovery outcomes, particularly diet resumption and discharge, may reflect the impact of accelerated discharge pathways on optimizing patient recovery.

Introduction

Scoliosis is a three-dimensional anatomic alteration of the spine, characterised by a curvature measured in the coronal plane of at least 10 degrees, as defined by the Cobb method, see image 1. [1]. The most prevalent form is adolescent idiopathic scoliosis (AIS), with a population prevalence of 2-4% of children aged 10-18 years [2,3]. Surgical intervention is indicated for curves with concern of progression and causing physiological distress, such as loss of pulmonary function [4]. Posterior spinal instrumented fusion (PSIF), has been the standard surgical approach, encompassing extensive midline dissection through subcutaneous fat, fascia and ligaments to affix alloy rods which impart corrective and distracting forces [5]. As such, post-operative pain is a challenging aspect of scoliosis corrective surgery and, if poorly controlled, can lead to increased morbidity, delayed recovery, prolonged duration of opioid use and higher health care costs [6].

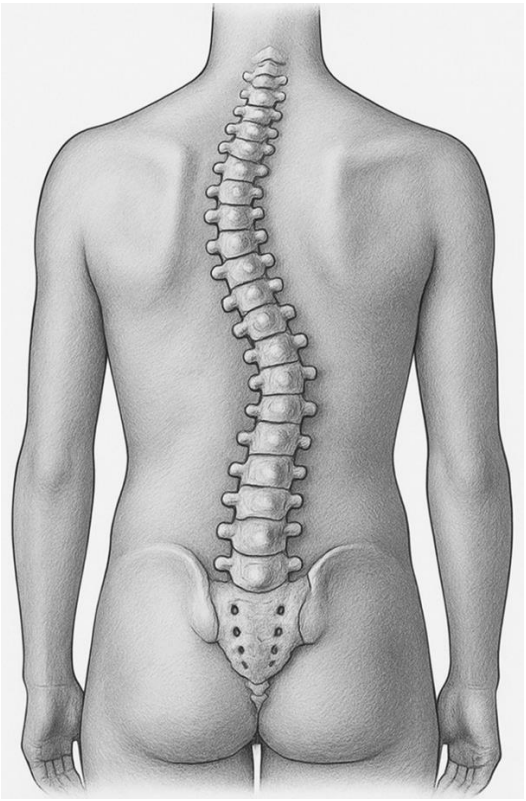

Image 1: Scoliosis diagram

Intravenous patient-controlled analgesia (PCA) is a widely studied and accepted method for managing post-operative pain for many procedures including PSIF in children with adolescent idiopathic scoliosis [7]. Despite its widespread use, commonly observed complications include nausea, vomiting, pruritus, respiratory depression, sedation, confusion, urinary retention and inadequate analgesia [8,9]. Epidural analgesia is an alternate method for management of post-operative pain. This requires the placement of an epidural catheter prior to closure of the surgical wound with infusion of a combination of local anaesthetic and an opioid agent post-operatively. Epidural analgesia has concerns related to epidural haematomas, epidural abscess, transient neurological changes and dural puncture headaches[10]. Occasionally, epidurals may create a temporary change in neurological examination requiring cessation. As such this method is cautiously utilised, particularly for patients who have undergone spinal correction surgery [7]. In a separate review, the authors of the present study conducted a thorough evaluation of the safety profile of epidural analgesia, which will be referred to within this paper [11]. Both methods of post-operative analgesic control have been utilised in the AIS field, however the use of PCA predominates, with limited literature on the use of continuous epidural analgesia (CEA) in the AIS patient cohort.

In carrying out a retrospective patient chart review, this study aimed to determine if the use of continuous epidural analgesia and patient controlled analgesia was comparable following posterior spinal fusion for adolescent idiopathic scoliosis. Specifically, post-operative outcomes related to the analgesic modality and conducted a safety profile review to ensure the comparability and acceptability of both pain relief methods for the AIS population.

Methods

Since its inauguration in 2015, the Queensland Children's Hospital (QCH) Brisbane, Australia has utilised CEA as the standard analgesic modality for PSIF surgical correction of AIS. In comparison, the Royal Children's Hospital (RCH) in Melbourne, Australia provides PCA as part of standard care. A multicentre retrospective chart review was therefore designed, with the QCH cohort compared against a matched PCA cohort from the Royal Children's Hospital.

Ethics in accordance with the National Health and Medical Research Council's "National Statement on Ethical Conduct in Human Research (2007), NHMRC and Universities Australia Australian Code for the Responsible Conduct of Research (2007) and the "CPMP/ICH Note for Guidance on Good Clinical Practice" was granted for this project. The study was approved by the appropriate Institutional Review Board (IRB), the Children's Health Queensland Hospital and Health Service Human Research Ethics Committee, reference LNR/21/QCHQ/75249, and as such the requirements for written informed consent was waived by the IRB. A retrospective chart review was performed for AIS patients who underwent PSIF and received CEA from 06/01/2020 to 19/12/2022, and PCA from 07/01/2020 – 13/12/2022. Patients with alternative causes of scoliosis (neuromuscular, congenital, post traumatic) or previous spinal surgery were excluded. Ages ranged from 10 to 18 at both centres, with body height ranging from 135-175cm and 140-185cm and body weight ranging from 30-110kg and 35-105kg at CEA and PCA centres respectively. Additional demographic data, including the distribution of females, pre-operative cobb angle and surgical levels fused were collected from the electronic medical records.

Data extraction included patient demographics (age, sex, height, weight), curve characteristics (major Cobb angle), operative details (levels fused), and postoperative course. Outcome measures included efficacy endpoints (days to first defecation, resumption of solid diet, and length of stay) and safety endpoints (sedation, respiratory depression, bowel motion, postoperative nausea and vomiting, readmission, surgical

infection, and temporary neurological change). All data were independently verified by two investigators. Statistical analysis was performed with IBM SPSS v28. Continuous variables were analysed using bootstrapped Student's t-tests, while categorical outcomes were compared with Chi-squared tests. A significance level of $p<0.05$ was adopted.

Continuous epidural analgesia protocol

Epidural catheters placement prior to surgical closure was typically conducted with an 18 gauge (French) size and was inserted by the surgeon under direct visualisation, or through the standard loss of resistance to air technique through the ligament flavum, using a Touhy needle, see image 2 [12]. The catheters were placed five centimetres within the epidural space at a chosen thoracic and/or lumbar level, to ensure adequate spread and coverage of local anaesthetic. Catheters were tunnelled to an exit point lateral to the midline incision utilised for the PSIF surgery. Upon completion of instrumentation and final neuromonitoring evoked stimulations, an epidural bolus of local anaesthetic containing 1 microgram/kg Fentanyl +/- 50 microgram/kg of morphine was administered. After awakening, an infusion of local anaesthetic (typically levobupivacaine 0.125%) was commenced at a total of 0.2 mls/kg/hr with a maximum rate of 0.3mls/kg/hr. No further opioid analgesia was provided through the catheter. Epidural infusion rates were typically commenced at a ratio of 1/3rd to the superior and 2/3rd to the inferior epidural and remained in-situ for 64-72 hours. Patients were placed on regular oral paracetamol and ibuprofen as required. In instances where analgesia was deemed insufficient, rescue oral opioids were offered. Oral analgesics were frequently timed to be given pre-physiotherapy. On the third post-operative morning, epidurals infusions were ceased at 0600 with a subsequent enteral opioid plan. If analgesic failure did not occur, catheters were removed later that day. While this centre does not follow a formalised discharge pathway, certain prerequisites were required for patient discharge as per Table 1.

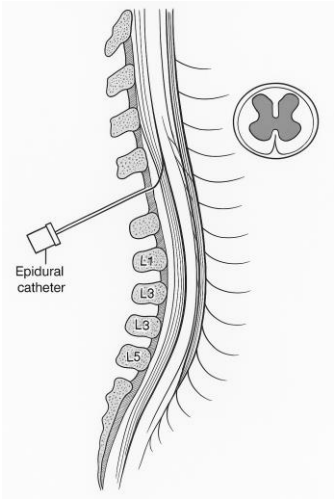

Image 2: Placement of epidural catheter

Table 1: Discharge criteria for CEA and PCA patients

Discharge requirements	CEA (QCH)	PCA (RCH)
Oral intake	Tolerating a solid diet	
Gastrointestinal	Passing urine Passed one formed bowel motion	Passing urine Passing flatus
Pain	Adequate pain control on oral analgesic (or pain relieving) medication	
Mobility	Deemed safe from physiotherapy and occupational therapy to have returned to reasonable activities of daily life (toileting, transfers, independent mobility)	

Patient controlled analgesia protocol

A PCA with a ketamine infusion commencing at 0.2mg/kg/hr was commenced post-operative day (POD) zero. Additional enteral Targin at a dose of 10mg/5mg PO BD for <60kg (15mg/7.5mg for ≥60kg) was commenced on the same afternoon if it were a morning case, and commenced the next morning if it was an afternoon case. Supplemental IV/oral Paracetamol, NSAIDs, Diazepam (PRN), tramadol (PRN) and clonidine (PRN) were also provided. Requirements for discharge were dictated as per Table 1. These patients were assigned an accelerated discharge pathway as per hospital protocol (see table series; 1). The pathway encouraged resumption of a solid diet, independent mobilisation and removal of the indwelling catheter on POD1. Patients were routinely discharged at 72-96 hours post-operatively if discharge goals had been met (See table 1). Requirements for discharge were dictated as per Table 1.

Table series 1: Accelerated Discharge Pathway for Adolescent idiopathic scoliosis patients following posterior spinal fusion

The Accelerated Discharge Pathway is to be used for

- Patients aged 10 years and older
- Who have undergone an uncomplicated Posterior Spinal Fusion for Adolescent Idiopathic Scoliosis
- Who do not have significant co-morbidities

Standard Post Operative Orders (for all Spinal Surgeons)

- Log Roll
- No brace (unless documented)
- Allowed to sit up in bed. The patients hips must be at the level of the angle of the bed to allow bending to occur at the hips only (ie they are not to be slumped/flexed at the trunk)
- Allowed to mobilise when tolerated
- See surgical scoliosis pathway below for details of diet

Discharge Goals:

- Patient should be drinking adequate amounts and tolerating some solid food
- Passing urine without difficulty
- Passing flatus
- Bowel movement is NOT required for discharge
- Adequate pain control on oral analgesic (or pain relieving) medication
- Patient needs to be deemed safe from Physiotherapy and Occupational Therapy

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Melbourne

	Day of Surgery	Day 1 Post Surgery	Day 2 Post Surgery	Day 3 Post Surgery
Pain Management	• PCA standard prescription opioid bolus • Ketamine infusion starting at 2mL/hr (=0.2mg/kg/h) • Targin Oral Dose: 10mg/5mg PO BD for <60kg (15mg/7.5mg for ≥60kg) For morning case to start PM dose on day of surgery Afternoon case to start AM dose day 1 • IV/oral Paracetamol regularly QID • IV intraoperative NSAIDS then commence post op oral NSAIDS • IV/Oral Diazepam PRN if needed • IV/Oral Tramadol 1-2mg/kg 6-8/24 if needed • Oral Clonidine 0.5-1mcg/kg tds PRN or Regular (per anaesthetist) • Anti-emetics as per PONV attachment chart	• Cease PCA after 24/24 • Continue Ketamine • Targin 10mg/5mg PO BD • Oxycodone 3-4/24 PRN once PCA ceased • Oral Paracetamol • Oral NSAIDS TDS • Oral Diazepam as necessary • Tramadol Oral 6-8/24 if needed • Clonidine if needed • Aperients to start (coloxyl with senna and lactulose)	• Cease Ketamine after 36hours • Targin BD dose titrated by CPMS based on Oxycodone requirements • Oxycodone PO 4/24 PRN • Oral Paracetamol • Oral NSAIDS TDS • Oral Diazepam as necessary • Tramadol Oral 6-8/24 if needed • Clonidine if needed • Aperients to continue	STRICT/REGULAR • Targin BD • Paracetamol PO 6/24 today then decrease to TDS on discharge • Ibuprofen PO TDS (5 days postop) • Aperients to continue PRN/AS NEEDED • Oxycodone PO 4/24 PRN • Tramadol PO 6-8/24 PRN Discharge at 72-96 hours post operatively if goals have been met. CPMS will call family to assist weaning analgesia

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	Day of Surgery	Day 1 Post Surgery	Day 2 Post Surgery	Day 3 Post Surgery
Nutrition/ Diet	• Evening: ice chips, sips of clear fluids	• Allowed clear fluids • Allowed small amounts of simple solids if tolerated • Encourage chewing sugarless gum • Aperients to start (coloxyl with senna and lactulose)	• Regular diet as tolerated • Encourage fluids • Encourage chewing sugarless gum • Aperients to continue	• Regular diet as tolerated • Encourage chewing sugarless gum • At time of discharge patient should be drinking adequate amounts and tolerating some solid food • Bowel movement is NOT required for discharge • Continue aperients • Ensure bowel education and home prescription of stool softeners given to patient and family
Nursing, IV's	• Continuous monitoring • Frequent vital signs - hourly • Frequent neurovascular checks • Oxygen if needed • IV fluids • Urinary Catheter • IV antibiotics for 24 hours	• Continuous monitoring • Vital signs every 4 hours • Neurovascular checks every 4 hours • Oxygen if needed • IV fluids • Check haematocrit • Removal of urinary catheter at 24 hrs or in the evening (~2000-2200h)	• Stop continuous monitoring when patient stable and on oral pain medication • Keep IV in place • Check haematocrit if needed • Spinal x-ray in the afternoon • Patient to be walking to bathroom and around ward with family/nurses	• Debulk dressing – post op site insitu

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	Day of Surgery	Day 1 Post Surgery	Day 2 Post Surgery	Day 3 Post Surgery

Activity, Physiotherapy, Occupational Therapy	• Log roll every 2 hours and PRN until patient rolling independently
	• Allowed to sit up in bed (ensure patients hips are at the bend of the bed. No slumped sitting)
		• Log roll every 2 hours and PRN until patient rolling independently
		• Encourage patient to assist with log roll
		• Physiotherapy input x 2 (AM and PM).
		• Physio goals – Stand, Sit in a chair x2 and walk x2
		• Independent feeding, drinking and grooming in bed or chair
		• Occupational Therapy review in PM (if caseload permits) for initial assessment and to encourage independent feeding, drinking and grooming in bed or chair
			• Patient should be able to log roll and reposition self with minimum assist (or independently)
			• Physiotherapy input x 2 (AM and PM)
			• Physio goals
			  ○ Sit out of bed x2 (increasing length of time in sitting)
			  ○ Walk x2 (longer distances)
			• Patient to be walking to bathroom and around ward with family/nurses
			• OT input x 1 (AM or PM)
			  ○ Toilet transfer practice +/- Over Toilet Frame
			  ○ OT to provide education on spinal precautions in context of daily activities.
				• Log roll independently
				• Physiotherapy review for stair clearance and advice for home
				• Goals for discharge from Physio
				  ○ Transfer supervision or Independent
				  ○ Ambulate supervision or Independent 80 meters
				  ○ Ambulate up/down stairs with assist x 1 or supervision
				• Physiotherapist to give Patient Satisfaction Survey to patient/family. If patient/family choose to fill this out it should be returned to the marked letterbox at the Platypus Ward Clerks desk before they go home
				• Sit out of bed
				• Goals for discharge from Occupational Therapy
				  ○ Independent/supervised toileting +/- Over Toilet Frame
				  ○ Indept/Supervision chair +/- other equipment transfer
				  ○ Independent upper body dressing. Carer to assist with lower body dressing (or independent with LH aids)
				  ○ Aware of and adhering to spinal precautions/activity limitations
				  ○ Appropriate home set up/discharge equipment organised

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	Day of Surgery	Day 1 Post Surgery	Day 2 Post Surgery	Day 3 Post Surgery
Discharge Planning	• Educate the patient and family on daily goal sheets and place these laminated copies up in their room	• Start discharge planning • Assess transportation needs • Assess home care needs	• Ensure patient/family ready for discharge home the next day • Ensure patient/family aware of ward discharge time • Ensure transport organised if needed •	• Give discharge information on bowel and pain management • Advice re: dressing • Advice re: orthopaedic review date • Ensure the Orthopaedic Doctor has written the medication discharge script • Page the Pharmacist on #6630 to advise them the medication discharge script is written and awaiting them • Ensure script given to family for home pain-relieving or analgesic medication • If patient/family choose to fill out Patient Satisfaction Survey (provided by Physiotherapist) it should be returned to the marked letterbox at the Platypus Ward Clerks desk before they go home • Discharge home

Post-operative outcome measures were chosen to assess both efficacy and safety of the analgesic methods. To evaluate efficacy, we measured time-to-event parameters including the number of days until the first bowel motion, resumption of a solid diet, and discharge from hospital.

Safety outcomes selected for review included sedation, respiratory depression, bowel motion, post-operative nausea and vomiting (PONV), readmission and deep infection. Elevated sedation scores were recorded based on any elevation noted in nursing charts entries or in accordance with the Children's Early Warning Tool (CEWT). Respiratory depression was marked by either (1) reduced respiratory rate (e.g., to less than 10 breaths/min) or (2) reduced oxygen saturation (e.g., arterial oxygen saturation less than 90%) [13]. Occurrence of post-operative nausea and vomiting was recorded if any nausea or vomiting, beyond POD 0, required pharmacological intervention. Discharge without bowel motion was also recorded. It is important to highlight the protocol governing the administration of PCA analgesia does not mandate a bowel movement occurring before discharge, however at QCH, this was recommended prior to discharge. Readmissions related to the initial PSIF admission were recorded. Instances of deep surgical infections necessitating surgical washout were included for both CEA and PCA cohorts considering the associated risk in the profile of epidural catheters [14].

Assessment of any temporary neurological changes was an important component in assessing the safety profile of CEA. Neurological examinations for these patients were conducted in accordance with the international standards for neurological classification of spinal cord injuries scale as established by the American spinal injury association (ASIA) [15]. A post operative neurological assessment was initially performed in the post-anaesthesia care unit (PACU) once the patient regained consciousness. Subsequent daily assessments were conducted by the treating clinicians, following ASIA examination guidelines, with documentation of motor and sensory scores. Immediate attention was given to any differences from the pre-operative baseline. This protocol has been further elaborated in a paper currently under in press[11]. All patients in this study had complete sensory perception and motor strength on discharge.

Data collected was analysed with IBM SPSS software. To obtain a robust result, a bootstrapped Students T test was utilised to compare demographics and all continuous outcomes; days to first bowel motion, days to return to full diet and days till discharge from hospital. Chi squared analysis was utilised for safety related measures. Further analysis of mobilisation utilised a bootstrapped Students T test and Chi squared analysis to obtain significance data.

Results

The study identified a cohort of 120 patients who received PCA analgesia and 83 patients who received CEA analgesia. Patient demographics, detailed in Table 2, showed comparable results. Comparison of the mean pre-operative major cobb angles neared statistical significance (p=0.06), with the CEA having a mean cobb angle of 70.55 degrees and the PCA cohort having a mean major cobb angle of 66.70 degrees. Statistical significance was observed in the variance of the number of levels fused (P<0.01).

Table 2: Patient demographics for PCA and CEA cohorts (mean (SD))

	PCA (n=120)	CEA (n=83)	P Value comparing PCA and CEA
Age (years)	14.92 (1.71)	14.64 (1.54)	0.28
Females	92	71	0.12
Height (cm)	163.31 (11.47)	159.57 (8.30)	0.11
Weight (kg)	56.48 (12.86)	56.68 (14.08)	0.91
Major Cobb angle (degrees)	66.70 (10.59)	70.55 (17.83)	0.06
Levels fused	10.02 (1.74)	10.7 (1.65)	<0.01

The study further examined time-to-event efficacy parameters, encompassing days to first defecation, days to return to a solid diet and days to hospital discharge, with associated P values presented in Table 5. All measured parameters had statistically significant disparities between the two cohorts (P<0.01). The significance of this outcome should be considered in the context of implementation of an accelerated discharge pathway for PCA patients, compared to CEA patients who did not.

Table 3: Mobilisation on POD1

POD1 mobilisation	PCA (n=120)	CEA (n=83)	P Value comparing PCA and CEA
Number of patients, (% of cohort)	112 (94.17%)	49 (59.04%)	<0.05

Table 4 shows the incidence of safety related complications within each cohort. There was statistically significance differences found between the cohorts in the comparison of sedation scores and rates of discharge without bowel motion (P<0.01). Of the 83 patients that received CEA, 26 patients experienced a temporary neurological change. No patients who received PCA experienced a neurological change given the innate nature of opioid analgesia, resulting in a statistically significant difference found in the result (P<0.01). Mobilisation that occurred on POD1 was recorded for both epidural and patient controlled analgesia patients. As per table 3, 59.04% (49) of CEA patients mobilised on post operative day 1 compared to 94.17% (112) of PCA patients. All patients discharged with independent mobilisation. Further assessment of mobilisation for CEA patients as per Figure 1 revealed a fall in cohort percentage of mobilisation on POD1 when comparing 2020 to subsequent years.

Table 4: Occurrence of patient safety related complications for PCA and CEA cohorts (Chi squared)

Safety outcomes	PCA (n=120)	CEA (n=83)	P Value comparing PCA and CEA
Elevated sedation	90	1	<0.01
Respiratory depression	9	5	0.68
Discharge without bowel motion*	91	7	<0.01
Post operative nausea and vomiting	88	56	0.37
Readmissions	6	6	0.49
Deep surgical infection requiring washout	2	1	0.79
Temporary neurological change	0	26	<0.01

**As per PCA accelerated discharge pathway, bowel motion is not required prior to discharge*

Discussion

There is a paucity of literature comparing CEA and PCA as modalities of pain management following posterior fusion in adolescent scoliosis patients. In attempt to assess the comparability and acceptability of both pain relief methods, an objective evaluation of metrics related to the effectiveness and safety of both modalities was conducted. Patient demographics between cohorts were similar, however statistical significance emerged in the number of vertebral levels fused for the CEA cohort when compared to PCA (P = <0.01). Additionally, comparison of mean major cobb angles yielded a result nearing a significant difference (P=0.06). Though operative hours were not collected for the purposes of this study, these results warrant consideration for larger curves to potentially generate more challenging and lengthy surgical procedures. This could potentially impact a patient's post operative recovery and the levels of pain experienced.

There were statistically significant differences observed in the time required to achieve post-operative efficacy outcomes (first defecation, return to diet, hospital discharge) between the two cohorts as per Table 5. Though the PCA protocol aims for the initiation of a solid diet on POD1 if tolerated, the statistically significant result (P<0.01) reflects the discretisation of time, indicating resumption of oral diet on POD2 for both cohorts. The contextualisation of the observed results (i.e. 1.2 vs 1.68 days) could be considered akin when considering the tolerance of solids in the morning or afternoon of the second post operative day. The prompt resumption of a full diet post-operatively is associated with benefits for wound healing and recovery, and an expedited recovery of gastrointestinal function. Whilst malnutrition is recognised to impede would healing and post-operative rehabilitation, the disparity in results between cohorts did not manifest in any patients presenting with chronic wound related concerns [16,17]. While postoperative nausea and vomiting could potentially limit the resumption of diet, pharmacological intervention was administered for all identified cases of PONV, possibly mitigating its impact on diet tolerance. The effectiveness of an accelerated discharge pathway for PCA patients is clearly demonstrated when examining days to discharge, revealing statistically significant differences between both cohorts. On average, patients who underwent PCA were discharged by day 3, compared to day 5 for CEA patients. Achieving earlier discharge is a shared goal for practitioners and healthcare facilities, particularly in light of escalating demands and pressures on hospitals and bed capacity. However, it is essential to acknowledge this accomplishment within the context of potential risks associated with readmission. Both cohorts had 6 readmissions, with no statistical significance between cohorts, suggesting that an accelerated discharge pathway does not increase the risk of readmissions. Other factors such as patient comorbidities, post-discharge care, and follow-up protocols may also influence readmission rates.

Table 5: Number of post-operative days required to achieve efficacy outcomes between cohorts (T tests), (mean (SD))

Efficacy outcomes (days)	PCA	CEA	P Value comparing PCA and CEA
First defecation	3.52 (1.38)	4.47 (1.31)	<0.01
Return to diet	1.20 (0.46)	1.68 (1.27)	<0.01
Discharge from hospital*	3.45 (1.15)	5.36 (1.69)	<0.01

**The accelerated discharge pathway for PCA recommends discharge on POD3 (refer to appendix 1).*

Similarly, enhanced recovery protocol for PCA patients encourages discharge on POD3, with no obligatory bowel motion required. As such, only 29 patients had a documented first day of defecation. Importantly, none of the 91 patients for PCA or 7 for CEA returned for reasons of constipation. When considering the early time to return to diet, in conjunction with recommended time to mobilisation for this cohort, two factors acknowledged to expedite return to gastrointestinal (GI) function, including bowel function, it can be appreciated why this is not a discharge requirement. For patients who received CEA analgesia, there was preference for bowel motion prior to discharge, resulting in a statistically significant difference between cohorts. In some instances, the decision to discharge prior to a bowel motion was based on a comprehensive evaluation of the patient's overall recovery status. As such, seven patients were discharged without a bowel motion in the CEA cohort. No patients across both cohorts were documented to have returned with concerns of post-operative ileus. Preference for a bowel motion prior to discharge is a consideration in the observed differences to discharge day from hospital. Mean time to discharge was statistically significantly different between the cohorts, with a mean result of 5.36 (1.69) days for CEA patients compared to 3.45 (1.15) days for PCA patients. This result is appreciated to be influenced by not only preferences for bowel motions before discharge , but also the requirement of epidural catheters to remain in-situ until the morning of POD3.

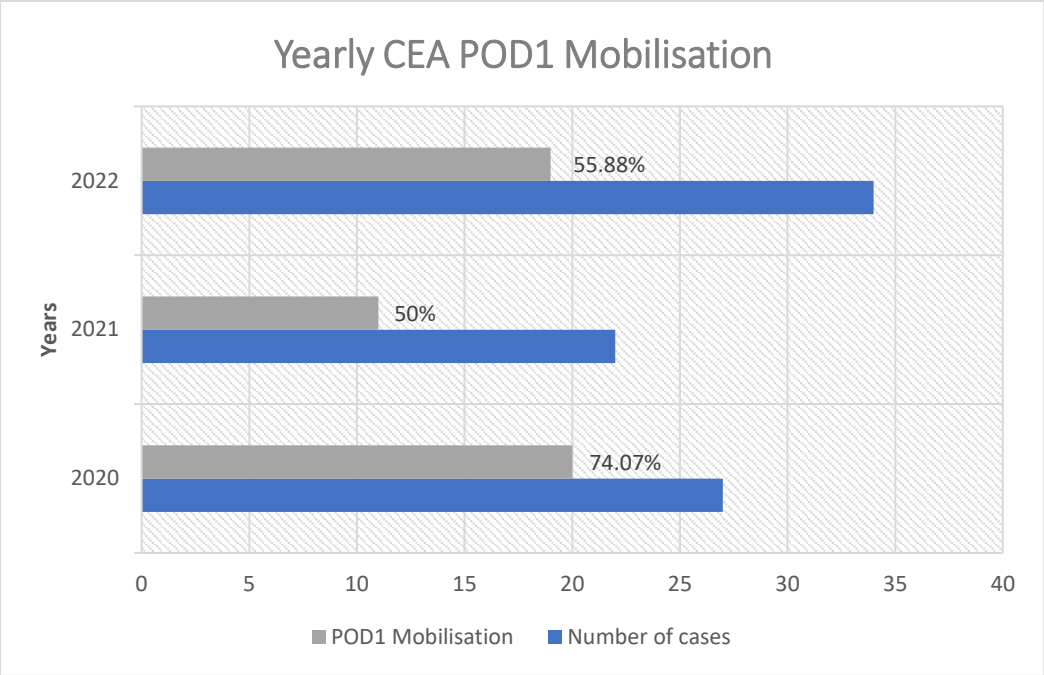
A review of the complication profile experienced between these cohorts, as per table 4, highlights the inherent risk profiles associated with each analgesic modality. In a separate review by the authors of the current study, a comprehensive assessment of the safety profile of epidural analgesia was conducted [11]. Amongst the 83 patients who received an epidural, 26 patients experienced a temporary neurological change. Of this cohort, three patients experienced sensory changes, ten experienced a reduction in motor strength and thirteen patients experienced both motor and sensory changes. All cases of temporary neurological change resolved on the same day of detection, following temporary cessation or reduction in the rate of epidural infusion. Only one patient went on to receive MRI imaging which was normal and neurological changes had improved.

No patient experienced permanent neurological changes and no patient returned to theatre for such changes. [11] Given the innate differences between these analgesia methods, no PCA patients experienced temporary neurological changes, resulting in an expected statistically significant result (P<0.01). In contrast however, the opioid administration in the PCA method is associated with heightened sedation by inhibiting ascending nociceptive circuits, which also modulate arousal [13,18–20]. Accordingly, it was expected that the PCA cohort exhibited a statistically higher incidence of sedation (Table 4, P <0.01). All instances of sedation related events were mild, and did not require medical intervention or escalation in the form a medical emergency team call. These incidents were resolved for all patients during their inpatient stay. Whilst constipation is a recognised GI effect of opioids, the lack of requirement for a bowel motion prior to discharge for the PCA patients complicates the accurate assessment of true constipation in this study. The occurrence of post operative nausea and vomiting was more prevalent in the PCA cohort compared to the CEA cohort, although not statistically significant. This was consistent with established opioid related side effects [18,19].

Statistical comparison of mobilisation between the PCA and CEA cohorts proved to be a challenge due to differing interpretations of mobility and mobilisation at each institution. As such, analysis was limited to any mobilisation that took place on postoperative day 1. Mobilisation is a crucial post-operative goal with established significance in preventing complications such as pressure sores, infections, constipation, pulmonary complications, venous stasis and deep venous thrombosis [21]. It is also a valuable indicator of overall patient recovery and general health, and as such has become integral to many enhanced recovery programs that outline detailed mobilisation goals [22]. Table 3 highlights a statistically significant disparity in mobilisation (P<0.05) between cohorts. A review of yearly mobilisation rates for CEA patients as per Figure 1 identified a fall of at least 18.19% from 2020 onwards. A retrospective audit exploring the adherence to clinical pathways for paediatric patients undergoing spinal fusion surgery at the same centre in 2023 identified reasons for delayed or prevented physiotherapy sessions, including patient distress, pain, unavailability, refusal or unavailability from family, nausea and vomiting, low blood pressure, staff shortages and the use of students and inexperienced staff [23]. These finding highlight the importance and role of enhanced recovery pathways, which may help to manage patient and family expectations and improve adherence to post-operative goals for both staff and patients. Despite the disparity in mobilisation rates on POD1, no patients developed venous stasis resulting in deep venous thrombosis, there were no occurrences of pressure sores and all patients discharged with independent mobilisation. To uphold objectivity, statistical analysis of pain between the cohorts was omitted, given the potential for subjective variability in the reporting and recording of pain. This variability stemmed from the use of different pain scoring systems for data collection across the centres. One patient who received CEA required an operative washout for a surgical site infection, whereas two PCA patients underwent operative washouts for the same. A statistical analysis using Chi-squared yielded this a non-significant

result (P=0.79). Comparison of respiratory depression did not show any statistically significant differences between the cohorts. Thus, despite a lower percentage of mobilisation for CEA patients on POD1, these patients did not experience any additional complications related to delayed mobilisation as acknowledged by the literature [24].

Figure 1: Yearly POD1 Mobilisation for CEA patients



Some limitations warrant acknowledgement in our study. Firstly, as a multi-centre investigation with involvement from numerous surgeons, it is crucial to recognise the potential for inherent variability in patient management despite the same procedure being performed for the same condition. Secondly, differences in department protocols and the retrospective nature of the study posed significant constraints on statistical comparisons, particularly for comparison of bowel motion prior to discharge, mobilisation and pain assessment. Use of a standardised pain scale and implementation of a shared mobility protocol among allied health staff could prove advantageous for future research. These constraints emphasise the need for additional prospective and standardised research to validate and expand upon our findings to contribute to a more comprehensive understanding of the matter.

Conclusion

This study aimed to evaluate differences in efficacy and safety of continuous epidural analgesia compared to patient controlled analgesia following posterior instrumented fusion for adolescent idiopathic scoliosis. Data between cohorts from two separate hospital were compared, revealing that while both approaches are safe, they exhibit inherently varying complication profiles. Epidural analgesia is linked to temporary neurological changes and PCA analgesia has associations with opioid induced sedation and respiratory depression. Notable statistically significant differences were observed, particularly regarding efficacy outcomes, such as return to diet and discharge from hospital. Though this result may be influenced by the implementation of an accelerated discharge pathway, this underscores the importance of such pathways in optimizing patient care and recovery.

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