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RESEARCH ARTICLE

A retrospective review of continuous epidural analgesia following posterior spinal instrumented fusion for adolescent idiopathic scoliosis

Maisha M Jamali[1,2], Gregory E Moloney[3], Maree T Izatt[1,2], Simon C Gatehouse[1,2], Adam F Parr[1,2], Robert D Labrom[1,2], Geoffrey N Askin[1,2], Dimitrios Vagenas[4], J.Paige Little [1]

[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

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ABSTRACT

Background context: Epidural analgesia has been demonstrated to be effective in managing post-operative pain across many surgical procedures including posterior spinal instrumented fusion. Since the inception of our paediatric orthopaedic spinal unit in 2015, continuous epidural analgesia has been provided to all posterior spinal instrumented fusion patients. This study presents data validating the safety and utility of continuous epidural analgesia.

Purpose: The study was set out to assess the safety and utility of continuous epidural analgesia used for post-operative pain control after all posterior spinal instrumented fusion for adolescent idiopathic scoliosis. Quantitative metrics known to relate to analgesic safety and post-operative recovery were selected for review.

Study Design: A retrospective clinical study of 83 patients was conducted via electronic medical chart review of records from 06/01/2020 to 19/12/2022 from this centre.

Methods: Data regarding the perioperative recovery and side effects of this group (i.e. days to mobilisation, first bowel motion, return to full diet and length of hospital stay) were compared to those who had no change to their neurological examination. Statistical analysis was performed using student's T-test and logistic regression modelling, using SPSS[1].

Results: Fifty-seven patients (68%) experienced no change of their neurological examination, whilst 26 patients (32%) did, while undergoing epidural analgesia. Time to achieve post-operative outcomes was similar between groups. Occurrence of a temporary neurological change did not relate to higher rates of secondary complications.

Conclusion: The association of temporary neurological changes with the use of continuous epidural analgesia for control of post-operative pain following posterior spinal instrumented fusion does not impede the attainment of post-operative milestones, nor do they elevate the risk of secondary complications.

Keywords: Posterior spinal instrumented fusion (PSIF), Adolescent idiopathic scoliosis (AIS), Continuous Epidural Analgesia (CEA), Post operative analgesia

Introduction

Surgical correction of scoliosis, most commonly performed through posterior spinal instrumented fusion (PSIF), requires extensive dissection of skin, soft tissue, bone, and ligaments to permit the introduction of instrumentation that applies corrective and distracting forces. While these techniques have dramatically improved deformity correction and long-term outcomes for patients with adolescent idiopathic scoliosis (AIS), they are also associated with significant perioperative morbidity, most notably severe post-operative pain. Post-operative pain remains a heightened concern for both the patient and the treating team, as poorly controlled pain is associated with increased risk of complications, prolonged hospitalisation, delayed mobilisation, patient dissatisfaction, and the potential for chronic pain syndromes[2–5]

Optimal pain management in adolescent idiopathic scoliosis surgery is therefore a cornerstone of perioperative care. Intravenous patient-controlled analgesia (PCA) with opioids has traditionally been the most widely studied and accepted method for post-operative pain management in PSIF.[6,7] However, PCA is limited by well-recognised adverse effects including nausea, vomiting, pruritus, respiratory depression, sedation, confusion, urinary retention, and, in some cases, inadequate analgesia[6,8]. These complications can significantly hinder early mobilisation and rehabilitation, which are critical for enhanced recovery pathways.

Continuous epidural analgesia (CEA) represents an alternative strategy. Placement of an epidural catheter at the time of wound closure allows for continuous infusion of local anaesthetics, often combined with opioids, to provide segmental analgesia [9]. While epidurals may offer improved pain control and reduced systemic opioid consumption, concerns remain regarding safety—including neurological changes, over-sedation, respiratory depression, epidural haematoma or abscess, transient neurological deficits, and dural puncture headaches. The potential for epidural-related neurological masking is of particular concern in spinal deformity surgery, where reliable post-operative neurological assessment is essential.[7] Consequently, epidural analgesia has been cautiously adopted, with practice patterns varying considerably between centres.

Since its inauguration in 2015, this paediatric orthopaedic spinal unit has provided continuous epidural analgesia as a standard of post-operative care following posterior fusion for adolescent idiopathic scoliosis. To the best of the authors' knowledge, this remains the only Australian paediatric centre in which CEA is routinely used in this context. A review of the literature identified only eleven studies internationally that have specifically evaluated epidural use in this patient population, with most focusing primarily on analgesic efficacy rather than broader clinical outcomes[8,10–19]. This highlights a gap in the evidence regarding the overall safety and utility of CEA beyond pain control.

The aim of this study was therefore to evaluate the role of continuous epidural analgesia following PSIF for AIS within a high-volume paediatric centre. Specifically, this study sought to determine whether epidural analgesia is safe and effective when assessed against objective post-operative recovery milestones, thereby providing a more comprehensive assessment of its clinical utility.

Methods

A National Health and Medical Research Council (NHMRC) approved retrospective chart review was performed for this centre from 06/01/2020 to 19/12/2022. All patients who underwent PSIF to correct an AIS deformity were reviewed. This timeframe was selected to capture a consecutive and contemporary cohort of patients, reflecting current surgical and peri-operative practices at our institution. As this was a retrospective review of all consecutive eligible cases within the defined timeframe, a prior sample size calculation was not performed. This design ensured that all available patients were captured, maximising external validity and minimising selection bias. Given the rarity of

temporary neurological changes, a post hoc consideration of statistical power was undertaken for this primary outcome to assess the adequacy of the cohort size (reported in the results).

All patients undergoing posterior spinal fusion for adolescent idiopathic scoliosis (AIS) during the study period were reviewed. Inclusion and exclusion criteria were applied to balance a broad, representative cohort with the need to minimise confounding. Patients with AIS who underwent posterior spinal fusion and received continuous epidural analgesia were included.

Exclusions were applied to ensure outcome measures reflected the safety and efficacy of epidural analgesia in a relatively homogeneous population. Specifically, patients with neuromuscular, congenital, or post-traumatic scoliosis were excluded, as these conditions are associated with different baseline neurological risks and functional outcomes. Patients with prior spinal surgery were excluded due to altered anatomy and potentially atypical recovery trajectories. Similarly, cases managed with alternative post-operative analgesia protocols were excluded to avoid confounding comparisons. Inclusion and exclusion criteria are listed as per Table 1.

Table I: Inclusion and Exclusion criteria

Inclusion Criteria	Exclusion criteria
• Adolescent idiopathic scoliosis • Continuous epidural analgesia • Posterior spinal fusion	• Alternative causes of scoliosis (Neuromuscular, congenital, post traumatic) • Previous spinal surgery • Alternative post-operative analgesia

Electronic medical records were reviewed with aim to determine patients who experienced a temporary neurological change, patient demographics (age, gender, weight, height and major cobb angle) and outcome measures related to safety and efficacy. Quantitative metrics known to relate to safety and efficacy of epidural analgesia were selected. The cohort was subdivided into patients who experienced temporary neurological changes and those who did not. Improvement following cessation or down-titration of epidural dosing was recorded to distinguish between epidural related deficits or a true cord pathology. Efficacy parameters included days to mobilisation, opening of bowels, return to full diet and length of stay. The safety profile was assessed as per occurrence of elevated sedation, respiratory depression, constipation (observed as discharge from hospital without bowel motion) and post-operative nausea and vomiting requiring pharmacological intervention.

Efficacy parameters included days to mobilisation, opening of bowels, return to full diet, and length of stay. The safety profile was assessed by occurrence of sedation, respiratory depression, constipation (defined as discharge prior to bowel motion), and post-operative nausea and vomiting requiring pharmacological treatment.

Posterior Spinal Fusion

Posterior spinal instrumented fusion entailed an extensive midline dissection of soft tissue, adipose planes, ligaments and bone for adequate exposure of levels selected for fusion. Pedicle screws were subsequently inserted bilaterally onto the vertebrae selected for fusion, with two rods per side serving to connect them.

Continuous epidural analgesia protocol

Prior to surgical closure of the wound, one or two epidural catheters were inserted by the surgeon under direct visualisation or by using the standard loss of resistance to air technique using a Touhy needle through ligamentum flavum.[20] Epidurals were inserted 5cm into the epidural space, at a chosen thoracic and/or lumbar level, to ensure adequate coverage and spread of local anaesthetic. The catheters were tunnelled to exit the skin lateral to the incision made for the posterior fusion. Occasionally, preferred vertebral levels could not be used due to an anatomical or mechanical block (e.g. small intralaminal distance or metal crosslink). As such, alternative vertebral levels would be selected for catheter placement. 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. The epidural infusion rate was 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. It should be noted, no preoperative analgesics or pain adjuvants were given to patients. Rescue oral opioids and additional simple analgesics (acetaminophen and non-steroidal anti-inflammatories) were offered if analgesia was still assessed as inadequate. Oral analgesics were frequently timed pre-physiotherapy. On the third post-operative morning, epidurals were ceased at 0600 with a subsequent enteral opioid plan. If analgesic failure did not occur, catheters were removed.

Neurological examination was conducted upon patient awakening and return of voluntary control to ensure a return to baseline function. Following this initial assessment, daily examinations were performed each morning. In the case of a neurological change in the post-operative examination, the standard protocol utilised involved the immediate cessation or down titration of the epidural agent, followed by close examination and observation by a surgical team member. Once a reasonable examination had returned, the epidural was resumed at a reduced rate following discussion with the acute pain service team. If examination findings suggested a cause not related to the epidural, or reasonable improvement was not observed as expected, immediate discussion with a spinal surgeon for consideration of prompt imaging and intervention was required.

Statistical analysis

As this was a retrospective review of all consecutive eligible cases within the defined timeframe, no a priori sample size calculation was performed. Instead, the study represents a complete capture of available cases, maximising statistical power within the institutional dataset.

In order to obtain robust results, a bootstrapped Students t test, with 2-tail significance was utilised for all continuous outcomes such as; the assessment of mobilisation (independent and dependent), Cobb angles, time to discharge, time to return to a solid diet and days until bowels opened. Chi squared analysis was used for contingency tables assessing sedation scores, respiratory depression, assessment of bowels opening, post-operative nausea and vomiting and the occurrence of neurological deficits. A binary logistic regression model was used to assess if there was a relationship between patient demographics (age, height and weight), local anaesthetic agent and occurrence of a neurological event.

Results

This study identified 83 patients who underwent PSIF for AIS from 2020 until 2022. Patients were divided into two cohorts; group 1 who experienced a temporary post-operative neurological change secondary to the epidural and group 2 who did not.

There was no statistically significant difference regarding patient demographics (age, height, weight, gender, cobb angle or levels fused) between groups. Table 2 displays the relevant patient demographics, displaying results as a mean and standard deviation (SD). Table 3 displays mean pain scores and relevant patient demographics. Due to circumstances beyond control, pain scores were not consistently collected for all patients. Therefore, the pain scores collected on a continuous scale were recorded on a categorical scale (i.e. No pain = 1, Mild =2, Moderate = 3, Severe =4). Figure 1 illustrates the distribution of pain scores. In comparing group 1 and group 2, there was no significant difference, implying pain management was comparable between these cohorts. Mean pain scores within groups 1 and 2 indicated mild-moderate pain, which echoed the mean pain score of the overall cohort. Practice at this institution accepted mild-moderate pain to not require further intervention.

Table 4 displays time (days) to achieve post-operative objectives. Both groups achieved similar efficacy parameters at similar times. Data for one patient in the return to diet cohort was unable to be retrieved as they were admitted to the paediatric intensive care unit (PICU). This admission to paediatric intensive care unit was organised pre-operatively based on the severity of the patients curve (Cobb angle of 140 degrees) and the planned intraoperative removal of a halo vest that had been applied pre-operatively. There were no post-operative concerns, particularly relating to epidural catheters, warranting admission to PICU. The patient was stepped down from paediatric intensive care unit on day 1 without complication. Similar results between group 1 and 2 were obtained for days to discharge. Two patients in group 2 had a longer time to discharge (11 and 14 days) confounded by a return to theatre for revision of screw placement and a wound washout. Screw revision occurred on post-operative day (POD) 7 following routine post-operative x-ray which identified an inferior pedicle screw to be abutting the adjacent disc space. The patient was asymptomatic and no further sequelae occurred secondary to this. The wound washout occurred on post-operative day 7 following persistent haemoserous ooze over the distal aspect of the posterior instrumented fusion surgical site. Intraoperative findings identified this to be superficial collection without metalwork involvement. The patient received a two week combination of intravenous and oral antibiotic for staphylococcus aureus (scant) identified from an intraoperative specimen. No further washout was required.

Table 5 shows the number of patients who experienced safety related complications. Sedation score was recorded as per any documentation of an elevated score in nursing charts or as per the Children's early warning tool (CEWT). Respiratory depression was indicated by (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%).[21] Post-operative nausea and vomiting (PONV) was identified as any nausea or vomiting, beyond POD 0, requiring medical intervention. Group 2 experienced safety related complications within all categories, however an intra-cohort analysis with Chi squared resulted in no statistical difference. A logistic regression analysis was performed to assess the relationship between a neurological change (dependent variable) and several explanatory variables including age, height, weight, and type of epidural agent used. As per corresponding P-values and regression coefficient in Table 6, no significant relationship or discernible trend was found.

Complications

As part of the complication profile, rates of epidural related infection and instances of epidural failure/ discontinuation were assessed. Four patients were identified to have had surgical site infections. One required a washout whilst an inpatient as previously discussed. Three patients represented to the emergency department with concerns of minor wound discharge, however these cases were managed with a limited course of oral antibiotics and did not require operative intervention. These infections were not identified to be epidural related as the

lateral exit point of catheters remained clean and infections occurred post hospital discharge with ooze localised to the PSIF surgical site. One patient from group 1 experienced technical issues with their epidural on POD 2, resulting in leakage from the catheter requiring a new connector and filter. A new infusion was recommenced without further leak.

Twenty six patients experienced a temporary neurological change. Of this, three patients experienced solely sensory changes, ten patients experienced solely motor changes and thirteen patients encountered a combination of motor and sensory changes. Table 7 quantifies the occurrence of sensory, motor or both sensory and motor neurological changes, and further denotes the anatomical location of the changes. Figure 2 illustrates these findings. All cases of temporary neurological change resolved with temporary cessation of the epidural. No patient experienced permanent neurological changes. No patient returned to theatre because of perioperative neurological changes.

Discussion

This study was aimed at reviewing the safety and utility of continuous epidural analgesia as practised at the Queensland Children's hospital following posterior spinal instrumented fusion for adolescent idiopathic scoliosis patients. The primary objective was to analyse the incidence of temporary neurological changes whilst patients received continuous epidural analgesia. Specific interest lay in extrapolating whether patients who encountered a change exhibited (a) attainment of post operative milestones within a similar timeframe and (b) an increased likelihood of developing subsequent secondary complications. Notably, to the best of the authors knowledge, the existing body of literature comprises 11 studies which largely investigated the analgesic effect of epidurals within the adolescent idiopathic scoliosis population undergoing posterior spinal instrumented fusion. Whilst previous research investigates pain management, this retrospective approach abstained from exploring pain-related facets due to the inherent heterogeneity involved with subjective pain assessments and subsequent risk of misinterpreting data. By comparison, this study centres on perioperative recovery milestones and the occurrence of analgesic complications, particularly neurological changes which are of high concern to surgical teams.

Neurological changes

Of the 83 patients who received epidural analgesia, 26 (31%) experienced a temporary neurological change (encompassing motor, sensory or both types of changes). Notable studies by Blumenthal et al., 2005[22] and O'Hara et al., 2004[23] reported similar rates of temporary neurological change in their cohorts. Blumenthal et al., 2005[22] reported 27% of a 15 patient cohort receiving epidural analgesia experienced a motor blockade of the lower limbs >1 on the modified Bromage scale post initial bolus. O'Hara et al., 2004[23] observed 41% of post-operative patients with active epidural infusions to experience lower extremity paraesthesia. Both studies reported full resolution of symptoms. It is noteworthy that comparative studies may have presented differing findings depending on the exclusive documentation of sensory or motor alterations. Our findings reinforce that temporary deficits in the context of epidural infusion are typically reversible with simple titration or cessation of the infusion, suggesting a pharmacological rather than structural cause. Clinically, this emphasises the importance of established monitoring protocols and clear interdisciplinary communication between surgical and acute pain teams.

Efficacy outcomes

There was no statistically significant discrepancy in the achievement of post-operative milestones between groups as demonstrated by table 4. Across all measured outcomes—mobilisation, return of diet, bowel function, and length of stay—patients with neurological changes progressed comparably to those without.

MOBILISATION

Independent mobilisation prior to POD3 is limited secondary to the epidural catheters. Time to independent mobilisation identified in this study is aligned with findings by Van Boerum et al., 2000[24] and O'Hara et al., 2004[23] who investigated time to independent ambulation in similar cohorts. Van Boerum et al., 2000[24] reported a mean time to independent mobilisation as 3.7 days, whilst O'Hara et al., 2004[23] reported a median of 4 days. This similarity in independent mobilisation times indicate comparable post-operative progress.

GASTROINTESTINAL FUNCTION

Return of bowel function (identified as days to first defecation) yielded a non-significant result between groups 1 and 2 (4.44 +/- 1.15 days, 4.49 +/- 1.4 days respectively. P=0.88). A comparative study by Milbrandt et al [25] also reported a non-significant difference, reporting averages of 3.4 and 3.73 days for epidural and PCA cohorts respectively. Mobilisation is known to influence return of bowel function, and is considered in many enhanced recover after surgery protocols (ERAS). As such, it should be considered as an influencing factor on the time to first defecation.[26,27] Specifically, the presence of epidural catheters which limit independent mobilisation until post operative day 3 suggests that the first bowel movement may only occur following removal of these catheters. Early diet advancements are also known to improve outcomes relating to return of bowel function and considered in many ERAS pathways.[27] For purposes of this study, diet was defined as a return to eating any solid food, acknowledging this may not have been an accurate representation of individualised baseline solid diet. Results between groups 1 and 2 was non-significant (1.37 +/- 1.04, 1.84 +/- 1.34 days respectively, (P=0.09). A comparable result was yielded by Milbrandt et al., 2009 (16) who identified a significantly faster return to diet in their epidural cohort (2.0 days) versus PCA (3.22 days) ($P < 0.05$). This may be attributed to study protocol, which allowed diet resumption upon resumption of bowel sounds. In comparison, this study allowed resumption of oral diet as tolerated by the patient at any timepoint. Findings of our study are further supported by Van Boerum et al., 2000[24] who noted an earlier return to full diet in the epidural cohort in comparison to patient controlled analgesia (3.1 days, 3.5 days respectively ((P < 0.03)). Variation in the definition of "return to full diet" should be considered.

TIME TO HOSPITAL DISCHARGE

Discharge from hospital is largely influenced by the achievement of other post operative milestones. The average time to hospital discharge was 5.15 +/- 1.41 days for patients with neurological changes and 5.46 +/- 1.81 days for those without. Importantly, there was no statistical significance between group 1 or 2 (P=0.39). With the introduction of standardised post-operative protocols dictating discharge times, length of hospital stay is not frequently discussed in literature. A comparable result was however identified by Klatt et al., 2013[28] who examined double epidural, single epidural and PCA analgesia and found length of hospital stays between 5.3, 5.1 and 5.5 days respectively. Another study by Cassady et al., 2000[16] reported an average stay of 4.7 days for their epidural cohort. Notably, a study by O'Hara et al., 2004[23] reported the longest length of hospital stay, with an average of 7 days for all cohorts (high dose, low dose epidurals and PCA). Although reasons for prolonged stay were not specified in this study, variable discharge criteria could be a contributing factor.

As such, our study shows that patients who experienced a temporary neurological change experienced no significant delays in achieving post-operative milestones. Our results align with previous studies on time to independent mobilization and length of hospital stay. Differences in post-operative protocols amongst comparative studies should be considered when comparing results.

Safety related complications

Similar rates of safety related complications were observed between group 1 and 2 as demonstrated in Table 4, however rates of constipation between

cohorts reached statistical significance (P=0.05). The role of opioids in causing constipation is well established, attributed to their influence on intestinal transit and enteric neurons.[29] Despite analgesic related constipation having been extensively studied, limited literature was found to discuss its occurrence within the epidural, local anaesthetic regimen. Notably, a study by Klatt et al., 2013 (19) was the only paper, to our knowledge, which discussed rates of constipation. The authors reported constipation rates of 83%, 86% and 95% for double, single epidurals and PCA patients respectively. Additionally, Van Boerum et al., 2000[24] noted 3 cases of post-operative ileus amongst patients who received a PCA, but none in the epidural group. The discrepancy in constipation rates from this study may be attributed to patients experiencing more pain, thus requiring additional opioids. Though pain scores on POD1 from this study indicate no statistically significant difference, pain scores and additional opioid requirement throughout the length of hospital stay were not captured, and as such this hypothesis cannot be validated. No statistical significance was otherwise found between group 1 or 2 when assessing sedation, respiratory depression or PONV. Notably, no patient with respiratory depression required supplemental oxygen beyond temporary nasal prongs. Taken together, the overall safety profile supports prior reports that epidural-based regimens can reduce systemic opioid exposure and its associated complications, while maintaining comparable or improved efficacy.

Some limitations necessitate acknowledgement in our study. Firstly, as a retrospective investigation involving multiple surgeons, the potential for variability in post-operative outcomes and patient management protocols must be considered. Secondly, reporting of efficacy and safety related complications relied on accurate documentation, which may have been inconsistently recorded or underreported. Thirdly, the limited size of the cohort sample restricts the ability to generalise the findings and apply them to other comparable cohorts. Finally, the authors acknowledge the underreporting on subjective parameters such as pain and appreciate further data on this parameter may supplement a more wholistic conclusion regarding the benefits of epidural analgesia.

Strengths of this study include the relatively large consecutive cohort, the comprehensive assessment of recovery milestones beyond pain scores, and the standardised institutional approach to epidural management. Limitations include its retrospective nature, reliance on clinical documentation, and the absence of a contemporaneous IV-PCA control arm, which constrains direct efficacy comparisons. While our study captures the only Australian centre routinely using epidurals for this indication, the findings may not be generalisable to institutions with different surgical or anaesthetic practices.

Future research should include multicentre, prospective trials comparing CEA directly with PCA, ideally incorporating standardised pain scoring and enhanced recovery metrics. Investigations into predictors of neurological change—such as catheter placement level, infusion rate, or patient anatomy—would also be valuable. Furthermore, qualitative studies exploring patient and caregiver perspectives on recovery may help clarify whether the observed clinical equivalence translates into differences in satisfaction or quality of life.

Conclusion

To conclude, our study underscores the occurrence of temporary neurological changes linked to epidural analgesia, stressing the importance of vigilant patient monitoring. Nevertheless, it is reassuring to ascertain that these neurological changes do not predispose patients to delays in achieving post-operative milestones, nor do they heighten the risk of encountering secondary complications. Furthermore, the management of pain was comparable between groups and further intervention was not required.

The authors duly recognise the significance of incorporating a control arm into the study design, specifically involving an AIS cohort that undergoes

intravenous patient controlled analgesia after posterior spinal instrumented fusion. This strategic inclusion would significantly amplify the insights drawn from gathered data.

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