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REPORTS OF ORIGINAL INVESTIGATIONS

Major complications related to epidural analgesia in children: a 15-year audit of 3,152 epidurals

Complications majeures liées à l'analgésie péridurale chez les enfants: une analyse sur 15 ans de 3152 péridurales

Gail K. Wong, MBBS · Abeer A. Arab, MBBS · Sue C. Chew, MBBS · Basem Naser, MBBS · Mark W. Crawford, MBBS

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Abstract

Background *Complications associated with epidural analgesia in children have a reported incidence of 40-90 in 10,000 epidurals. We sought to determine the incidence of major complications with the use of continuous epidural analgesia that occurred in our centre over the past 15 years and to describe the nature of these complications.*

Methods *The Acute Pain Service database at a tertiary care academic pediatric hospital was reviewed retrospectively over a 15-year period. Data were categorized according to patient age (neonate, infant, child one through eight years, and child > eight years), mode of insertion of the epidural (caudal, transsacral, lumbar, thoracic), complication type, and complication severity.*

Results *Over the 15-year period, 3,152 epidurals were performed. The use of caudal-thoracic epidurals in neonates and infants has increased since 2007. Twenty-four major complications were identified (incidence, 7.6 in 1,000 epidurals). The rate of complications in neonates was 4.2% compared with 1.4% in infants, 0.5% in children aged one through eight years, and 0.8% in children over eight years of age. The two most common complications were local skin infection and drug error.*

Conclusions *Our incidence of major complications and our finding that complications were more common in neonates and infants are both consistent with previously published data. The two most common types of complications are potentially preventable.*

Résumé

Contexte *On rapporte une incidence de 40-90 cas de complications associées à l'analgésie péridurale sur 10 000 péridurales réalisées chez les enfants. Nous avons tenté de déterminer l'incidence de complications majeures apparues lors du recours à une analgésie péridurale continue survenues dans notre centre au cours des 15 dernières années et de décrire la nature de ces complications.*

Méthode *La base de données du Service de douleur aiguë dans un hôpital pédiatrique universitaire de soins tertiaires a été rétrospectivement passée en revue sur une période de 15 ans. Les données ont été catégorisées selon l'âge des patients (nouveau-né, nourrisson, enfant de un à huit ans, et enfant > huit ans), le mode d'insertion de la péridurale (caudal, trans-sacré, lombaire, thoracique), le type de complication et la gravité de la complication.*

Résultats *Au cours de la période de 15 ans à l'étude, 3152 péridurales ont été réalisées. L'utilisation de péridurales caudales et thoraciques chez les nouveau-nés et les nourrissons a augmenté depuis 2007. Vingt-quatre complications majeures ont été identifiées (incidence, 7,6 sur 1000 péridurales). Le taux de complications chez les nouveau-nés était de 4,2 % par rapport à 1,4 % chez les nourrissons, 0,5 % chez les enfants de un à huit ans, et de*

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G. K. Wong, MBBS (✉) · A. A. Arab, MBBS · S. C. Chew, MBBS · B. Naser, MBBS · M. W. Crawford, MBBS
Department of Anesthesia and Pain Medicine, The Hospital for Sick Children, University of Toronto, 555 University Avenue, Toronto, ON M5G 1X8, Canada
e-mail: gail.wong@sickkids.ca

0,8 % chez les enfants de plus de huit ans. Les deux complications les plus fréquentes étaient une infection locale de la peau et l'erreur médicamenteuse.

Conclusion *L'incidence de complications majeures que nous avons observée et le fait que les complications étaient plus fréquentes chez les nouveau-nés et les nourrissons correspondent aux données publiées précédemment. Les deux types de complications les plus fréquents sont potentiellement évitables.*

Epidural analgesia is a commonly used and effective method of postoperative analgesia in children.[1-4] While it is generally considered safe, major complications may arise from its use.[5] Large-scale studies conducted in adults have reported an incidence of transient or permanent neurological injury of 1-8 in 10,000 epidurals.[6-13] There is a paucity of studies examining major complications related to epidural analgesia in children. Many pediatric studies contain patient numbers of 200 or less.[14-16] In the larger pediatric studies that do exist, the reported incidence of complications in children is almost ten-fold greater than in adults, ranging from 40-90 in 10,000 epidurals.[17-20]

Two prospective studies[18,19] that report the incidence of complications with epidural analgesia in children were reliant on self-reported or questionnaire-based data. While the accuracy of data in these studies may be limited by underreporting of complications and selection or recall bias, both studies were multicentre studies with patient numbers in excess of 10,000 and provide the best quality of evidence thus far. These data are from the United Kingdom and European centres, however, and may not reflect North American practice. Contemporary prospective data from the United States are available from the Pediatric Regional Anesthesia Network who report an incidence of 71 complications in 10,000 continuous epidural infusions.[20]

The purpose of this retrospective review is to determine the incidence of major complications occurring in our Canadian tertiary referral pediatric centre over a 15-year period and to describe demographic data in relation to usage of epidural analgesia during this period.

Methods

Following approval from the institutional Research Ethics Board, the Acute Pain Service (APS) database was reviewed retrospectively to examine data from every patient for whom continuous epidural analgesia was used for pain management within the 15 years from January 1, 1997 to December 31, 2011.

Since January 1997, the APS at our hospital has maintained a computerized information database of all patients referred to the service. This database captures all epidural analgesia infusions used in the perioperative period. All patients aged newborn to 18 yr and referred to the APS for postoperative management of continuous epidural infusion were included in this study. The APS database records patient demographic information, type of surgery, details regarding epidural catheter insertion, and incidents that occurred during the provision of epidural analgesia. The database is updated twice daily following APS rounds. Patients who experienced major complications were followed up by the APS until there was resolution of signs and/or symptoms related to the complication or until the determination of a permanent deficit. The database does not capture the use of single-shot epidural or single-shot caudal techniques.

We defined a major complication as that which resulted in or had the potential to result in significant morbidity or mortality.[19] We did not include common transient complications, such as pruritus, nausea, vomiting, excessive motor block (with the exception of total spinal anesthesia), or inadequate sensory block.

The APS database was interrogated to identify major complications which we subsequently categorized into the following groups: infection, drug error, systematic error, misplaced catheters (including unrecognized intravascular or intrathecal catheters), postdural puncture headache, pressure sores/compartment syndrome, neurological injury, and local anesthetic toxicity. When a major complication was identified from the database, the patient record was examined in detail by three authors independently to determine the circumstances under which the complication occurred. Incidents that occurred in the presence of epidural analgesia but were not directly related to the use of epidural analgesia were included for consideration and discussion.

After major complications were identified and categorized according to type, a grading of severity was assigned.[19] Grade 3 complications were defined as those that were immediately life-threatening or that resulted in permanent deficit; grade 2 complications were those that resolved with intervention, and grade 1 complications were those that resolved without intervention.

Patients were considered in four age categories: neonates (less than 31 days old), infants (from 31 days to one year of age), children from one year through eight years of age, and children older than eight years of age.

Statistical analysis

Data retrieved from our computerized database (FileMaker version 9, Santa Clara, CA, USA) are presented

descriptively. Incidences of complications in different age groups and epidural site subcategories are presented with 95% confidence intervals (CI). A two-tailed Fisher's exact test was used to compare the overall incidence of complications in neonates and infants (< one year of age) with that in patients older than one year. Odds ratio (OR) was calculated and presented with 95% CI. The incidence of infectious complications associated with caudal epidurals was also compared with that for other epidural insertion sites using a two-tailed Fisher's exact test. $P < 0.05$ was considered statistically significant. Data analysis was performed using Stata version 10.0 (StataCorp, College Station, TX, USA).

Results

Demographic and denominator data

Over the 15-year period, 3,152 epidurals were performed. The number of epidural catheters inserted by age group and year is shown in Fig. 1. Following a decrease in epidural use from 2000 to 2005, there was a general trend for increased epidural usage from 2006 to 2011 in all age groups, but particularly in neonates (Fig. 2) and infants (Fig. 3) where there was a marked increase in caudal-thoracic epidurals in the latter years. In comparison, there has been an increase in lumbar and thoracic epidurals in older children (Figs. 4 and 5).

Table 1 shows the sites of epidural insertion by age group. Neonatal and infant epidurals accounted for 1% and 11% of all epidurals inserted, respectively. In neonates, 81% of epidurals were inserted via the caudal route. This percentage decreased in older patients—64% in infants, 30% in children aged one through eight years, and 3% in children older than eight years. Lumbar epidurals were most commonly used in older patients.

Complications

Twenty-four major complications occurred in the 15-year period (incidence, 7.6 in 1,000 epidurals) (Tables 1 and 2). The rate of complications in neonates was 4.2% compared with 1.4% in infants, 0.5% in children aged one through eight years, and 0.8% in children older than eight years (Table 1). Complications were more common in neonates and infants than in older children (OR 2.9; 95% CI 1.2 to 7.0; $P = 0.03$, Fisher's exact test).

Twelve complications were deemed grade 1 severity, and nine were deemed grade 2 severity. All three grade 3 complications (one fatal cardiac arrest, one permanent nerve injury, and one compartment syndrome) were associated with epidural analgesia but were not shown to be directly attributable to it. The cardiac arrest occurred in a six-year-old child with significant comorbidities. This case was reported previously, and the arrest may have been associated with intravascular migration of the epidural catheter, although measured bupivacaine concentrations were below the toxic range at the time of the arrest.[21]

Nerve injury occurred in a 15-yr-old patient who underwent excision of a femoral tumour. After induction of general anesthesia, an L3-4 epidural catheter was inserted uneventfully in a single attempt. Postoperatively, there was reduced sensation and power in both lower limbs with good analgesia. On the third postoperative day, the patient had persistent left-sided motor and sensory loss in his left foot

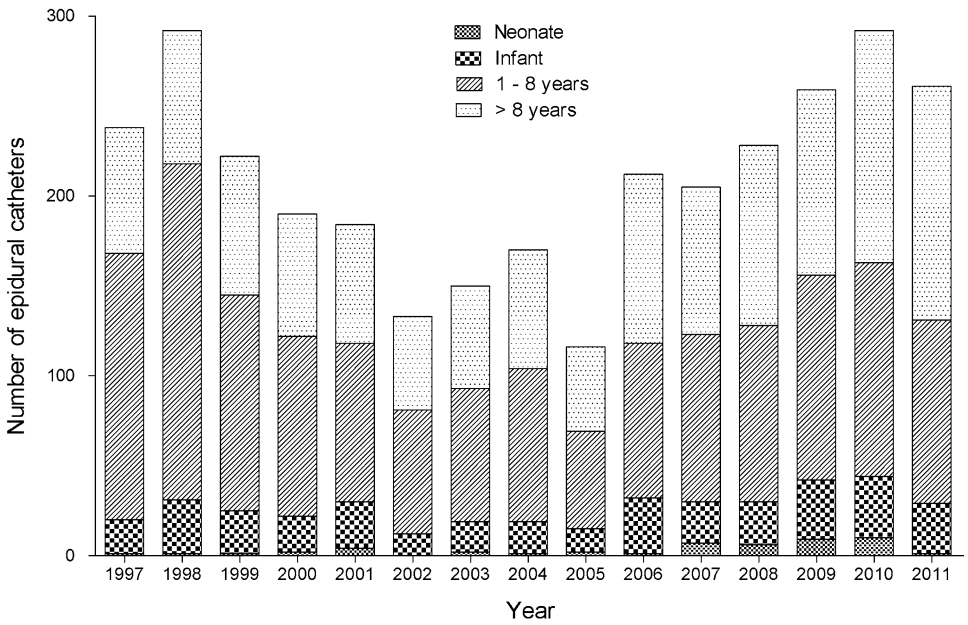

Fig. 1 Epidural use per year by age group

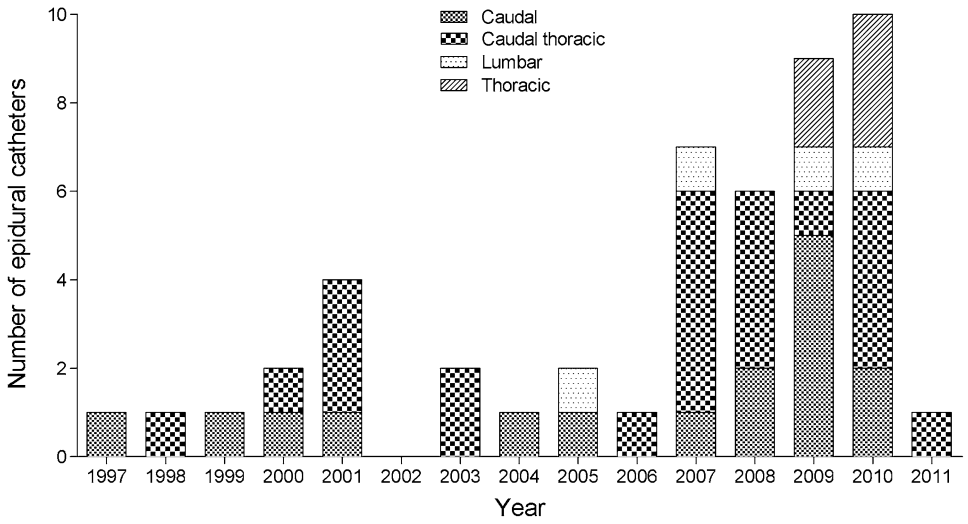

Fig. 2 Neonatal epidurals per year by insertion point

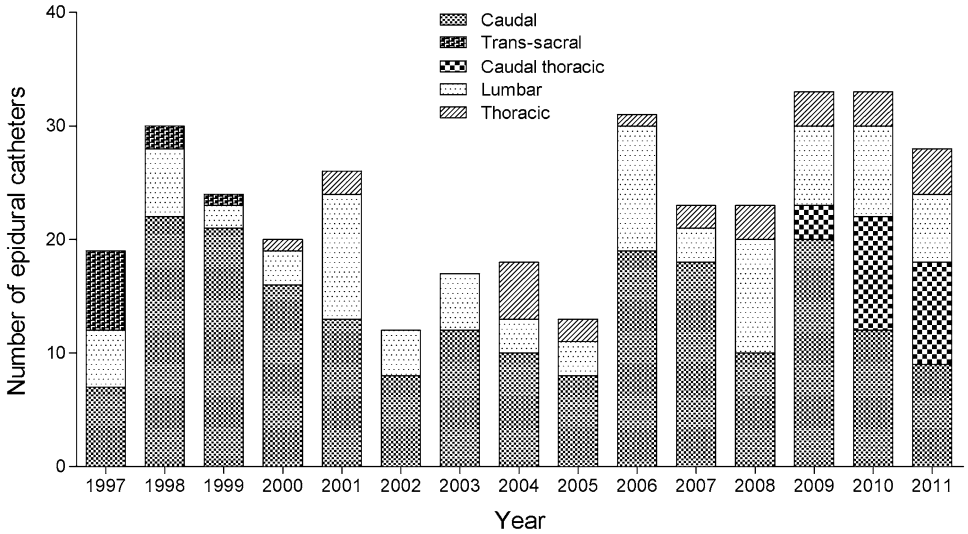

Fig. 3 Infant epidurals per year by insertion point

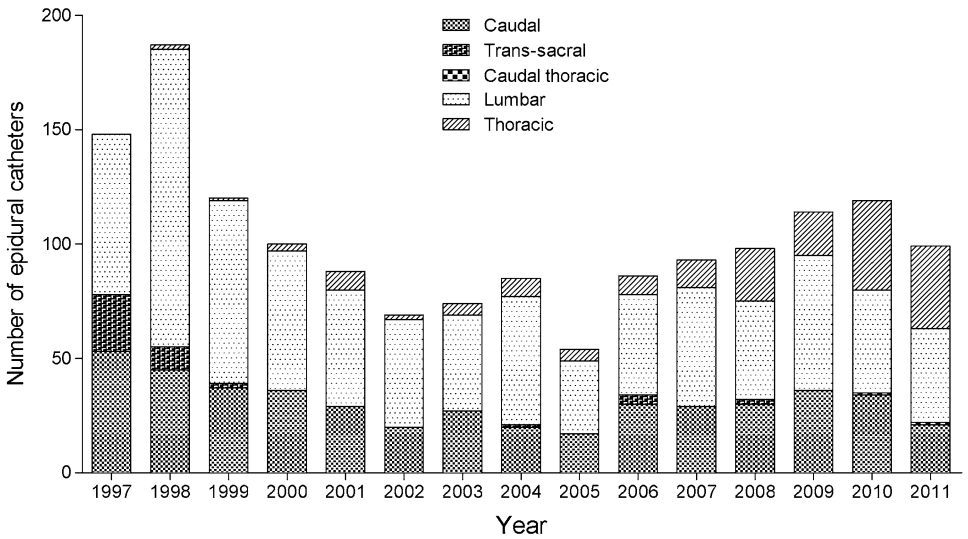

Fig. 4 Epidurals in one through eight-year-olds per year by insertion point

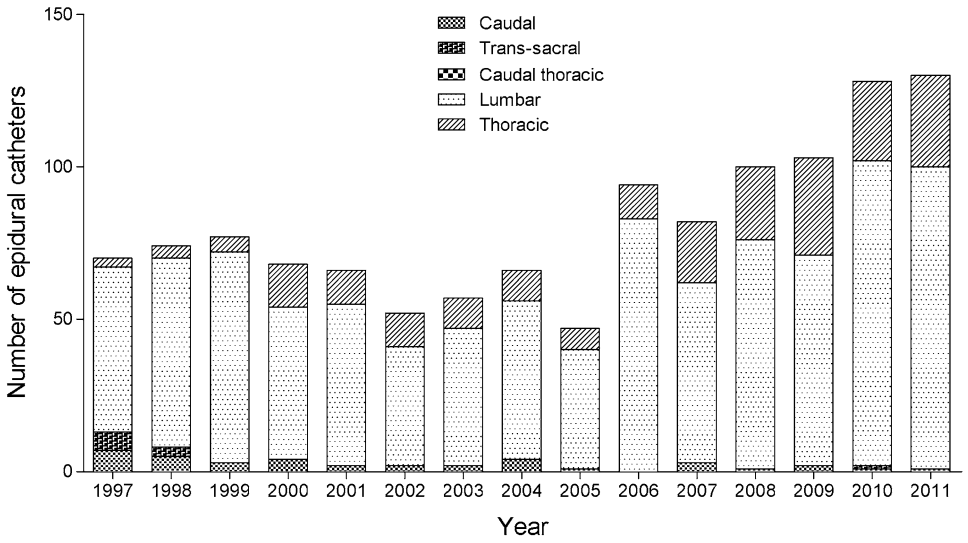

Fig. 5 Epidurals in > eight-yr-olds per year by insertion point

Table 1 Epidural catheter insertion sites and complication rates by age group

Age	Site	Denominator	% of total epidurals per age group	No. of complications	Incidence of complications (95% CI)
Neonates	Caudal	16	33	0	-
	Transsacral	0	0	0	-
	Caudal-thoracic	23	48	2	8.7% (1.1 to 28.0)
	Lumbar	4	8	0	-
	Thoracic	5	11	0	-
Total neonates (% of total epidurals)		48 (1%)	100	2	4.2% (0.5 to 12.3)
Infants	Caudal	205	58	3	1.5% (0.3 to 4.2)
	Transsacral	10	3	0	-
	Caudal-thoracic	22	6	0	-
	Lumbar	89	26	1	1.1% (0.03 to 6.1)
	Thoracic	26	7	1	3.8% (0.1 to 19.6)
Total infants (% of total epidurals)		352 (11%)	100	5	1.4% (0.5 to 3.3)
Child aged one through 8 yr	Caudal	464	30	2	0.4% (0.05 to 1.5)
	Transsacral	44	3	0	-
	Caudal-thoracic	2	0.1	0	-
	Lumbar	856	56	3	0.4% (0.07 to 1.0)
	Thoracic	171	11	2	1.2% (0.1 to 4.2)
Total child aged one through 8 yr (% of total epidurals)		1,537 (49%)	100	7	0.5% (0.2 to 0.9)
Child > 8 yr	Caudal	38	3	0	-
	Transsacral	10	1	1	10% (0.3 to 44.5)
	Caudal-thoracic	0	0	0	-
	Lumbar	948	78	9	0.9% (0.4 to 1.8)
	Thoracic	219	18	0	-
Total child > 8 yr (% of total epidurals)		1,215 (39%)	100	10	0.8% (0.4 to 1.5)
Total		3,152	-	24	0.76% (0.5 to 1.1)

CI = confidence interval

Table 2 Complications by type

Type of complication	Total	% of Total complications
Local skin infection	11	46
Drug error	3	13
PDPH	1	4
Catheter removal while coagulopathic	1	4
Unrecognized intravascular catheter	1	4
Unrecognized intrathecal catheter	1	4
Misplaced catheter	1	4
Respiratory depression	1	4
Pressure sore*	1	4
Peripheral nerve injury*	1	4
Compartment syndrome*	1	4
Cardiac arrest*	1	4
All complications	24	100

*Associated with but not attributable to epidural analgesia

PDPH = postdural puncture headache

throughout the L5-S1 distribution despite discontinuation of the epidural infusion and removal of the catheter one day earlier. Magnetic resonance imaging on the fourth day showed a small amount of blood staining the dural sac on the left side at the L3-4 level, extending along the nerve root sheath from L3 to S2. There was no evidence of epidural hematoma or spinal cord or nerve root compression. Electromyographic and nerve conduction studies found intact sensory but absent motor responses in the posterior tibial, sural, superficial, and deep peroneal nerves. The imaging and electromyographic findings suggested a preganglionic injury, and although epidural analgesia was implicated, the exact cause was uncertain. Over the course of two years, the patient gradually recovered motor function to his foot to a power grade of 3-4/5.

Compartment syndrome occurred in the lower limb of a ten-year-old patient who had undergone perineal surgery in the lithotomy position with the lower limbs supported by boot-style stirrups over a period of six hours. A transsacral catheter provided analgesia at the surgical site and did not result in motor or sensory loss in the lower limbs. Compartment syndrome was diagnosed eight hours after surgery when persistent pain, swelling, and reduced perfusion were evident in the patient's right calf. Fasciotomies were performed, and the patient subsequently returned to the operating room for dressing changes and wound closure.

Local skin infections varied in severity from inflammation around the insertion site to the presence of frank pus. Six infections resolved spontaneously and five required antibiotic treatment. There was no extension of infection from the skin to the epidural space or beyond. *Escherichia coli* (E. coli), enterobacter, and coagulase negative staphylococci were cultured from swabs of the insertion sites. In keeping with departmental practice, all epidural catheters were removed before the end of the third postoperative day, at the latest. Five of the epidural catheters associated with infection were removed within 48 hr. Perhaps owing to the risk of stool soiling, infectious complications were two times more frequent with epidurals inserted via the caudal route (five infectious complications of 770 caudal epidurals, incidence 0.6%) compared with more cephalad sites (six infectious complications of 2,382 epidurals, incidence 0.3%); however, this difference was not statistically significant ($P = 0.2$, Fisher's exact test).

The three drug errors included two drug concentration errors in which 0.25% bupivacaine was prepared and infused instead of the intended 0.125% bupivacaine. In both cases, the epidural infusion was ceased when the error was discovered. One patient was a 6 kg infant who appeared agitated prior to the cessation of the thoracic epidural infusion on the second postoperative day and settled shortly after the infusion was discontinued. In the second drug concentration error, a 20 kg patient received 0.25% bupivacaine 20 mL intraoperatively, resulting in hypotension requiring pressor support and prolonged emergence. In the third drug error, magnesium sulphate 4 mL was inadvertently injected into the epidural catheter in a 16-yr-old patient. No harm occurred. The epidural catheter was removed when the error was discovered.

A caudal-thoracic epidural catheter was inadvertently removed in the presence of coagulopathy (international normalized ratio 1.8) in a neonate; however, no morbidity resulted. Intravascular migration of a catheter was detected postoperatively in a 4 kg infant because of sustained tachycardia and hypertension that resolved once the epidural infusion containing epinephrine was discontinued. Intrathecal placement of a catheter was diagnosed in a 13-yr-old who showed prolonged emergence after a urological procedure. The patient was hemodynamically stable but showed fixed mid-sized pupils and complete unresponsiveness. Cerebral spinal fluid was aspirated from the catheter. This resulted in a three-hour admission to the intensive care unit for postoperative ventilation; however, no long-term morbidity ensued. During surgery, one catheter, inserted preoperatively, was found to have been placed into the retrorectal peritoneal cavity. The catheter was removed without sequelae. A 25 kg patient with Trisomy 21 received bupivacaine with fentanyl 2 $\mu g \cdot mL^{-1}$ infused at a rate of 6 $mL \cdot hr^{-1}$ via a lumbar epidural for orthopedic surgery. In the postoperative period, the patient gradually developed respiratory depression owing to the opioid content in the epidural solution and required a naloxone infusion and transfer to a high-dependency ward.

Discussion

We present a single-centre audit of our experience with continuous epidural analgesia in more than 3,000 children. This novel and extensive Canadian study addresses complications related to epidural infusion analgesia in this patient population. Our results show an overall incidence of 7.6 complications per 1,000 epidural analgesia infusions over the 15-year period, which is in keeping with published data in pediatric patients.[14,17-20] In our current sample, we did not identify any known major complications directly attributable to continuous epidural analgesia, such as epidural hematoma, abscess formation, or local anesthetic neurotoxicity. The two most common types of incidents, namely, local infection and drug error, are potentially preventable and accounted for 58% of all complications.

While our data suggest a tendency for increased infectious complications with caudal epidurals, this was not a statistically significant finding. Previous studies have shown a variable association between caudal epidurals and infection.[19,22-25] In children, duration of catheterization appears to be the most significant factor associated with epidural site infection.[24,25] One study showed 13 infections in 10,653 epidurals, all of which occurred from days three to 11 after catheter insertion.[24] Methods to reduce infection may include the use of antibiotic prophylaxis and the timing of antibiotic administration prior to epidural insertion, although the latter remains controversial.[23-27] Alcohol-based skin preparation solutions have been reported to be more effective than aqueous solutions for the prevention of central venous line infections in intensive care settings;[28-30] however, findings for the prevention of infectious complications related to epidural catheters have been inconsistent.[22,25,31,32]

Ultrasound-guided regional analgesia was introduced to our practice in 2008. In infants and neonates, ultrasound enables visualization of epidural catheters that are inserted via the easily accessible caudal space and threaded to the desired vertebral level in the thoracic or lumbar regions.[33-35] The availability of ultrasound to guide placement of caudal-thoracic epidurals has resulted in an increased use of epidural analgesia in infants during the last three years of this review.

After accounting for the number of epidurals performed, overall complications were relatively more common in neonates and infants than in the older age groups, which is consistent with previously published data.[18,19] Children less than one year of age were almost three (95% CI 1.2 to 7) times more likely to have a complication related to continuous epidural analgesia than children older than one year. We were unable to provide a clear explanation for this trend in this cohort.

Neonates and infants accounted for only 12% of total epidural usage. As such, there is less overall experience with both the insertion of epidural catheters and the perioperative management of epidural analgesia in these age groups, which may explain the higher complication rate. Owing to the consistent finding that neonates and infants are at increased risk of complications,[18,19] it may be argued that epidural catheter insertion in these patients should be performed only by proficient consultant pediatric anesthesiologists. Given the average of only 26 infant or neonatal epidural catheter insertions per year, maintenance of proficiency may require the formation of a small group with a special interest in regional techniques in children. Nevertheless, it should be pointed out that the complications in neonates and infants were mostly deemed grade 1 severity and resolved without intervention, which is consistent with previous findings.[19] It is also worth mentioning that five of seven complications in this age group occurred during the postoperative management of epidural analgesia. As in the older age categories, most of the complications that occurred in neonates and infants were potentially preventable (one drug error, one catheter removal in a coagulopathic patient, and three infectious complications). The fact that the majority of epidurals in these age groups were inserted via the caudal space may explain the high proportion of infectious complications, particularly as patients in these age groups are not toilet trained.[24,25] These findings support the need for increased education in the postoperative management of continuous epidural analgesia in ward areas that accept post-surgical neonates and infants.

This study has several important limitations. It was conducted in a single institution; consequently, external validity of our results may be limited as the local practice for managing epidural analgesia is standardized. Complication rates were relatively small, and the power of the study to evaluate predictors for complications is limited. During the period of this study, the APS database was not independently audited to establish the accuracy of the collected data; however, it is updated twice daily following APS rounds in response to changes in patient care. Epidural infusions are typically run for up to three days at our institution, and we consider it unlikely that major complications were omitted from the database with six database entries or updates over three days. Seeing as the data source is a complete and comprehensive database of epidural activity in the hospital, we consider the denominator data to be an accurate reflection of local practice. In our view, the numerator data are also accurate because all major complications encountered with the use of epidural infusion analgesia are collected in the database. As this is a retrospective study, there remain unanswered questions, including details regarding the level of experience of the

personnel performing epidural insertion, the degree of sterile technique used, the type of skin preparation used, and the use, timing, and duration of antibiotic prophylaxis.

In summary, our incidence of major complications and our finding that complications were more common in younger age groups are both consistent with previously published data. Identifying incidents from all causes is an important step toward changing clinical practice to reduce the incidence of preventable complications associated with epidural analgesia in children. Our most common complication, local skin infection, is potentially preventable, but there has been no reduction in incidence over the course of this audit. Further work is required to determine susceptibility to local infections associated with epidural catheters in order to ascertain methods to reduce its incidence. Ultrasound-guided techniques have made epidural infusion analgesia more accessible in neonates and infants via the caudal-thoracic route.

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Conflicts of interest None declared.

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