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Incidence of Epidural Catheter-associated Infections after Continuous Epidural Analgesia in Children

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ABSTRACT

Clinical observation suggests that the number of serious epidural catheter-associated infections have increased recently in children. This increase is likely attributed to an increase in reporting and in frequency of epidural analgesia usage. Estimates of infection rates are difficult to determine primarily because of insufficient study of large pediatric populations. In this retrospective study, the authors investigated the incidence of epidural catheter-associated soft tissue and epidural infections after use of continuous epidural analgesia spanning 17 yr. A total of 10,653 epidural catheters were used in 7,792 children. The majority of catheters, 10,437 (98%), were placed for the management of postoperative pain, and 216 (2%) were placed for the management of chronic pain. The authors identified 13 cases of infections (nine cellulitis, two paravertebral musculature infections, one epidural inflammation, and one epidural abscess) between 3 and 11 days after catheter insertion. The incidence of infection was significantly higher in patients treated for chronic pain (7 of 216 = 3.2%) compared with postoperative pain (6 of 10,437 = 0.06%; $P < 0.0001$). Surgical drainage of subcutaneous pus was performed in three patients, and medical therapy was administered in the remainder of patients; all patients recovered without sequelae. Although rare, epidural catheter-associated infections remain a serious concern in high-risk children who may benefit the most from epidural analgesia. The findings of the authors support the low rate of epidural infection previously reported despite growing concerns of serious infections in children. These findings highlight the importance of vigilance to early diagnostic indicators of infection and provide practitioners and families with incidence data to guide informed medical decision-making.

SHORT-term epidural catheters (ECs) are used increasingly to manage severe postoperative and chronic pain in children. Epidural analgesia is effective and relatively safe because of improved pediatric regional anesthesia training and better understanding of the pharmacology of local anesthetics.[1–3] ECs are commonly placed in the operating room under aseptic conditions and used for an average of 2–5 days. When infection occurs, it necessitates early catheter removal and in some cases antibiotic therapy.[3,4] Although ECs are implicated in serious infection, few serious EC-related infections in children are reported in the literature. Any delay in recognition or treatment may lead to serious complications, including abscess, meningitis, and neurologic deficit.[5,6]

Knowledge of the incidence of EC-associated infections is necessary for safe medical decision-making by healthcare providers and enhances patient or family autonomy in making an informed choice of epidural analgesia. As with adults, pediatric EC-related infectious complications and, to a lesser extent, epidural abscess, are rare and are more likely to be identified in a large observational studies than in small randomized trials. Therefore, we reviewed our experience over a 17-yr period to estimate the true incidence of such events and to better define populations at risk.

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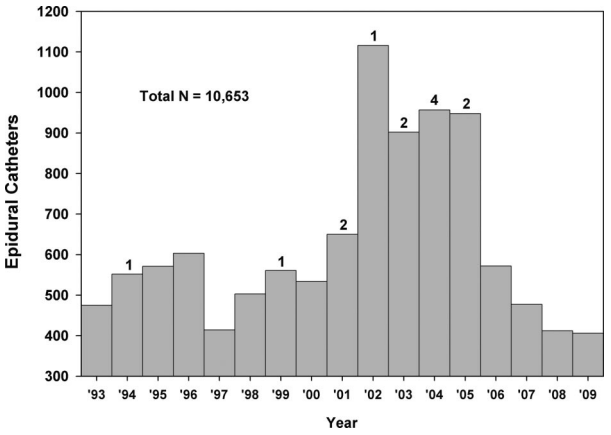

Fig. 1. Annual number of epidural catheters distribution. The number of epidural catheter-related infection cases is shown at the *top* of the frequency bars.

Materials and Methods

We reviewed EC-related infectious complications in children aged newborn to 18 yr at Children's Hospital Boston between January 1993 and December 2009. Institutional review board (Children's Hospital Boston, Boston, Massachusetts) approval was obtained to review patients' medical documents and data analysis.

We defined catheter-associated infections as follows: patients in whom infection of soft tissue (cellulitis and paraspinal musculature) or epidural space was confirmed by blood culture test or skin purulent discharge culture in combination with radiologic imaging. Patients with local dermal erythema and/or induration that resolved spontaneously or with disinfection care were excluded.

Staff anesthesiologists or trainees under staff supervision placed all ECs for postoperative and chronic pain management in the operating room. Standard practice at our institution is to place ECs under aseptic conditions using surgical gloves, caps, facemasks, and small sterile drapes. Additional preprocedural hand washing with antiseptic solution, surgical gown, and large drapes were used in all EC placements for chronic pain management. Historically, three applications of a single-use aqueous 10% povidone iodine preparation were performed for skin disinfection. For the past 6 yr, a single-use alcohol-based solution of 2% chlorhexidine (three applications) has virtually replaced povidone as the antiseptic of choice. All catheter insertion sites were covered with a clear sterile dressing (Tegaderm; 3M Health Care, St. Paul, MN). This dressing was not routinely changed unless its integrity was compromised.

The on-site pharmacy prepared all epidural infusates under sterile conditions using laminar flow hood technique. All infusates were refrigerated at 25°C for a maximum of 1 week and then discarded if unused. Epidural infusates were administered from 50-ml syringe infusion pumps for the first 12 yr, whereas in the past 5 yr, epidural infusates were delivered from infusion bags of patient-controlled epidural analgesia pumps. One of the following analgesic preparations were used: 0.1 or 0.125% bupivacaine; 0.1% bupivacaine and 2 μg/ml fentanyl with or without clonidine; 0.1% bupivacaine and 10 μg/ml hydromorphone with or without clonidine; and 1.5% chloroprocaine with or without clonidine. After an initial loading dose of a local anesthetic was administered in the operating room, the epidural analgesia was maintained by continuous infusion. The integrity of the infusion system remained intact and was interrupted only for syringe or bag replacement. The range of infusion rates was between 0.1 and 0.4 $ml \cdot kg^{-1} \cdot h^{-1}$ for bupivacaine and 0.3 and 0.7 $ml \cdot kg^{-1} \cdot h^{-1}$ for chloroprocaine. All the ECs used were 20-gauge polyamide catheters with screw caps for the first 12

Table 2. Duration of Epidural Catheter Stratified by Age and Procedure

Procedure	0–1 yr	2–5 yr	6–12 yr	13–18 yr
Abdominal/GU	3 (1–9)	3 (1–9)	3 (1–10)	3 (1–11)
Thoracic	3 (1–9)	3 (1–11)	3 (1–10)	3 (1–10)
Orthopedic	2 (1–6)	3 (1–7)	3 (1–9)	3 (1–9)
Chronic pain	3 (3–3)	3 (3–3)	4 (1–9)	4 (1–12)
Total	3 (1–9)	3 (1–11)	3 (1–10)	3 (1–12)

Data represent median catheter duration in days (range).
GU = genitourinary.

Table 1. Surgical Procedures and Routes of Administration by Age (N = 10,653)

	0–1 yr	2–5 yr	6–12 yr	13–18 yr
Procedure*				
Abdominal/GU	2431 (37.3)	1601 (24.5)	1730 (26.5)	760 (11.7)
Thoracic	273 (29.5)	113 (12.2)	180 (19.4)	360 (38.9)
Orthopedic	164 (5.5)	530 (17.7)	1217 (40.7)	1078 (36.1)
Pain management	1 (0.5)	1 (0.5)	63 (29.1)	151 (69.9)
Epidural route*				
Lumbar	1825 (23.0)	1911 (24.1)	2635 (33.3)	1555 (19.6)
Thoracic	368 (18.3)	311 (15.4)	547 (27.2)	788 (39.1)
Caudal	676 (95.6)	23 (3.3)	7 (1.0)	1 (0.1)
Cervical	0 (0.0)	0 (0.0)	1 (16.7)	5 (83.3)
Total cases	2869 (26.9)	2245 (21.1)	3190 (29.9)	2349 (22.1)

Data are presented as n (%), calculated horizontally to highlight the differences between age groups.
* $P < 0.001$, highly significant association between type of procedure and route *vs.* age group.
GU = genitourinary.

Table 3. Duration of Epidural Catheter Stratified by Age and Route

Route	0–1 yr	2–5 yr	6–12 yr	13–18 yr
Lumbar	3 (1–9)	3 (1–8)	3 (1–10)	3 (1–12)
Thoracic	3 (1–8)	3 (1–11)	3 (1–10)	3 (1–11)
Caudal	3 (1–9)	3 (1–4)	2 (1–4)	4 (4–4)
Cervical	NP	NP	3 (3–3)	5 (4–8)
Total	3 (1–9)	3 (1–11)	3 (1–10)	3 (1–12)

Data represent median catheter duration in days (range).
NP = not performed.

yr, whereas in the past 5 yr, snap-lock connectors were used. For a small number of patients, wire-reinforced catheters were used. Bacterial filters (0.2 μm) were used with almost all ECs. The closed epidural infusion system was rarely breached for catheter flushing and infusate replacement. The breach of the closed system has been increasingly infrequent after introduction of patient-controlled epidural analgesia.

For the management of postoperative analgesia, catheters were maintained for an average of 2 days or longer if the benefits exceeded the potential risk of infection. For the management of chronic pain, catheters were routinely maintained for longer periods of 3–5 days. Catheters were removed sooner if a patient developed pyrexia (higher than or equal to 39.0°C) or persistent low-grade pyrexia (higher than or equal to 38.5°C) when other causes of infection were ruled out.

ECs were secured *via* subcutaneous tunneling over 5–10 cm in most patients with chronic pain. Advancement of the ECs from caudal or lumbar to thoracic spinal segments was confirmed by epidurogram with iohexol with iodine 180 mg/ml, epidural nerve root stimulation, plane radiograph of the wire-reinforced catheters, or fluoroscopic guidance.

Prophylactic cephalosporins and other antibiotics were administered usually within 30 min of surgical incision as directed by the institutional surgical wound infection guidelines and were usually continued for 72 h postoperatively or after removal of the EC. Documentation of whether antibiotics were administered before EC placement was not always available. Prophylactic antibiotics were not administered to patients who received EC for chronic pain management.

Patients exhibiting early signs and symptoms suggestive of infection, including severe back pain and pyrexia, were referred for urgent magnetic resonance imaging (MRI) scan. Purulent discharges from the EC exit site and blood samples were cultured for the identification of microorganisms and their sensitivity to antibiotics. Some patients also had erythrocyte sedimentation rate, leukocyte counts, and C-reactive protein screening. If imaging studies were suggestive of inflammation or abscess of deep subcutaneous, paraspinal musculature, or epidural space, intravenous antibiotic therapy was initiated. In addition, formal infectious disease and/or neurosurgical consultation was obtained in cases suspected of epidural and deep tissue infections. EC sites were inspected daily by the acute pain service staff and nursing staff at 4-h assessment intervals for evidence of infection, back pain, cellulitis, swelling, tenderness, or pyrexia.

Table 4. Epidural Catheter-related Infections in Postoperative Patients

Age (yr)/ Gender	ASA-PS	Diagnosis	Catheter Entry Site	Catheter Duration (d)	Infection Diagnosis Post-EC Insertion (d)	Clinical Presentation
1.4/M	III	Panhypopituitarism on chronic steroid replacement therapy and gastroesophageal reflux disease	T10	4	4	Back pain, swelling, and pyrexia (40°C)
3/M	III	Pelvic stage IV neuroblastoma	T12–L1	3	3	Back pain, pyrexia (38.8°C), leukocytosis, and blood culture negative
17/F	III	Abdominal desmoplastic small round blue cell tumor	T10–11	5	5	Back pain, pyrexia (39.5°C), leukocytosis, and increased ESR and CRP
6/F	III	Pre–B-cell ALL necrotizing colitis	T11–12	4	4	Back pain and pyrexia (39.2°C)
3 wk/M	II	Retroperitoneal teratoma	T10–11	3	3	Back pain, pyrexia (38.9°C), and leukocytosis
15 wk/M	III	Ileostomy closure and history of NEC and bowel perforation	L2–3	3	3	Back pain and febrile

ALL = acute lymphoblastic leukemia; ASA-PS = American Society of Anesthesiologists-Physical Status; CRP = C-reactive protein; EC = epidural catheter; ESR = erythrocyte sedimentation rate; MRI = magnetic resonance image; ND = not done; NEC = necrotizing enterocolitis.

Statistical Analysis

Descriptive statistics including medians and ranges were used to summarize duration of infusion and means and SDs for age. The actual incidence of infection was described using a 95% CI based on Wilson's method to best capture the true incidence in the pediatric population. The incidence of infection between patients managed for postoperative pain compared with those with chronic pain was compared using Fisher exact test. Association between the age and the type and route of the procedure was evaluated using Pearson chi-square test. Two-tailed values of $P < 0.05$ were considered statistically significant. Data analysis was performed using SPSS statistical software (version 16.0; SPSS Inc., Chicago, IL).

Results

A total of 10,653 consecutive ECs were placed in 7,792 children (4,044 girls [52%] and 3,748 boys [48%]) over a 17-yr period. There was no clustering of infection cases in any particular year(s). The annual epidural utilization peaked between 2001 and 2005 and declined thereafter due to an increased use of ultrasound-guided peripheral nerve blocks (fig. 1).

Overall, the numbers of ECs placed for various surgical procedures were 6,522 for abdominal and genitourinary, 2,989 for orthopedic, and 926 for thoracic procedures. A total of 216 ECs were placed for chronic pain management. The frequency of these procedures differed significantly among the four age groups (chi-square = 2,064 on 9 degrees of freedom, table 1). Regarding the route of administration, of the 10,653 total procedures, 7,926 (74%) were lumbar, 2,014 (19%) were thoracic, 707 (7%) were caudal, and only 6 were cervical. The route of EC was significantly associated with age (chi-square = 2198 on 9 degrees of freedom, table 1). A high proportion of EC was used for abdominal and genitourinary procedures (61.2%), followed by orthopedics (28.1%), thoracic (8.7%), and chronic pain management (2%) procedures (table 1).

Median duration of infusion was 3 days (range, 1–11 days) for the management of postoperative pain and 4 days (range, 1–12 days) for chronic pain management (tables 2 and 3). Mean patient age was 6.9 ± 5.5 yr (range, newborn to 18 yr) with similar distribution among girls (52%) and boys (48%). The majority of patients were between 6 and 12 yr (29.9%), followed by 0–1 yr (26.9%), 13–18 yr (22.1%), and 2–5 yr (21.1%; table 1).

Postoperative epidural analgesia was provided to 10,437 patients. Of these, we identified six American Society of Anesthesia (ASA) physical status II and III cases of EC-related infections, including one epidural inflammation without abscess and five cases of cellulitis (0.06%; 95% CI, 0.03–0.13; table 4). Thus, the expected rate of infection in postoperative patients is between 3 and 13 per 10,000 catheters. The ECs were inserted at the thoracic site in five patients and the lumbar site in one patient. The time to diagnosis of infection ranged from 3 to 5 days after catheter insertion. All patients

Table 4. Continued

Site of Infection	Organism	Imaging Scans	Treatment	Recovery
Cellulitis at EC exist site	Hemolytic streptococci in blood culture	MRI: epidural phlegmon T2–L1	Vancomycin and ceftriaxone	Complete. Normal repeat MRI after 4 wk
Cellulitis and pus at EC exist site	*Staphylococcus aureus*	MRI: subcutaneous fluid collection	Surgical drainage on day 4. Vancomycin, piperacillin, and tazobactam initially followed by cefazolin	Complete
Cellulitis and pus at EC exist site	*S. aureus*	MRI: subcutaneous fluid collection	Surgical drainage on day 5. Amikacin and meropenem	Complete
Cellulitis and pus at EC exist site	*S. aureus*	ND	Cefazolin	Complete
Cellulitis and pus at EC exist site	ND	ND	Surgical drainage. Cephalexin	Complete
Cellulitis and pus at EC exist site	*Staphylococcus* species	ND	Cefoxitin	Complete

were given perioperative antibiotics for at least 48 h after surgery.

Epidural analgesia was provided to 216 patients with complex regional pain syndrome (CRPS) for the management of chronic pain. Of these, we identified seven ASA physical status I cases of EC-related infections, including one epidural abscess and six with cellulitis (table 5; fig. 2). The incidence of infection was significantly higher in the chronic pain management group (7 of 216 = 3.2%) compared with acute postoperative pain management group (6 of 10,437 = 0.06%; $P < 0.0001$, Fisher exact test). The ECs were inserted at the thoracic site in two patients and the lumbar site in five patients (table 5). The time to diagnosis of infection ranged from 3 to 11 days after catheter insertion. In one child, the epidural abscess developed 2 days after the removal of EC. Two of these 13 cases of EC-related infection were reported previously.[7]

MRI scans were sought for suspected epidural and deep infections in three acute postoperative patients and five patients with chronic pain (tables 4 and 5). Epidural abscess was confirmed in one child with chronic pain, and an inflammatory mass (phlegmon) was diagnosed in a second child with postoperative epidural analgesia. The remaining patients had either paraspinal musculature inflammation (n = 2) or subcutaneous infections (n = 4). Neuroimaging scans were not performed in five patients who developed subcutaneous inflammation or abscess (tables 4 and 5).

All patients presented with severe back pain, and nine patients developed pyrexia (38.6°–40°C), including five postoperative patients and four patients with chronic pain. Local examination of the EC sites revealed cellulitis and purulent discharge in five patients and cellulitis in one patient after surgery. Cellulitis and purulent discharge were present in six patients with chronic pain. There was no evidence of cellulitis or subcutaneous infection in one patient who developed epidural abscess.

The risk factors for EC-associated infection were present in four postoperative patients (table 4). All four patients were immunosuppressed, three because of malignancies and one because of chronic steroid replacement therapy.

All patients with chronic pain were healthy except for affliction with CRPS. The one child who developed epidural abscess presented with back pain without local cellulitis or pyrexia on the fourth post-EC insertion day. Leukocyte count and erythrocyte sedimentation rate tests were normal. An MRI of the thoracic and lumbar spine revealed only deep paraspinal muscle inflammation. Antibiotic therapy was initiated, and the patient was discharged. Two days later, the child was readmitted for worsening back pain, pyrexia (38.9°C), and difficult ambulation. A repeat gadolinium-enhanced MRI demonstrated an epidural abscess extending from the T10–11 levels and inflammation of the paravertebral soft tissue from T10–12 (fig. 2). Leukocyte count, erythrocyte sedimentation rate, and C-reactive protein levels were increased, and the blood culture revealed the presence of *Staphylococcus aureus*. Intravenous vancomycin and ceftriaxone therapy were administered for 4 weeks. A follow-up

Table 5. Epidural Catheter-related Infections in Patients with Chronic Pain

Age (yr)/ Gender	ASA-PS	Diagnosis	Catheter Entry Site	Catheter Duration (d)	Infection Diagnosis Post-EC Insertion (d)	Clinical Presentation
12/F	I	CRPS 1	L3–4	4	6	Back pain and febrile on day 4. Normal MRI. Two days after discharge, developed severe back pain, pyrexia (38.5°C) and inability to walk. Increased leukocyte, ESR, and CRP
15/F	I	CRPS 2	T3–4	4	4	Back pain and pyrexia (38.8°C)
11/M	I	CRPS 1	L4–5	6	6	Back pain and pyrexia (38.5°C)
12/F	I	CRPS 1	L1–2	8	8	Back pain and pyrexia (38.7°C)
14/M	I	CRPS 1	L3–4	4	4	Back pain
16/F	I	CRPS 1	T12–L1	11	11	Back pain
10/F	I	CRPS 1	L3–4	3	3	Back pain and increased leukocyte and ESR

ASA-PS = American Society of Anesthesiologists-Physical Status; CRP = C-reactive protein; CRPS = complex regional pain syndrome; EC = epidural catheter; ESR = erythrocyte sedimentation rate; MRI = magnetic resonance image; MRSA = methicillin-resistannt *Staphylococcus aureus*; ND = not done.

MRI scan showed complete resolution of the infection. In none of the patients were difficulties encountered during EC instrumentation that might have accounted for excessive tissue trauma or development of hematoma predisposing to infection.

Methicillin-sensitive *S. aureus* was the predominant pathogen and was identified in four postoperative patients and in six patients with chronic pain. Methicillin-resistant *S. aureus* was identified in one child with chronic pain, and hemolytic *Streptococcus* species was present in one postoperative child.

Surgical drainage of subcutaneous pus was performed in three postoperative patients, and ultrasound-guided drainage was attempted unsuccessfully in one child with chronic pain. The remainder of patients, including one chronic pain patient with epidural abscess and a second postoperative patient with epidural phlegmon, were treated with intravenous antibiotics (tables 4 and 5). All patients recovered fully after antibiotic and surgical therapies.

Discussion

The overall incidence of EC-associated soft tissue and epidural infection in this review is 13:10,653, and the incidence of epidural abscess is 1:10,653 EC over a 17-yr period, 6:10,437 catheters for the postoperative pain management and a significantly higher rate of 7:216 catheters for the management of chronic pain (tables 4 and 5). Only two children developed epidural space infection, epidural inflammation in an immunocompromised child and frank abscess in a healthy child (tables 4 and 5). The overall incidence of epidural abscess is lower than the reported incidence in adult trials, 1:1,930 catheters in a large prospective 1-year trial and 1:1,368 catheters in a second prospective 6-yr trial of postsurgical analgesia.[5,8] This overall incidence is comparable with the estimated incidences of spontaneous spinal epidural abscess of 0.2–1.2 per 10,000 hospitalized children.[9]

Two epidural infections were promptly diagnosed, one of which was a true epidural abscess diagnosed in a child with chronic pain (table 5) and the second an epidural inflammatory mass in a postoperative child (table 4). Both infections were treated conservatively without the need for surgical intervention and without adverse sequelae. The epidural abscess developed in a healthy patient 2 days after EC removal and was likely because of rapid progression of paraspinal muscle inflammation unresponsive to an empiric broad-spectrum antibiotic. Data suggest that most epidural abscesses not associated with neurologic deficit can be safely and effectively treated with antibiotics alone.[10] All patients, whether managed with antibiotic therapy alone or in combination with surgical drainage of the subcutaneous abscesses, recovered without sequelae. The most consistent early symptom presenting with EC infections in this and previous pediatric reports is back pain. The back pain was present in all patients with EC-related infection. Pyrexia (upto 38.5°C) was present in five of six patients after surgery and in four of seven children with chronic pain.

Table 5. Continued

Site of Infection	Organism	Imaging Scans	Treatment	Recovery
Epidural abscess	*Staphylococcus aureus* in blood culture	Contrast-enhanced MRI: T10–11 epidural abscess and paraspinal musculature inflammation	Vancomycin and ceftriaxone	Complete. Normal repeat MRI after 4 wk
Cellulitis and pus at EC tunnel exit	*S. aureus*	MRI: paraspinal musculature inflammation	Vancomycin and cephalexin	Complete. Normal repeat MRI after 3 wk
Cellulitis and pus at EC tunnel exit	*S. aureus*	ND	Oxacillin	Complete
Cellulitis and pus at EC tunnel exit	*S. aureus*	ND	Cefazolin	Complete
Cellulitis and pus at EC exist site	*S. aureus*	MRI: paraspinal muscles inflammation	Vancomycin	Complete
Cellulitis and pus at EC exist site	*S. aureus*	MRI: subcutaneous inflammation	Vancomycin, cefoxitin and dicloxacillin	Complete
Cellulitis and pus at EC exist site	MRSA	MRI: subcutaneous inflammation	Vancomycin. unsuccessful ultrasound-guided attempt to drain the pus	Complete. Normal repeat MRI after 5 wk

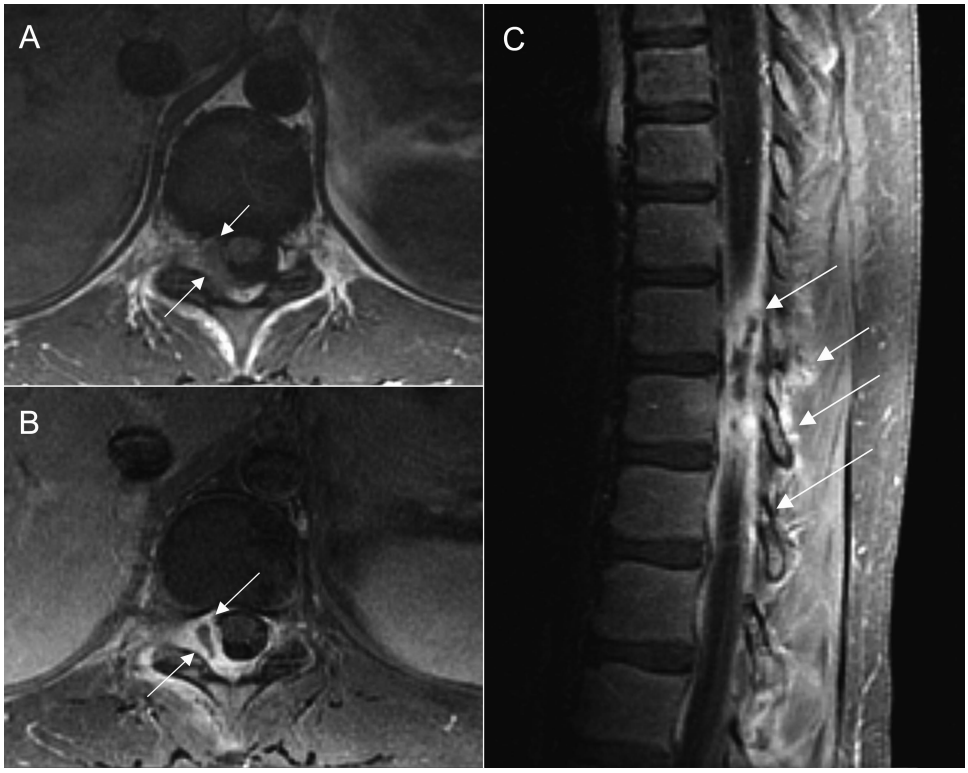

Fig. 2. (*A–C*) Magnetic resonance imaging of an epidural abscess in a 12-yr-old child. Axial T1-weighted images (*A*) before and (*B*) after administration of contrast material demonstrate an epidural abscess from the level of T10–T11. Mass effect is present on the right side of the thecal sac. Postcontrast sagittal T1-weighted image demonstrates the extension of the epidural abscess with associated inflammatory changes of the deep paravertebral soft tissues (*C*). All *arrows* point to epidural abscess.

Cellulitis was present at the EC exit sites in all but one patient with epidural abscess.

Although not extensively studied, catheter-related infection in children is a rare event, but it seems to have increased recently because of the increased reporting and increased epidural analgesia practice. There are only 10 published cases of epidural abscesses (n = 5) and soft tissue infections (n = 5) in the literature.[2,3,11–15] In 8 of the10 patients, infection occurred after EC placement for postoperative analgesia. In one patient, the infection followed use of EC for the management of CRPS-1 pain and a second for the management of pain from metastatic malignancy.[3,12]

The mechanisms by which ECs can become infected are highlighted in the literature, although the risk associated with each mechanism is uncertain. Both exogenous contamination during EC placement and patient factors of immunosuppression, skin colonization, systemic sepsis, and prolonged EC retention may contribute to these mechanisms of infection.[5,16]

We noted unusually high frequencies of EC-related infections in previously healthy children with CRPS (table 5). A similar high rate of EC-related infections is reported in adults with CRPS after placement of an externalized tunneled EC system for 6 weeks or longer. This infection rate was significantly higher compared with that observed with EC use in other adult painful chronic neuropathies.[17] The reasons for this high frequency are not entirely understood but are attributed to impaired immune response caused by chronic pain and stress.[2,6,13,15,18,19]

Skin colonization and propagation of microorganisms along the external surface of the catheter is proposed as the most likely avenue to epidural infection in a prospective adult trial.[18] In pediatric controlled studies, skin colonization at catheter exit sites are relatively higher than in adults particularly in younger children with an overall incidence range of 12–35%. The high rate of colonization is likely because of catheter soiling in children with no toilet training.[20–22] The incidence of catheter tip colonization with bacteria ranges from 11 to 16% in the presence of cellulitis.[20,22] Catheter colonization rates are low with lumbar EC and vary from 4 (n = 46), to 23 (n = 40), to 32% (n = 100).[20–22] Catheter colonization *via* caudal route is higher (20–37%), with a high rate of gram-negative bacteria colonization (16–44%), particularly in younger children.[20,21] *Staphylococcus epidermidis* is the most common organism cultured from the skin and catheter tips.[20,21] Despite the high rate of bacterial colonization at the caudal site when catheters were retained for 2–3 days, the colonization did not lead to infection.[18] However, it is conceivable that when a critical level of skin colonization is reached, the potential for infection risk increases; therefore, effective skin antisepsis may play a major role in EC-related infections.[23]

In this report, methicillin-sensitive and one methicillin-resistant *S. aureus* cultures were isolated from healthy non-

surgical and surgical patients irrespective of prophylactic antibiotics administration. Neither *S. aureus* nor *Streptococcus hemolyticus* is a typical skin commensal organism, and so virulent strains of these organisms may have gained entry through a breach in the skin barrier or droplet contamination from the anesthesiologists.[24,25]

The EC-associated infections in this study occurred after the use of either a single-use formulation of aqueous 10% povidone-iodine or a 2% alcohol-based chlorhexidine skin disinfectant. Although the latter is proven to be more effective for reducing skin colonization because of the alcohol content, we observed no differences in infection rates between these two disinfectants.[26,27]

The benefit of prophylactic antibiotics before epidural catheterization is controversial.[28] A recent prospective adult trial reported no association between the frequency of colonization or infections after short-term 2–4 days EC retention and the use of perioperative antibiotics.[29] Similarly, a previous study reported no association between the use of a common perioperative intravenous cefazolin and the risk of intraspinal catheter infection.[30] Given the low incidence of epidural infection and lack of a controlled trial, it is difficult to evaluate the efficacy of prophylactic antibiotics.

Anesthesiologists practice variable infection control measures during EC placement to minimize the risk of contamination. These range from simple wearing of gloves, masks, and caps, disinfecting the skin, and using short drapes to maximal barrier precautions that include the additional measures of removal of hand jewelry, hand washing, wearing of a sterile gown, disinfecting skin with alcohol-based antiseptics, and using large drapes. Implementation of maximum barrier precautions is proven to be superior to inconsistent aseptic measures used by practitioners during central venous catheter insertion to minimize bloodstream infection.[31,32] In the absence of best aseptic practice and given the serious risk of infection during EC placement, adherence to strict maximum sterile barriers is a prudent consideration.[33,34]

Short duration EC use ($\leq$ 3 days) does not consistently result in superficial or epidural infections in adult or pediatric patients, although the probability of such a risk is likely to increase with longer use.[3,8,29,35] In this report, the rate of infection was significantly higher with longer EC use for the management of chronic pain when compared with postoperative pain (3.2 *vs.* 0.06%; $P < 0.0001$).

In conclusion, as with adults, pediatric EC-associated soft tissue and epidural infections are expected to increase as the overall usage of pediatric ECs increases for the management of acute and chronic pain. Delay in recognition or treatment of the infection may lead to dreadful outcomes. The most prominent early symptom of EC-associated infections in children is back pain. Physical signs of suspected epidural infection, including severe local tenderness, pyrexia, meningism, or persistent neurologic deficit after infusion discontinuation, should be promptly investigated with MRI scan to rule out infection. Timely antibiotic therapy is indicated while waiting for microbial sensitivity test to antibiotics. Verbal and written instructions about specific symptoms of EC-related infection should be provided to patients and families on discharge and should explain how and when to seek urgent medical attention if symptoms of EC-related infection occur.

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