Review

What Is Currently Known about Intramedullary Spinal Cord Abscess among Children? A Concise Review

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Abstract: Intramedullary spinal cord abscesses (ISCA) are rare. Typical symptoms include signs of infection and neurological deficits. Symptoms among (younger) children can be highly uncharacteristic. Therefore, prompt and proper diagnoses may be difficult. Typical therapeutic options include antibiotics and neurosurgical exploration and drainage. In this review, we analyze published cases of ISCA among children. Most pediatric cases were found to be under the age of 6 years. The typical symptoms included motor deficits in 89.06%, infection signs in 85.94%, and sensory deficits in 39.06%. Urinary dysfunction was observed in 43.75%, and bowel dysfunction in 17.19%. The predisposing factors included dermal sinuses, (epi)dermoid cysts, prior infection, iatrogenic disorder, and trauma. The most common pathogens were: *Staphylococcus aureus*, *Mycobacterium tuberculosis*, *Escherichia coli*, and *Proteus mirabilis*. The pediatric population has good outcomes as 45.93% of patients had complete neurological recovery and only 26.56% had residual neurological deficits. Fifteen (23.44%) had persistent neurological deficits. Only one (1.56%) patient died with an ISCA. In two (3.13%) cases, there were no details about follow-up examinations.

Keywords: intramedullary spinal cord abscess; ISCA; abscess; spinal cord tumor; antibiotics; dermal sinus; epidermoid cyst; dermoid cyst

1. Introduction

The intramedullary spinal cord abscesses (ISCAs) remain a rare, albeit widely publicized entity since the first reported case in 1830 [1,2]. Their rarity may be explained by the following factors: (1) the small volume of the spinal cord compared to the brain, (2) the small area of the spinal canal and acute angle of origin of the spinal arteries, and (3) the protected condition of the cord within the vertebral canal (see Figure 1) [3].
The typical symptoms include infection signs (fever/meningitis), neurological deficits (motor and/or sensory), and also pain (see Figure 1). These symptoms among children, especially younger ones, can be highly uncharacteristic and regrettably, can be associated with significant mortality. Therefore, a rapid and proper diagnosis may be difficult. Typical therapeutic options include antibiotics and neurosurgical exploration and drainage [4].

In this review, we analyze the currently published cases of ISCA among children in the terms of basic demographic data, location, symptoms (ISCA signs, infection parameters, additional information), course, pathogens, comorbidities, treatment methods, and follow-up examinations.

2. Literature Search

Three of us (B.S., R.J., and W.L.) performed a screening of all the relevant original English language papers published in the Pubmed before 1 May 2022 using the following query: “(intramedullary AND spinal cord) AND abscess”. As it is shown in Figure 2, we obtained 206 papers: 201 from the Pubmed database and 5 from additional sources). They were screened three times. In the case of any discrepancies between authors extracting data, the final decision was taken by the senior author (MR). In total, 122 papers potentially pertaining to the topic of the study were enrolled in the full-text assessment for eligibility. In these 122 papers, we identified 58 papers regarding pediatric ISCA with the description on 64 cases [5–62].

![Figure 1. The protective factors and typical symptoms of intramedullary spinal cord abscess. Legend: ISCA—intramedullary spinal cord abscess.](image-url)
3. What Is Currently Known about Intramedullary Spinal Cord Abscesses in Children?

This diagnosis of ISCA was confirmed in 37 (57.81%) boys and 25 (39.06%) girls. In two cases (3.13%), there were no data regarding sex. The analyzed ages did not reveal a normal distribution (Shapiro–Wilk test; \( p < 0.001 \); see Figure 3). The median age of the patients was 2.00 years (IQR: 1.17–5.00). Boys were significantly older than girls: 3.60 (IQR: 1.42–6.00) vs. 1.33 (IQR: 1.00–2.25; \( p = 0.007 \)).

Figure 2. The flow-chart of publications included process.

Figure 3. The age distribution among pediatric patients who developed intramedullary spinal cord abscesses (Shapiro–Wilk test: \( p < 0.001 \)). Legend: red curve — expected normal distribution.
3.1. ISCA Course and Localization

The course of ISCA can be divided into acute (<1 week), subacute (1–6 weeks), and chronic (>6 weeks) [44]. The most frequently observed manifestation was acute: 25 (39.06%) followed by 21 (32.81%) subacute cases. Chronic onset was observed in 13 (20.31%) cases. In five (7.82%) cases there were no detailed data. Neither sex ($p = 0.350$) nor age ($R = -0.010, p = 0.940$) affected the onset of ISCA [63].

The exact location was identified in 60 cases (including seven holocords [28,29,35,51,52,54,56] and two isolated lesions in the conus medullaris [5,36]). The location of ISCA lesions in the remaining 51 cases is shown in Figure 4. The precise localization was not directly provided in four of the cases. In the newborn/infant group the spinal cord terminated most frequently at the level of L2/L3. As we age, the level of spinal cord termination is changing, and in the adolescent population, it was most often found at the level of the middle third of L1 and L1/L2 [64]. Therefore, it seems to be interesting that in 16 (25%) cases the abscess was observed below the L3 level. The possible reasons for these observations were found in 12 (75%) cases. There were distinguished the following causes: five (31.25%) cases of spina bifida [16,43,48,49,53], four (25.0%) cases of (possible) coexistence of ISCA and intradural extramedullary lesion [8,18,31,61], two (12.5%) cases of low conus medullaris [36,49]. Moreover, we identified one case of the following explanation: retained medullary cord [62], tethered cord [16], and mild thoracolumbar scoliosis with upper anal cleft [36]. Theoretically, the classification of the lesion within the terminal filum may be the next issue. Lesions in this localization are considered intraspinal, which may be in contradiction to the aforementioned end of the spinal cord.

![Figure 4. The localization of the intramedullary spinal cord abscess in children.](image)

3.2. Symptoms Present in ISCA Patients

Laboratory results indicative of inflammation/infection were identified in 55 (85.94%) patients. These included fever—39 (60.94%), abnormalities in laboratory tests (elevated white blood cell counts, C-reactive protein concentration, and erythrocyte sedimentation rate)—34 (53.13%), and symptoms of meningitis—12 (18.75%). Motor deficits were observed in 28 (43.06%) patients. Moreover, urinary and bowel dysfunction were observed in 28 (43.75%) and 11 (17.19%) cases, respectively.
3.3. Predisposing Factors and Comorbidities

3.3.1. Dermal Sinus Tracts

Congenital midline defects, as well as anatomic abnormalities of the spinal cord or vertebral column, are some of the key predisposing factors for ISCA. One of these is dermal sinus tracts (see Figure 5), an abnormality present at birth over the dorsal midline where an abnormal epithelialized connection from the skin tracks inwards toward the spine, especially in the lumbar (32–43%) and the lumbosacral regions (32–54%) [65]. Their prevalence is estimated at 1 in 2500 live births.

![Figure 5. The schematic representation of a dermal tract as a predisposing factor for intramedullary spinal cord abscesses.](image)

In our literature search, dermal sinus sinuses were observed in 35 (54.68%) children. The causative organisms among these patients include the microorganisms colonizing the skin surrounding the sinus tract openings [66].

3.3.2. (Epi)dermoid Cyst

Epidermoid and dermoid cysts are two major variants of ectodermal-derived neural axis cysts [52]. Here we found three cases of this condition in ISCA patients [8,12,52]. Interestingly, these pathological entities can be related to a dermal sinus tract it is not mandatory [52].

3.3.3. Spina Bifida

We identified nine cases of ISCA related to spina bifida (see Figure 6) [8,13,16,42,43,48,49,53]. In almost all of these cases, the presence of dermal sinus tracts was noted. Therefore, it should be assumed, that the true predisposing factor, dermal sinus tracts, is more frequently observed among patients with abnormalities of the ectodermal, mesenchymal, or neural crest derivatives such as myelomeningocele, lipomyelomeningocele, and other forms of spina bifida occulta [42]. Perhaps a similar explanation can be given in the case of ISCA among adult patients born with talipes equinovarus [67,68].
3.3.4. Prior Inflammation

Prior inflammation is a risk factor for developing ISCA. It may lead to a hematogenous or contagious spread of infection. The following scenarios were observed: general infection [30,34], respiratory system infection [14,24,27], maxillary sinus abscesses [33], Brucella infection [19], and long-term diarrhea [11]. Interestingly, there were noted some cases of previous tuberculosis, e.g., [22,33,41].

3.3.5. Others

Other risk factors included iatrogenic ones as well as trauma. In our literature search, we have identified one case of ISCA which developed in the course of multiple attempts to perform a lumbar puncture and a second one due to spinal cord injury [44,47].

3.4. Available Treatments

Currently used treatments incorporate both neurosurgical management and anti-biotic/antifungal agents. Neurosurgeons may propose a (hemi)laminectomy with a myelotomy [4]. The abscess drainage with or without capsule removal may also be considered. In the cases of dermal sinuses, the dermal sinus tract should be identified and resected [36,59], and/or ligated [10]. Proper antimicrobial therapy depends on single cases beginning with empiric therapy and should be modified based on an antibiogram (see Section 3.5 for further information). In selected cases, glucocorticoids were administered to reduce edema [9,14,19,22,25,60].

3.5. Pathogens

Data regarding ISCA pathogens could not be obtained for four patients. In the other 60 cases, fifteen patients had culture-negative results (see Supplementary Table S1). Among those positive for just one microorganism, the most common pathogens were Staphylococcus aureus (8; 12.5%), Mycobacterium tuberculosis (6, 9.38%), Escherichia coli (4; 6.25%), and Proteus mirabilis (4; 6.25%). Moreover, Brucella and Streptococcus were identified in some cases. There were single cases of Bacillus fusiformis, Enterobacter sakazakii, Finegoldia magna, Micrococcus sapproticus, Mycoplasma hominis, and Propionibacterium (see Table S1). In 12 (18.75%) cases, there was more than one pathogen (see Table 1).
Table 1. Microbiological examination among pediatric ISCA patients.

| Microbiological Examination       | Number |
|----------------------------------|--------|
| Culture-negative                 | 15     |
| *Staphylococcus aureus*          | 8      |
| *Mycobacterium tuberculosis*     | 6      |
| *Escherichia coli*               | 4      |
| *Proteus mirabilis*              | 4      |
| Others                           | 11     |
| No data                          | 4      |
| More than one pathogen           | 12     |

The antimicrobial therapy in *Staphylococcus aureus* ISCA cases was mainly six weeks of the administration of intravenous vancomycin in combination with other antibiotics (especially tazocin). The patients with *Escherichia coli* were treated with the usage of third-generation cephalosporin-based therapy. Finally, cases with *Proteus mirabilis* were treated as follows: one case using methicillin and chloramphenicol and a second case using ceftriaxone and clarithromycin, in the last two cases there were no data regarding antimicrobial drugs.

3.6. Follow-Up

The median time of follow-up examinations was six months (IQR: 2–18.25). The obtained follow-ups in the pediatric population seem to be optimistic: 29 (45.31%) patients revealed complete neurological recovery and 17 (26.56%) had residual neurological deficits. Fifteen (23.44%) had persistent neurological deficits. Just one (1.56%) child died in the course of ISCA [43]. In two cases (3.13%), there was detailed information about a follow-up examination (see Table 2).

Table 2. Follow-up findings of pediatric ISCA patients.

| Follow-Up                              | Number |
|----------------------------------------|--------|
| Survived; complete neurological recovery | 29     |
| Survived, residual neurological deficits | 17     |
| Survived, persistent neurological deficits | 15     |
| Died                                   | 1      |
| No data                                | 2      |

4. Conclusions

ISCA remains a rare condition. Most pediatric cases are less than six years old. The typical symptoms include motor deficits in 89.06% of patients, infection signs in 85.94% of patients, and sensory deficits in 39.06% of patients. Moreover, urinary and bowel dysfunction was observed in 43.75%, and 17.19% of patients, respectively. Predisposing factors include dermal sinus tracts, (epi)dermoid cysts, prior inflammation, iatrogenic disorder as well as trauma. Currently used treatments incorporate both neurosurgical management and antimicrobial agents. In certain cases, glucocorticoids were administered. The most common pathogens were *Staphylococcus aureus, Mycobacterium tuberculosis, Escherichia coli,* and *Proteus mirabilis.* The most frequent antimicrobial treatment was six weeks of vancomycin in combination with other antibiotics (especially tazocin) for *Staphylococcus aureus;* third-generation cephalosporin-based therapy for *Escherichia coli;* and there was no consensus for *Proteus mirabilis*-related cases. At follow-up, 45.93% of patients revealed complete neurological recovery and 26.56% had residual neurological deficits. Fifteen (23.44%) had persistent neurological deficits. Just one (1.56%) child died of ISCA. In two (3.13%) cases, there were no details about follow-up examinations.
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