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Review article

Management of spinal infections in children with cerebral palsy

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ABSTRACT

Cerebral palsy patients who undergo posterior spinal instrumentation for scoliosis are at a greater risk of surgical site infection compared to adolescents with idiopathic scoliosis. Many infecting organisms are reported. Risk factors include patients' specific factors, nutritional status as well as surgery related factors. Although surgical management is still controversial, it is always based on irrigation and debridement followed or not by implant removal. The purpose of this paper is to review the pathophysiology of surgical site infection in this patient population and to propose a treatment algorithm, based on a thorough review of the current literature and personal experience.

1. Introduction

Cerebral palsy (CP) is a static encephalopathy with an onset before the age of 3 years presenting with posture and motor dysfunction. Of its subtypes, spastic quadriplegia is the most severe form and accounts for the highest rate of scoliosis (60%) [1]. Function improvement as well as back pain and respiratory function are restored with surgical correction [2]. Nevertheless, scoliosis surgery bears a high risk of complications (11–71%) [1,3]. Infections, in general, and surgical site infection (SSI) in particular, are the most common complications of scoliosis surgery in CP patients [1].

SSI is defined based on location and time it took to develop. Early infections (acute) occur usually during the first 90 days postoperatively while late infections (subacute) manifest after the 90 days landmark [4]. While acute infections are caused by direct inoculation from the surgical field, subacute infections may be either caused by contamination or hematogenous spread of infecting organisms. Superficial SSI is an infection involving only the dermis and the subcutaneous tissue and doesnot trespass the paraspinous fascia; a deep SSI is in direct contact with the implants and is therefore more severe [5].

2. Epidemiology and pathophysiology

When compared to idiopathic scoliosis, the incidence of SSI in neuromuscular scoliosis in general, and in CP patients in particular, is higher. The Scoliosis research society morbidity and mortality committee reports a 0.9% incidence of deep wound infection in children with idiopathic scoliosis undergoing spinal fusion [6,7] while infection rate in CP ranges from 1.1% to 15.2% [3,8–12] (Table 1), but remains inferior to the rate observed in myelomeningocele [13]. The majority of SSI in CP occur in the early period following surgery with a mean time to infection of 34 days [5].

The most common infecting organism in CP is debatable. While gram positive are the most common organisms responsible of infection in adolescent idiopathic scoliosis, gram negatives were most frequently found in CP [8]. Chidambaran found the same ratio for gram positives and gram negatives in CP patients [14]. When allocating organisms to SSI subgroups, deep infections are caused more frequently by gram negative organisms while superficial infections seem to be equally caused by gram positive and gram negative organisms [5,14]. The most common organisms by order of incidence are *Escherichia coli*, followed by *Pseudomonas aeruginosa* and gram positive organisms [8,14]. Contaminations of the surgical field or hematogenous spread from colonization sites are plausible reasons to explain this high incidence of gram-negative infections. In fact, CP patients that lack bowel and bladder control have a higher risk of seeding organisms from feces or urine, in addition to the negative effect of decubitus [15].

3. Risk factors

Reasons for a higher than matched aged non CP patients' incidence of SSI are not well understood. Authors tried to identify possible risk factors which could be allocated to surgical factors, patients' comorbidities and nutritional status (Table 2).

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Table 1
Incidence of SSI in different studies.

Author	Year	Overall (%)	Deep (%)	Superficial (%)
Caird et al. [21]	2008	6.25		
Dias [30]	1996		6.10	
Jasevar [22]	1993	6.80	4.50	2.30
Lonstein et al. [10]	2012		1.07	
Mohammad Ali et al. [16]	2010		9.30	
Sponseller et al. [5]	2010	10	6	4
Sponseller et al. [8]	2013	6.40		
Szöke et al. [11]	1998	9	4	5
Tsirikos [31]	2003	13.20	6.60	6.60
Tsirikos et al. [18]	2008		6.70	
Tsirikos et Mains [2]	2012	9.20	2.60	6.60

Logically, the risk of SSI is increased with any skin breakdown [16]. Skin complications occur in patients with pressure sores, tape blisters, superficial suture reactions and prominent hardware, all of these favoring bacterial migration in this immunocompromised population [16]. The type of instrumentation also affects the incidence of SSI: unit rod instrumentation have a three times increase of the risk of infection when compared to custom bent rods [5] and with a 2.5-increased risk when compared to pedicular screws [2,17,18]. A greater incidence of infection is found with increased implant prominence [19]. Additionally, increased blood loss increases the incidence of SSI [11]. SSI was also found to be related to a higher preoperative Cobb angle as this could cause lengthier surgeries, greater blood loss, as well as more prominent hardware [5,16]. Finally, graft type used for fusion is also a risk factor. In fact, Sponseller found that allograft is associated with an increased risk of SSI [9] whereas Borkhuu decreased the incidence of SSI by 4 times by mixing graft with antibiotics (gentamycin) [4]. The recent trend of mixing the graft with vancomycin is not widely studied in the pediatric population but Gans et al. found 500 mg of powder vancomycin to be safe in adolescent idiopathic scoliosis, and associated with decreased SSI [20]. However, the use of powder vancomycin in the surgical site remains baseless and we could not recommend its regular use especially when considering infecting organisms in CP scoliosis.

Patients' specific factors include cognitive impairment, age as well as comorbidities like seizures and gastroesophageal reflux disease (GERD). First of all, the degree of cognitive impairment positively correlates with the incidence of SSI [9,11,16] while age was found to inversely correlate with it [7].The presence of ventriculoperitoneal shunt and/or baclofen pump as well as revision surgeries increase the infection risk [21]. Epilepsy is another comorbidity associated with a higher incidence of SSI due to higher likelihood of aspiration and lower cognitive abilities [11]. Patients with GERD have threefold risk increase of development of SSI in scoliosis [14]. This may be caused by suboptimal nutritional status while treatment with acid inhibitors annihilates the protective acid barrier of the stomach [14]. On the contrary, urinary tract infection was not found to be a risk factor for SSI [5].

Table 2
Risk factors for SSI in CP patients.

Surgery related factors	*Patient's related characteristics*
Skin breakdown	Age
Higher postoperative Cobb angle	Cognitive impairment
Increased implant prominence	Baclofen pumps
Allograft	Ventriculoperitoneal shunt
Unit rod instrumentation	Seizures
Increased blood loss	High preoperative WBC and platelet counts
Nutritional status	
Poor nutritional status	Gastrostomy tube
High body weight	Gastroesophageal reflux disease

Nutrition is one of the most important factors predicting the development of SSI as lower body mass index correlates with a higher risk of SSI because of poor wound healing and immunological compromise in this subpopulation [22]. The lowest incidence of SSI in CP patients in the literature of 1% (equaling the incidence in non CP patients) was found by Lonstein et al. with routine use of preoperative nutritional assessment and supplementation protocols [10]. In addition gastrostomy tube was found to be an independent risk factor with a risk ratio of 1.9 (marker of a more profound neurological impairment) [8]. On the contrary, high body weight is also associated to deep infections; one-kilogram increase in weight increases infection rate by 5% [16,19]. Adipose tissue seems to have a higher electrical resistance and following the use of electrocautery, it may result in hematoma with a higher risk of infection.

4. Clinical findings

Infection in CP patients may be completely asymptomatic. A minor change in nutritional intake should raise the suspicion to an underlying infection. When present, the most common symptom is pain [1,3]. Pain at night and a postoperative pain free period followed by a new onset of painful episodes are characteristic. Systemic symptoms may be absent, but if any fever is the most common. The addition of chills, sweats, or lethargy are red flags for severity and sepsis should be suspected. On the other hand, erythema or tenderness over a healed incision could be the only signs of late infection. Superficial SSI differs little from deep SSI but physicians must always consider the infection deep until proven otherwise. While early symptoms of local pain, erythema, drainage and warmth suggest a superficial SSI, systemic signs of fever and chills are signs of more serious deep infection. Finally, deep infection must be assumed when a short course treatment with antibiotics does not improve the clinical status.

5. Outcomes and prevention

The presence of infection affects the outcomes of the surgical treatment of scoliosis in CP patients. First, infection, especially deep infection, increases the likelihood of implant removal and the incidence of pseudarthrosis. In fact, up to the fourth of infected patients develop non-union which is associated with instability and low back pain [7]. Even without the presence of pseudarthrosis, CP patients with history of treated and healed SSI report more back pain compared to non-infected patients [5]. Therefore, the best way to achieve a better outcome is to prevent infections. Table 3 describes our own strategy to prevent spine infections.

As discussed above, surgical parameters are important risk factors for SSI. Although baseless, one of the reported efficient ways to decrease infection is by mixing the used graft with vancomycin powder [9]. Moreover, the rate of wound infection is decreased with modern instrumentations [2] and up to ten times with the use of pulse irrigation system [23]. Wound closure techniques seem to influence the rate of infection; Ward et al. decreased the rate of SSI in non-idiopathic scoliosis with the use of plastic multilayered closure techniques and rotational flap coverage [24]. Antibiotic prophylaxis are tailored to hospital protocols and given prior to incision. Nonetheless, with the presence of gastrostomy tube, gram negative prophylaxis added to the standards is recommend to these patients [8]. Inanmaz found a three times decrease of the incidence of SSI in neuromuscular scoliosis with the use of prophylactic hyperbaric oxygen [25]. Even more, hyperbaric oxygen could be used as an adjuvant for treating SSI [26]. Despite this, its use could not be an alternative to preoperative antibiotic prophylaxis. The most important modifiable preoperative factor is nutritional