Infection Rate after Spine Surgery in Cerebral Palsy is High and Impairs Results

Multicenter Analysis of Risk Factors and Treatment

Paul D. Sponseller MD, Suken A. Shah MD, Mark F. Abel MD,
Peter O. Newton MD, Lynn Letko MD, Michelle Marks MS, PT

Published online: 19 June 2009

© The Association of Bone and Joint Surgeons® 2009

Abstract Infection is a serious complication of surgery to correct scoliosis in patients with cerebral palsy (CP). We obtained multicenter representative figures for deep and superficial infection rates, analyzed risk factors and treatment outcomes, and compared deformity correction relative to infection. We retrospectively reviewed 157 patients who had posterior spinal fusion for CP at one of eight centers. Preoperative and intraoperative variables were subjected to multivariate analysis to determine factors

predictive of infection. There were 16 wound infections (10%; nine deep, seven superficial). Only two study factors predicted infection: higher preoperative white blood cell count (8.5 versus 6.4 [in those without infection] $\times 10^3$) and use of a unit rod (15% versus 5% for bent rods). Fourteen patients underwent irrigation and débridement procedures. Five infections required 2 months or longer to resolve. Two had implant removal. Final curve correction was lower for those with deep infections than those without (67% versus 53%, respectively). We noted a trend toward greater percentages of pain at last followup in those with deep infection than in those without infection (50% versus 18%, respectively) but the study was not adequately powered to confirm this point. Our infection rate in scoliosis surgery for CP was higher than that for most elective spinal deformity surgery.

Level of Evidence: Level III, retrospective case-control study. See Guidelines for Authors for a complete description of levels of evidence.

One or more authors (PDS, SAS, MFA, PON, LL, MM) received funding from DePuy Spine, Inc through unrestricted support of the Harms Study Group.

Each author certifies that his or her institution has approved or waived approval for the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research.

This work was performed at the Johns Hopkins Medical Institutions, Baltimore, MD, the Alfred I duPont Institute, Wilmington, DE, the University of Virginia, Charlottesville, VA, the Rady Children's Hospital, San Diego, CA, and the Klinikum Karlsbad, Langensteinbach, Germany.

P. D. Sponseller (✉)
The Johns Hopkins Medical Institutions, 601 North Caroline
St #5212, Baltimore, MD 21287-0882, USA
e-mail: psponse@jhmi.edu

S. A. Shah
Alfred I duPont Institute, Wilmington, DE, USA

M. F. Abel
University of Virginia, Charlottesville, VA, USA

P. O. Newton, M. Marks
Rady Children's Hospital, San Diego, CA, USA

L. Letko
Klinikum Karlsbad, Langensteinbach, Karlsbad, Germany

Introduction

Infection is a major setback in spinal deformity surgery, especially when it occurs in a compromised host such as the patient with cerebral palsy (CP). Several reports suggest an increased rate of surgical infection in this population [3, 5, 6]. However, most studies involved the results of a single surgeon or center, results that may reflect center- or physician-dependent treatment and patient groups rather than those of the overall population. In addition, some centers may have considered infection in this population to be an aberration rather than a clinically important issue, leading to an underestimate of its true occurrence.

Wound infection is the subject of intense study and preventive efforts. To develop effective strategies for prevention and treatment, it is important to understand the scope of the problem and the risk factors for its development. Therefore, we elected to use a broader base of surgeons and patients in an effort to provide data more representative of the general community. We also elected to focus attention on the outcomes after infection develops, a concept that, to our knowledge, has not been studied.

In a large group of patients with cerebral palsy who had spinal fusion for spinal deformity we (1) determined the rates of overall, deep, and superficial infection; (2) analyzed risk factors for infection; and (3) analyzed outcomes of the treatment of the infection, including the deformity correction in patients with and without infection.

Materials and Methods

We retrospectively reviewed the data of eight treatment centers from 1995 to 2004 to identify patients who had had spinal fusion for CP. Surgeons contributed cases for the portion of this time during which they were operating.

During the collection time, 384 patients had surgery for scoliosis. Of those 384 patients, the 157 (41%) who had returned for a minimum of 2 years of followup formed our study group. The 157 patients had a mean ($\pm$ standard deviation) age at surgery of 13.5 ± 2 years, a mean preoperative curve size of $77^\circ \pm 22^\circ$ (range, 22° – 128°), and a mean followup of 3.5 years (range, 2–12 years) (Table 1). Of the identified 157 index procedures performed, 109 were posterior-only fusions and 48 were anterior and posterior fusions; 39 of the latter were same-day procedures and nine were staged. Implants used were classified as unit rods (79 patients) or custom-bent rods (78 patients). None of the patients had an open ulcer at the time of surgery. We had prior institutional review board approval from all participating institutions.

We defined an infection as superficial if it was confined to the level above the paraspinous fascia and if it required antibiotics or wound dressing changes (determined during wound care). We defined an infection as deep if it extended below that fascia. Organisms isolated from the infections included pseudomonas (4), proteus (1), methicillin-sensitive (2) or methicillin-resistant (2) *Staphylococcus aureus*, and methicillin-resistant *Staphylococcus epidermidis* (1).

Table 1. Factors entered into logistic regression and corresponding values in the noninfected and infected groups

Factor	Uninfected patients	Infected patients	p Value
Anterior and posterior versus posterior only	69% posterior only	75% posterior only	0.61
Staged procedure	6% staged	6.3% staged	0.93
Posterior rod type	75% unit rod	48% unit rod	0.04*
Overall estimated blood loss	1985	2186	0.63
Overall operating room time	356	377	0.49
Age	13.4	14.5	0.14
Mental retardation	87%	82%	0.62
Nonverbal?	68%	81%	0.27
Weight for age	57.4% (3rd percentile)	57.1% (3rd percentile)	0.45
Past medical history: seizures	66%	69%	0.83
Past medical history: hydrocephalus	11%	6%	0.54
Past surgical history: feeding tube	42%	50%	0.53
Gross motor function classification system	61% Level 5	69% Level 5	0.59
Ambulatory status	19% ambulatory	20% ambulatory	0.95
Hemoglobin	14	15	0.96
Hematocrit	42	45	0.79
Platelet count	241	265	0.56
White blood cell count	6.4	8.5	0.003*
Lymphocyte count	33	30	0.83
Albumin count	4.3	3.8	0.59
Total protein	7.25	7.33	0.99
Prophylactic antibiotics	72% received one	87% received one	0.68
Preoperative major curve	78°	70°	0.19
Preoperative pelvic obliquity	7.5	5.6	0.14

* Significant finding.

The frequency of Gram-negative organisms equaled or exceeded that of Gram-positive organisms, as reported previously in the neuromuscular population [5].

We analyzed the following factors we presumed might predict infection: age, mental retardation, ambulatory status, weight for age, presence of feeding tubes, total protein and total lymphocyte count preoperatively, estimated blood loss, use of broad-spectrum prophylactic antibiotics, performance of a posterior-only versus a one- or two-stage anteroposterior procedure, and preoperative curve magnitude.

We analyzed the outcomes of the infection (eradication of infection, percent curve correction, pseudarthrosis seen on conventional radiographs as sclerosis or discontinuity in the fusion mass, pain as reported by caregivers, and need for implant removal).

Preoperative and intraoperative variables previously presumed associated with infection were subjected to multivariate analysis to determine factors predictive of infection. Binary logistic regression analysis was performed to determine which of the factors predicted infection. Analysis of variance was used to further evaluate

differences in predictive variables between patients with and without infection. Data were checked for normality of distribution (Q–Q plots) and equality of variances (Levene's test). For categorical predictors, chi square analysis was used. Data were analyzed using Statistical Package for the Social Sciences version 12.0.1 (SPSS, Inc., Chicago, IL).

Results

We identified 16 patients among the 157 (10%) who had wound infections. Of those 16, nine (6% of the total series) were deep and seven (4% of the total series) were superficial. All infections presented within 3 months after surgery.

Patients with postoperative infections had higher ($p = 0.003$) preoperative platelet (265 versus 241×10^3) and white blood cell counts (8.5 versus 6.4×10^3) than those without. Unit rods were associated with a higher ($p = 0.03$) overall infection rate than were custom-bent rods (15% versus 5%, respectively). Of the nine deep

Table 2. Information on the 16 patients with infection

Type of infection (patient number)	Age (years)	Preoperative curve (°)	Estimated blood loss (mL)	Approach	Organism	Irrigation and débridement (# times and other treatments)	Time to infection eradication	Implant removal	Final correction (%)
Deep (1)	18	73	1400	Posterior	Pseudomonas/ MRSA	1 + VAC	44 days	Revision due to PJK	65
Deep (2)	14	90	2000	Posterior		2	94 days		62
Deep (3)	12	42	700	Posterior		1	—*		32
Deep (4)	14	43	1980	Posterior		1	2 weeks		100
Deep (5)	14	57	1000	Posterior	S. aureus	3	8 months	Rod removal 1 year postoperative	35
Deep (6)	18	35	3020	Posterior	S. aureus	1 + packing	15 days		60
Deep (7)	20	105	1000	Posterior		4 + VAC	18 months	Implant removal	58
Deep (8)	15	72	2000	Posterior		1 + VAC	11 days		67
Deep (9)	15	50	700	Posterior		1 + VAC	—		27
SF (1)	9	75	3300	Posterior	MRSA	1	—		64
SF (2)	14	52	3700	Posterior		packed	3.5 months		63
SF (3)	11	96	7376	Posterior	S. aureus	y	43 days		16
SF (4)	19	75	1500	Posterior/ anterior	S. aureus	y	41 days		57
SF (5)	13	95	1000	Posterior/ anterior		2	—		84
SF (6)	12	47	1550	Posterior/ anterior		2	6 months		67
SF (7)	15	120	1500	Posterior/ anterior		packed	2 months		58

MRSA = methicillin-resistant *Staphylococcus aureus*; VAC = vacuum-assisted closure; PJK = proximal junctional kyphosis; S. aureus = *Staphylococcus aureus*; SF = superficial; * Unknown.

infections, we found similar infection rates ($p = 0.19$) for unit rods and custom-bent rods (9% versus 4%, respectively). The other variables also did not predict infection (Table 1). Urinary tract infections occurred in similar percentages ($p = 0.23$) of patients without and with wound infection (seven of the 141 patients [5%] without a wound infection and two of the 16 [13%] with wound infections. Patients who had an infection develop had a similar ($p = 0.19$) preoperative curve magnitude as did patients who did not have an infection develop ($70^\circ \pm 25^\circ$ versus $78^\circ \pm 22^\circ$, respectively) (Table 2).

The final curve correction was lower ($p = 0.04$) for those patients with deep infections than for those without infection (67% versus 53%, respectively). We observed no pseudarthroses on conventional radiographs. Fourteen patients underwent irrigation and débridement procedures (11, once; one, twice; one, three times; and one, four times), five infections required 2 months or longer to resolve, and two patients had implant removal; both of the latter had deep infections. Four patients had deep wound infections, all of which were successfully treated with vacuum-assisted closure. Pain was reported at last followup in 50% of those with deep infection and 18% of those without infection ($p = 0.09$); the power for pain analysis was too low (35%) to allow definitive conclusions.

Discussion

Understanding the scope of a healthcare problem and its associated risk factors are critical elements for the development of effective prevention and treatment strategies. For patients with CP who undergo spinal surgery, infection can affect outcome. In addition, payment to hospitals for treatment of acquired infections is at risk. Much of the available relevant literature is single-surgeon or single-center generated, and the resultant data may not be applicable to the overall population. Therefore, we used a multicenter approach to provide more representative data and to address the outcome after infection. Our purposes were to (1) obtain representative figures for the rates of overall, deep, and superficial infection; (2) analyze risk factors for infection; and (3) analyze outcomes of the treatment of the infection, including the deformity correction, in patients with and without infection.

There were five major limitations to our study. First, with the retrospective nature of the study we did not have consistent definitions of infection; a prospective analysis might provide a clearer definition of infection, with more attention paid to identifying associated organisms and to defining more clearly superficial versus deep infections. Second, the accuracy of all data may arguably be better in a prospective than a retrospective study. Such a study is

currently underway. Third, our varying surgeon experience may have had both positive and negative effects: it may appropriately reflect the surgical experience in general, but it may not represent the optimal state of the art. Fourth, we did not perform any interobserver or intra-observer reliability analyses. Fifth, fewer than 50% of patients returned for 2-year followup. This return rate was the result of many factors, including aging beyond the pediatric realm, lowered motivation for followup once active issues were resolved, and others. Although we are unaware of a bias that might have bearing on the infection rate, the study would have been stronger with a larger percentage of followup. There is a potential for misinterpretation of the data based on the sample that returned for followup.

We found overall, deep, and superficial infection rates of 10%, 6%, and 4%, respectively. Infection is a common problem after spinal fusion in patients with CP. Our rate of 6% deep infection contrasts to the commonly observed 1% to 2% rate for adolescent idiopathic scoliosis [1, 4], but is well within the range quoted in the literature [1, 7, 10, 11]. The data on the rate of superficial infection are less clear, but at least another 4% of our patients had superficial infection.

We identified two risk factors for developing infection: higher preoperative platelet and white blood cell counts. The reason for the finding of the unit rod as a predictive factor of overall infections is speculative, but it may be related to the higher blood replacement needed for the patients treated with a unit rod. Alternatively, it may be related to differences in the surgical process or reporting at the institutions performing unit rods.

In terms of outcome, the occurrence of an infection represents a major setback for the patient, with short-term and long-term implications [4]. In the short term, most of our patients (14 of 16) underwent at least one reoperation for débridement and possible closure, and five infections required at least 2 months to resolve. The long-term implications often involve compromise of the final result; in our series, two patients had implant removal, and we found less final coronal curve correction in patients with a deep infection (53% of preoperative curve versus 67% for the noninfected cohort). Probable reasons for this finding may have included an increased rate of pseudarthrosis or delayed fusion and the occurrence of compromised fixation because of the infection. Finally, there was a greater reporting of postoperative pain in patients who had had infection than in those who had not. This finding may represent the same factors listed for deep infection, as well as soft-tissue problems related to the paraspinal muscle or incision.

Risk factors for infection were difficult to elucidate. A widely reported tenet is that preoperative nutritional

Table 3. Infection data from published and current series on surgical correction of cerebral palsy scoliosis

Series	Number of patients	Instrumentation	Mean followup (years)	Number (%) of infections (deep/ superficial)	Type of organisms (#)	Risk factors	Treatment of deep infections	Implant removal	Comments
Jevsevar and Karlin 1993 [3]	44	Harrington or Luque	Not stated	2 (4.5)/1 (2.3)	Not stated	Low albumin Low total lymphocyte count	Not stated	Not stated	Low albumin and total lymphocyte count increased infection risk
Cassidy et al. 1994 [2]	17	Harrington, Luque, CD	4.7	0/0	N/A	N/A	N/A	N/A	Small series
Szoke et al. 1998 [6]	172	Unit rod	3.3	7 (4)/8 (5)	Staphylococcus aureus (15) Citrobacter (2) Proteus (2) Enterococcus (2) Escherichia coli, pseudomonas, streptococcus B, serratia, morganella (1)	Severe mental retardation Nonambulatory status Seizure disorders	Irrigation and débridement Wound left open	1	All deep infections were distal.
Tsirikos et al. 2003 [8]	45	Unit	3.2	3 (6.6)/3 (6.6)	Not stated	None	Irrigation and débridement Wound left open	2	All patients had anterior and posterior surgery
Teli et al. 2006 [7]	60	CD	6.5	2 (3.3)/Not stated	Not stated	Not stated	Irrigation and débridement	2	Not stated
Tsirikos et al. 2008 [9]	287	Unit	8.3	12 early deep (4.2) and 6 late deep (2.1) [did not address superficial]	Not stated	Not stated	Irrigation and débridement Wound left open	3	Includes patients from Szoke et al. 1998 [6] and Tsirikos et al. 2003 [8]
Sponseller et al. (current study)	157	Segmental or unit rods	3.5	9 (6)/7 (4)	Pseudomonas (4) Proteus (1) MSSA (2) MRSA (2) MRSE (1)	Unit rod Elevated white blood cell count	Irrigation and débridement	2	Multicenter study

CD = Cotrel-Dubousset; MSSA = Methicillin-sensitive Staphylococcus aureus; MRSA = Methicillin-resistant Staphylococcus aureus; MRSE = Methicillin-resistant Staphylococcus epidermidis.

indicators such as total protein, albumin, and weight for age would predict an increased infection rate [3, 6]. These findings were not supported by our study. The finding that an increased white blood cell count was associated with an increased risk of infection was unexpected and remains to be explained. It seems that a preventive strategy should be aimed at improving the operative process for all patients having this surgery, not only the preoperatively malnourished (Table 3) [2, 8, 9].

With the experience of eight centers, we provide a representative figure of 6% deep and 4% superficial infection rate in scoliosis surgery for CP. This is higher than in most elective spinal deformity surgery. Higher preoperative white blood cell count and use of a unit rod (for the overall infection rate) were the two factors associated with an increased risk of infection. The final result may be compromised, and implant removal is sometimes required to clear infection in these medically fragile, complex hosts.

Acknowledgments We thank the following additional surgeons for contributing patients to the study: Daniel Sucato, MD, James Guille, MD, Harry Shufflebarger, MD, Lawrence Lenke, MD, Jurgen Harms, MD, Keith Bridwell, MD, Freeman Miller, MD, Kirk W. Dabney, MD, and Randal R. Betz, MD.

References

1. Benli IT, Ates B, Akalin S, Citak M, Kaya A, Alanay A. Minimum 10 years follow-up surgical results of adolescent idiopathic scoliosis patients treated with TSRH instrumentation. *Eur Spine J*. 2007;16:381–391.
2. Cassidy C, Craig CL, Perry A, Karlin LI, Goldberg MJ. A reassessment of spinal stabilization in severe cerebral palsy. *J Pediatr Orthop*. 1994;14:731–739.
3. Jevsevar DS, Karlin LI. The relationship between preoperative nutritional status and complications after an operation for scoliosis in patients who have cerebral palsy. *J Bone Joint Surg Am*. 1993;75:880–884.
4. Richards BS, Hasley BP, Casey VF. Repeat surgical interventions following “definitive” instrumentation and fusion for idiopathic scoliosis. *Spine*. 2006;31:3018–3026.
5. Sponseller PD, LaPorte DM, Hungerford MW, Eck K, Bridwell KH, Lenke LG. Deep wound infections after neuromuscular scoliosis surgery. *Spine*. 2000;25:2461–2466.
6. Szoke G, Lipton G, Miller F, Dabney K. Wound infection after spinal fusion in children with cerebral palsy. *J Pediatr Orthop*. 1998;18:727–733.
7. Teli MGA, Cinnella P, Vincitorio F, Lovi A, Grava G, Brayda-Bruno M. Spinal fusion with Cotrel-Dubousset instrumentation for neuropathic scoliosis in patients with cerebral palsy. *Spine*. 2006;31:E441–E447.
8. Tsirikos AI, Chang WN, Dabney KW, Miller F. Comparison of one-stage versus two-stage anteroposterior spinal fusion in pediatric patients with cerebral palsy and neuromuscular scoliosis. *Spine*. 2003;28:1300–1305.
9. Tsirikos AI, Lipton G, Chang WN, Dabney KW, Miller F. Surgical correction of scoliosis in pediatric patients with cerebral palsy using the unit rod instrumentation. *Spine*. 2008;33:1133–1140.
10. Wimmer C, Gluch H. Aseptic loosening after CD instrumentation in the treatment of scoliosis: a report about eight cases. *J Spinal Disord*. 1998;11:440–443.
11. Wimmer C, Nogler M, Frischhut B. Influence of antibiotics on infection in spinal surgery: a prospective study of 110 patients. *J Spinal Disord*. 1998;11:498–500.