

Major perioperative complications after spine surgery in patients with cerebral palsy: assessment of risk factors

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Abstract

Purpose A prospective, longitudinal cohort was studied to determine the incidence, consequences, and risk factors of major perioperative complications in patients with cerebral palsy (CP) treated with spinal fusion. There is a wide variety of data available on the complications of spine surgery; however, little exists on the perioperative complications in patients with CP.

Methods A prospective multicenter dataset of consecutive patients with CP treated with spinal fusion was evaluated. All major perioperative complications were identified and stratified into categories: pulmonary,

gastrointestinal, other medical, wound infection, neurological, instrumentation related, and unplanned staged surgery. Univariate and multivariate analyses were performed to identify various risk factors for major perioperative complications.

Results 127 patients were identified with a mean age of 14.3 ± 2.6 years. Overall, 39.4 % of the patients had a major perioperative complication. Occurrence of a complication [no complication (NC), yes complication (YC)] resulted in significantly increased intensive care unit (ICU) (NC = 3.2 days, YC = 7.8 days, $p < 0.05$) and hospital stays (NC = 7.7 days, YC = 15.6 days, $p < 0.05$). Variables associated with greater risk of a complication included: increased estimated blood loss (EBL) ($p < 0.001$), larger preoperative kyphosis ($p = 0.05$), staged procedures ($p < 0.05$), a lack of antifibrinolytic use ($p < 0.05$), and a trend toward lower body mass index (BMI) ($p = 0.08$). Multivariate regression analysis revealed an increased EBL as independently associated with a major perioperative complication ($p < 0.05$).

Conclusions In this cohort of patients with CP who underwent spinal fusion, 39.4 % experienced a major perioperative complication, with pulmonary being the most common. The occurrence of a major perioperative complication lengthened both ICU and hospital stay. Risk factors for major perioperative complications included greater preoperative kyphosis, staged procedures, a lack of antifibrinolytic use, and increased EBL, with the latter being an independent predictor of a major perioperative complication.

Level of evidence 2.

Keywords Perioperative complications · Spinal fusion · Cerebral palsy

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Introduction

Scoliosis is the most common spinal abnormality in patients with cerebral palsy (CP), with an incidence ranging from 15 to 80 % [1–3]. There is a vast literature published on the surgical treatment of neuromuscular scoliosis in patients with CP [4–12], but few studies have documented the complications involved with those procedures [8, 12–21], with the majority including patients with CP as a subgroup of patients with neuromuscular scoliosis [16–21].

Based on the current literature, complications involving the treatment of neuromuscular scoliosis are common, with rates ranging from 44 to 62 % [16–18, 20, 21]. In 2007, Mohamad et al. [19] reported on 175 patients with neuromuscular scoliosis, 73.7 % of whom had CP. They found an overall perioperative complication rate of 33.1 % (58/175) and concluded that patients with a history of seizures or those who experienced increased intraoperative blood loss were more likely to experience complications [19]. To date, Tsirikos et al. [12] have published the largest study on complications in a series of 287 patients with CP treated with unit rod instrumentation, reporting an intraoperative complication rate of 10.8 % (38/287), an early postoperative (within 6 weeks) complication rate of 9.4 % (27/287), and a late postoperative complication rate of 10.1 % (29/287). However, this study was retrospective and did not report on the risk factors that may lead to major perioperative complications in the treatment of scoliosis in patients with CP.

The purpose of this study was to define the incidence of major perioperative complications in patients with CP treated with spinal fusion and determine its impact on the length of intensive care unit (ICU) and hospital stays. Furthermore, this study sought to identify the risk factors that may be associated with major perioperative complications in these patients.

Materials and methods

Institutional Review Board approval for the study was obtained locally from each contributing institution's review board, and written and informed consent was obtained from each patient prior to preoperative data collection. The prospectively collected multicenter database of consecutive patients with CP treated with spinal fusion was queried to identify cases with at least 90 days of follow-up. From a total of 131 patients, the 127 patients with at least 90 days of follow-up were included.

Data collection forms were completed by the investigators at the preoperative, operative and postoperative visits. Clinical, radiographic, and intraoperative measurements were recorded. All major perioperative (within 90 days of

surgery) complications as defined by Hod-Feins et al. [22] were identified by the treating physicians at the times of evaluation and stratified into categories including: pulmonary, gastrointestinal, other medical, wound infection, neurologic, instrumentation related, and unplanned staged surgery. The major pulmonary complications included were respiratory compromise requiring reintubation or prolonged intubation and pneumonia or significant pleural effusion requiring chest tube placement. Pulmonary complications including asymptomatic atelectasis, pulmonary contusions, or pleural effusion were not included. We excluded the aforementioned complications as there was variability among the sites in reporting these entities. However, any complication which necessitated an intervention, such as placement of a chest tube, was included. The major gastrointestinal complications included gastrointestinal bleeding, superior mesenteric artery syndrome, and pancreatitis. Gastrointestinal complications including constipation, elevated liver enzymes or bilirubin, nausea, or vomiting were not included. The major "other" medical complications included postoperative coagulopathy or acute hemodynamic instability requiring resuscitation with inotropic support. The major neurologic complications included any motor or sensory complications or changes in bladder continence. Infections and instrumentation-related complications were only considered major complications if they required a reoperation. Unplanned second surgery included those patients in whom the first attempt was aborted.

Univariate and multivariate analyses were performed on a variety of possible risk factors for major perioperative complications including: age, gender, body mass index (BMI), gross motor function classification system level, ambulatory status, seizure status, use of divalproex sodium (Depakote), preoperative major coronal Cobb angle, preoperative kyphosis (T2–T12), preoperative pelvic obliquity, fusion to the pelvis, preoperative albumin, preoperative white blood cell count (WBC), preoperative total protein, antifibrinolytic use, estimated blood loss (EBL), operative time, surgical approach, and staged procedures.

Statistical analysis was performed using the SPSS 12.0.2 statistical package (SPSS Inc., Chicago, IL). All results were reported as means plus or minus standard deviation (SD) with a significance level of 0.05 and a confidence interval of 95 %.

Results

Patient demographics (Table 1)

A total of 127 patients with CP treated with spinal fusion were identified with a mean age of 14.3 ± 2.6 years. 58.3 % (74/127) of the patients were male. The mean

Table 1 Patient demographics

Patients (N)	127
Age \pm SD (years)	14.3 \pm 2.6
Males (%)	58.3
Approach	
Posterior	112
Anterior/posterior	14
Anterior	1
Coronal Cobb angle	
Major \pm SD ($^{\circ}$)	80.9 \pm 27.4
Minor \pm SD ($^{\circ}$)	35.6 \pm 16.8
% Flexibility	
Major \pm SD (%)	36.0 \pm 16.9
Minor \pm SD (%)	29.1 \pm 22.5
Kyphosis (T2–T12) \pm SD ($^{\circ}$)	43.1 \pm 23.1
Lordosis (T12 to top of sacrum) \pm SD ($^{\circ}$)	–38.4 \pm 33.6
Sagittal balance (C7 to sacrum) \pm SD (cm)	1.6 \pm 6.9
Pelvic obliquity \pm SD ($^{\circ}$)	63.1 \pm 14.9

SD Standard deviation

Table 2 Distribution of major perioperative complications

Total Complications (%)	39.4
Pulmonary	29.9
Gastrointestinal	18.9
Other medical	11.8
Wound infection	4.7
Instrumentation related	1.6
Unplanned staged surgery	0.8
Neurologic	0.8

preoperative radiographic measurements were: major coronal Cobb angle $80.9^{\circ} \pm 27.4^{\circ}$, minor coronal Cobb angle $35.6^{\circ} \pm 16.8^{\circ}$, major coronal curve percent flexibility $36.0 \pm 16.9\%$, minor coronal curve percent flexibility $29.1 \pm 22.5\%$, kyphosis (T2–T12) $43.1^{\circ} \pm 23.1^{\circ}$, lordosis (T12 to top of sacrum) $-38.4^{\circ} \pm 33.6^{\circ}$, sagittal balance (C7 to sacrum) 1.6 ± 6.9 cm, and pelvic obliquity $63.1^{\circ} \pm 14.9^{\circ}$. Eleven patients had staged procedures.

Major perioperative complications (Table 2)

Overall, there were 87 major perioperative complications in 50 patients for a major perioperative complication rate of 39.4 % (50/127). The major perioperative complications occurred at the following rates: Pulmonary 29.9 % (38/127), gastrointestinal 18.9 % (24/127), other medical (coagulopathy and severe hypotension) 11.8 % (15/127), wound infection 4.7 % (6/127), instrumentation related 1.6 % (2/127), unplanned staged surgery 0.8 % (1/127), and neurologic 0.8 % (1/127).

Of the pulmonary complications, five patients required reintubation for respiratory failure, seven patients required prolonged intubation, three patients required CT placement for effusion, and two patients required tracheostomy. In addition, 73.7 % (28/38) of these patients had a past medical history significant for asthma, pneumonia, or aspiration. Of the gastrointestinal complications, 22 patients had pancreatitis, one patient experienced ischemic colitis requiring bowel resection, and one patient experienced *Clostridium difficile* colitis. We hypothesize that the cause of pancreatitis is multifactorial and includes lengthy time in the prone position, blood loss, and potential stretching of the vascular supply after deformity correction. Thirteen patients had an acute hypotensive event requiring support for hemodynamic instability. There was one patient who died from cardiorespiratory failure. Two patients experienced severe intraoperative coagulopathy. Regarding wound infection complications, five patients required reoperation for deep wound infections, and one patient had an incision and drainage for a suspected deep wound infection. Of the instrumentation-related complications, one patient experienced proximal junctional kyphosis requiring a reoperation, and the other required revision surgery for prominent instrumentation with removal of the superior aspect of the unit rod and application of a cross-connector. One patient had the primary attempt at correction halted prior to completion after experiencing excessive blood loss; the patient had an unplanned second procedure 4 days later. One patient experienced a neurologic complication involving a nerve root injury resulting in neuropathy to the right upper leg.

Occurrence of a complication [no complication (NC), yes complication (YC)] resulted in a significantly increased ICU (NC = 3.2 days, YC = 7.8 days, $p < 0.05$) and hospital stay (NC = 7.7 days, YC = 15.6 days, $p < 0.05$).

Risk factors (Table 3)

Univariate analysis revealed the following as risk factors associated with major perioperative complications: increased EBL ($p < 0.001$), larger preoperative kyphosis ($p = 0.05$), staged procedures ($p < 0.05$), a lack of antifibrinolytic use ($p < 0.05$), and a trend toward lower BMI ($p = 0.08$). Multivariate regression analysis revealed increased EBL as an independent predictor of a major perioperative complication ($p < 0.05$).

Discussion

Several studies have documented the incidence of complications in patients with CP treated with spinal fusion. In this study, the incidence of a major perioperative

Table 3 Risk factors for major perioperative complications

	Yes complication (<i>n</i> = 50)	No complication (<i>n</i> = 77)	<i>p</i> value
Estimated blood loss ± SD (cc)	2843.7 ± 1732.0	1656.2 ± 1150.2	<0.001
WBC ± SD (10 ⁹ cells/L)	7.4 ± 2.5	7.2 ± 2.8	0.70
Albumin count ± SD (g/dL)	4.5 ± 0.5	5.1 ± 6.6	0.53
Total protein ± SD (g/dL)	7.5 ± 0.7	8.8 ± 10.5	0.42
BMI ± SD (kg/m ²)	17.8 ± 5.5	20.9 ± 9.9	0.08
Major coronal Cobb ± SD (°)	77.5 ± 29.4	83.2 ± 26.0	0.26
Pelvic obliquity ± SD (°)	64.6 ± 14.6	62.2 ± 15.1	0.38
Kyphosis (T2–T12) ± SD (°)	48.0 ± 21.3	39.8 ± 23.8	0.05
Age at surgery ± SD (years)	14.2 ± 2.8	14.6 ± 2.5	0.42
Operative time ± SD (min)	409.3 ± 169.9	398.2 ± 202.5	0.75
Staged procedure (%)	72.7	27.3	<0.05
Antifibrinolytic use (%)	30.3	69.7	<0.05
Ambulation (%)	26.7	73.3	0.30
Fused to ilium (%)	39.8	60.2	0.70
Depakote use (%)	50.0	50.0	0.29
Male gender (%)	39.2	60.8	0.96

Bold indicates statistical significance

WBC White blood cell, BMI Body mass index, SD Standard deviation

complication was 39.4 %, with pulmonary being the most common category. The occurrence of a major perioperative complication significantly increased ICU and hospital length of stay. Risk factors for major perioperative complications included greater preoperative kyphosis, staged procedures, a lack of antifibrinolytic use, and increased EBL, with the latter being an independent predictor of a major perioperative complication.

Lonstein et al. [13] reported a 58 % rate for early complications (complications that occurred intraoperatively or during the hospital stay), and a 47 % rate for late complications (complications that occurred after discharge) in 93 patients with CP treated with the Luque–Galveston method. These values were higher than the 39.4 % rate of major perioperative complications in the current study because they included all complications rather than just the major perioperative complications (as defined by Hod-Feins et al. [22]) that we reported. Mohamad et al. [19] and Lonstein et al. [13] noted that respiratory complications were the most common complication in patients with neuromuscular scoliosis (mostly pneumonia and atelectasis). Previous studies have shown that respiratory diseases may be the most common cause of death in patients with CP [23–29]. The current study found that the majority (29.9 %) of major perioperative complications were pulmonary, and that 73 % of the pulmonary complications were for respiratory failure. In addition, 73.7 % (28/38) of the patients with major perioperative pulmonary complications had a past medical history significant for asthma, pneumonia, or aspiration. This leads the authors to suggest that a thorough

evaluation of the respiratory medical history (pneumonia, aspiration, or asthma) is necessary before proceeding with surgery in this cohort of patients. Some reasons for the high incidence of pulmonary issues may include the preexisting spine deformity impacting pulmonary volume and the fact that many of these patients are sitters and thus do not push their pulmonary capacity. Preoperative pulmonary optimization, whenever possible, may be most important in those patients identified preoperatively to have the most significant dysfunction.

Based on the Kaplan–Meier survival analysis, Tsirikos et al. [30] concluded that 68 % of patients with CP who have spinal instrumentation are expected to survive at least 11 years, with the most predictive determinant for survival rate being the number of days the patient had to spend after surgery in the ICU. Our study showed that there was a significant increase in both ICU and hospital length of stay in patients with CP who experienced major perioperative complications. This corresponds with Lonstein et al. [13] who also found a statistically significant increase in hospital length of stay associated with early infections. As a result, it is important for surgeons to try to minimize major perioperative complications in this patient population not only because these complications have an immediate impact on hospital and ICU length of stay, but because they may have a greater long-term impact on patient mortality. Longer follow-up time of the current study would be necessary to show this correlation.

In 2003, Tsirikos et al. [30] suggested that there was a weak relationship with kyphosis >90° decreasing survival rates in patients with CP undergoing spinal fusion. Our

study showed a similar relationship with preoperative kyphosis (T2–T12) being a risk factor for major perioperative complications in patients of the same subset.

In a different study, Tsirikos et al. [31] compared one-stage versus two-stage anteroposterior spinal fusion in patients with CP and found a higher rate of intraoperative blood loss, longer surgery times, and increased complications in the group that received single-stage anteroposterior spinal fusions. Our study showed different results, with univariate analysis revealing staged procedures as a risk factor for a major perioperative complication in patients with CP treated with spinal fusion. This was also supported by Ferguson et al. [32] who showed fewer complications in patients with neuromuscular scoliosis treated with a single-stage anteroposterior procedure compared to a two-stage anteroposterior procedure. This was supported by our study that showed 54.5 % (6/11) of the patients with staged procedures sustained major perioperative pulmonary complications (one of those patients also had pancreatitis, and one required a reoperation for an infection). Of the remaining five patients, one required an unplanned staged procedure due to increased blood loss leading to hypotension, one had pancreatitis, and the other three did not have any major perioperative complications.

In 1992, Kalen et al. [33] suggested that the best predictor for postoperative complications in children with CP who undergo spinal surgery is their degree of neurologic disability, along with associated medical problems and a curve $>70^\circ$.

The current study also revealed that the lack of antifibrinolytic use and increased estimated blood loss as risk factors for major perioperative complications in patients with CP treated with spinal fusion. There are studies that suggest that increased blood loss may lead to complications, mainly infections, in scoliosis surgery [34–37], but none have reported this finding in patients with CP. Our data did not show a relationship between increased estimated blood loss and higher rates of infection, but this is most likely due to the small number of complications in the study.

As would be expected, patients with CP undergoing spinal fusion sustain very different complications when compared to other pediatric cohorts, such as patients with adolescent idiopathic scoliosis. Utilizing the Morbidity and Mortality database from the Scoliosis Research Society [38], we found an overall complication rate of 5.7 %, which was substantially lower than the 39.4 % in our current series. In addition, the most common complication in their cohort of patients with posterior instrumentation and fusion for AIS was wound infection, whereas ours was pulmonary.

In conclusion, in this cohort of patients with CP who underwent spinal fusion, 39.4 % experienced a major perioperative complication, with pulmonary being the most common. The occurrence of a major perioperative

complication lengthened both ICU and hospital stay. Risk factors for major perioperative complications included greater preoperative kyphosis, staged procedures, a lack of antifibrinolytic use, and increased EBL, with the latter being an independent predictor of a major perioperative complication.

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Conflict of interest Research supported by a grant from the Setting Scoliosis Straight Foundation for the Harms Study Group

Informed consent IRB approval for the study was obtained locally from each contributing institution's review board, and consent was obtained from each patient prior to data collection.

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