

# In-hospital mortality and morbidity of pediatric scoliosis surgery in Japan

## Analysis using a national inpatient database

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### Abstract

Several previous reports have elucidated the mortality and incidence of complications after pediatric scoliosis surgery using nationwide databases. However, all of these studies were conducted in North America. Hence, this study aimed to identify the incidence and risk factors for in-hospital mortality and morbidity in pediatric scoliosis surgery, utilizing the Diagnosis Procedure Combination database, a national inpatient database in Japan.

We retrospectively extracted data for patients aged less than 19 years who were admitted between 01 June 2010 and 31 March 2013 and underwent scoliosis surgery with fusion. The primary outcomes were in-hospital death and postoperative complications, including surgical site infection, ischemic heart disease, acute renal failure, pneumonia, stroke, disseminated intravascular coagulation, pulmonary embolism, and urinary tract infection.

We identified 1,703 eligible patients (346 males and 1,357 females) with a mean age of 14.1 years. There were no deaths among the patients. At least one postoperative complication was found in 49 patients (2.9%). The most common complication was surgical site infection (1.4%). The multivariable logistic regression analysis showed that male sex (odds ratio, 2.22; 95% confidence interval, 1.28–3.70), comorbid diabetes (7.00; 1.56–31.51), and use of allogeneic blood transfusion (3.43; 1.86–6.41) were associated with the occurrence of postoperative complications. The present nationwide study elucidated the incidence and risk factors for in-hospital mortality and morbidity following surgery for pediatric scoliosis in an area other than North America. Diabetes was identified for the first time as a risk factor for postoperative complications in pediatric scoliosis surgery.

**Abbreviations:** DIC = disseminated intravascular coagulation, SSI = surgical site infection.

**Keywords:** allogeneic blood transfusion, diabetes, Japanese nationwide database, mortality, pediatric scoliosis, postoperative complications, risk factors

## 1. Introduction

Surgery for scoliosis is a relatively invasive procedure and can be associated with a high incidence of complications. There have been numerous studies regarding mortality and morbidity after

surgery for adult spinal deformities.<sup>[1–7]</sup> However, the spinal pathology of pediatric patients is distinctly different from that of adult patients. To understand the risks of surgery for pediatric scoliosis, studies focusing on pediatric populations are warranted. To date, several reports have elucidated the mortality and incidence of complications after pediatric scoliosis surgery using nationwide databases.<sup>[8–14]</sup> In these studies, postoperative mortality and morbidity were reported to range from 0.12% to 0.17% and from 3.7% to 14.9%, respectively.<sup>[8–14]</sup> These studies also identified risk factors for postoperative complications, including increased Elixhauser Comorbidity Score, combined anterior and posterior fusion surgery, hepatobiliary disease, cognitive impairment, elevated American Society of Anesthesiologists class, male sex, revision surgery, high body mass index, and prolonged operation time.<sup>[8,10–14]</sup> However, all of these studies were conducted in North America, and no national data have been reported from other areas. Hence, the present study aimed to investigate mortality and morbidity in pediatric scoliosis surgery in Japan, using a national inpatient database.

## 2. Materials and methods

### 2.1. Data source

The Diagnosis Procedure Combination database is a national administrative claims and discharge abstract database for

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acute-care inpatients in Japan, the details of which have been described elsewhere.<sup>[15–18]</sup>

We obtained inpatient data for a total of 33 months, comprising July 1, 2010 to March 31, 2013. In 2011, 980 hospitals participated in the database and provided data for 6.3 million patients, representing approximately 50% of all inpatient admissions to acute-care hospitals in Japan. The database includes International Classification of Diseases 10th Revision codes for primary and secondary diagnoses, comorbid conditions existing at admission, and complications occurring after admission. To optimize the accuracy of the recorded diagnoses, the physicians in charge are obliged to record the diagnoses with reference to medical charts. The Institutional Review Board at The University of Tokyo approved the study design.

## 2.2. Patients

We included all patients aged less than 19 years who underwent scoliosis surgery with fusion. Patients undergoing growth-friendly surgery, using growing rods or vertical expandable prosthetic titanium ribs (VEPTR) were not included in the study. Collected covariates included age, sex, diabetes mellitus, anesthesia time, use of allogeneic blood transfusion, hospital volume, and length of hospital stay. Hospital volume was categorized into tertiles, according to the annual number of spine surgeries at each hospital.

## 2.3. Outcomes

The outcomes evaluated in the study were in-hospital death and postoperative complications, including surgical site infection (SSI), ischemic heart disease, acute renal failure, pneumonia, stroke, disseminated intravascular coagulation (DIC), pulmonary embolism, and urinary tract infection.

## 2.4. Statistical analysis

Continuous variables were compared by a *t*-test. The chi-square test was used to compare categorical data. A multivariable logistic regression analysis was performed to determine factors associated with the occurrence of at least one postoperative complication. The threshold for significance was a value of  $P < .05$ . All statistical analyses were performed using SPSS ver. 23.0 (IBM Corp., Armonk, NY)

## 3. Results

We identified a total of 1703 patients who underwent scoliosis surgery with fusion and were aged  $< 19$  years. The patients comprised 346 males (20.3%) and 1357 females (79.7%) with a mean age of 14.1 years. Table 1 shows the characteristics of patients. Allogeneic blood transfusion was performed in 207 patients (12.2%). The median anesthesia time was 395 minutes. Diabetes was found in 11 patients (0.6%). The median length of hospital stay was 19 days.

There were no deaths among the patients. At least one complication was found in 49 patients (2.9%). The most common complication was SSI (1.4%), followed by pneumonia (0.6%), urinary tract infection (0.5%), DIC (0.2%), ischemic heart disease (0.2%), and acute renal failure (0.1%). Stroke and pulmonary embolism were not identified (Table 2).

Univariate comparisons showed that male sex, comorbid diabetes, and use of allogeneic blood transfusion were signifi-

**Table 1**

**Characteristics of the study population.**

Total	Overall	
	1703	(%)
Age, years; mean (SD)	14.1 [2.5]	
Sex		
Male	346	(20.3)
Female	1357	(79.7)
Anesthesia time, minutes; median (IQR)	395 [262–500]	
Diabetes	11	(0.6)
Allogeneic blood transfusion	207	(12.2)
Hospital volume		
$\geq 234$	830	(48.7)
130–233	664	(39.0)
$\leq 129$	209	(12.3)
Length of stay, days; median (IQR)	19 [16–26]	

IQR = interquartile range, SD = standard deviation.

cantly associated with the occurrence of at least 1 postoperative complication (Table 3). The mean length of hospital stay was significantly longer in patients with at least 1 complication than in patients without any complications (32.5 days vs 22.4 days;  $P < .001$ ).

The multivariable logistic regression analysis showed that postoperative complications were significantly associated with male sex (odds ratio, 2.22; 95% confidence interval, 1.28–3.70), comorbid diabetes (7.00; 1.56–31.51), and use of allogeneic blood transfusion (3.43; 1.86–6.41) (Table 4).

## 4. Discussion

This is the first study to demonstrate the in-hospital mortality and morbidity after pediatric scoliosis surgery in a nationwide clinical setting in an area other than North America. The study identified several predictive factors for postoperative complications after pediatric scoliosis surgery.

In Japan, length of hospital stay after surgery is relatively long compared with those in other countries, because postoperative rehabilitation is also performed during hospitalization. As the median length of hospital stay was 19 days, we believe that almost all postoperative complications in the acute phase were successfully captured in the present study.

No deaths were observed among the 1703 patients in the study. This is probably because of the small sample size, compared with other studies.<sup>[8–12]</sup>

**Table 2**

**Mortality and postoperative complications after surgery for pediatric scoliosis (n = 1703).**

	N	(%)
In-hospital death	0	(0)
Postoperative complications		
Surgical-site infection	24	(1.4)
Ischemic heart disease	3	(0.2)
Acute renal failure	2	(0.1)
Pneumoniae	10	(0.6)
Stroke	0	(0)
DIC	4	(0.2)
Pulmonary embolism	0	(0)
Urinary tract infection	9	(0.5)
At least one complication	49	(2.9)

DIC = disseminated intravascular coagulation.

**Table 3**  
Occurrence of at least one complication during hospitalization.

	N	(%)	P
Overall	49 /1703	(2.9)	
Age, years			.384
≥15	20/817	(2.4)	
≤14	29/886	(3.3)	
Sex			.001*
Male	20/346	(5.8)	
Female	29/1357	(2.1)	
Anesthesia time, minutes			0.306
≥361	32/980	(3.3)	
≤360	17/723	(2.4)	
Missing data	0 /4	(0)	
Diabetes			.038*
yes	2/11	(18.2)	
no	47/1692	(2.8)	
Allogenic blood transfusion			<.001*
yes	17/207	(8.2)	
no	32/1496	(2.1)	
Hospital volume per year			.806
≥234	26/830	(3.1)	
130–233	17/664	(2.6)	
≤129	6 /209	(2.9)	

\*  $P < .05$ .

The morbidity rate was 2.9% in the present study, which was lower than those in previous studies, ranging from 3.7% to 14.9%.<sup>[8–12,14]</sup> This discrepancy possibly arose through underestimation in the present study, because mild complications might have been underreported in the database as is reported in other studies utilizing the same database.<sup>[19–21]</sup>

This study identified several predictive factors for postoperative complications, including male sex, comorbid diabetes, and use of allogenic blood transfusion. De la Garza Ramos et al<sup>[12,13]</sup> reported that male sex was a risk factor for postoperative complications in pediatric fusion surgery. Roddy and Diab<sup>[22]</sup> revealed that unplanned readmission after fusion for pediatric spinal deformity was significantly higher in male patients. The results of the present study were compatible with the findings of these previous studies. The present study included about 4 times as many female patients as males. This is presumably because females are known to be much more likely to be affected by idiopathic scoliosis, which is the most frequent cause of scoliosis.

**Table 4**  
Multivariable logistic regression analysis for at least one complication during hospitalization.

	Odds ratio (95% confidence interval)	P
Age, years		.554
≥15	0.86 (0.52–1.43)	
≤14	Reference	
Sex		.004*
Male	2.22 (1.28–3.70)	
Female	Reference	
Diabetes		.011*
Yes	7.00 (1.56–31.51)	
No	Reference	
Allogenic blood transfusion		<.001*
Yes	3.43 (1.84–6.41)	
No	Reference	

\*  $P < .05$ .

The ratio of male-to-female patients in the present study was comparable with those in previous studies.<sup>[12,13,22]</sup>

This is the first report to identify diabetes as an independent risk factor for postoperative complications in pediatric scoliosis surgery. The risk of diabetes for postoperative SSI in spinal surgery has been well described.<sup>[23–25]</sup> In particular, patients with insulin-dependent diabetes or poorly controlled diabetes were more likely to have postoperative SSI.<sup>[26,27]</sup> Meanwhile, Cho et al<sup>[28]</sup> reported that comorbidity of non-insulin-dependent diabetes mellitus was not a risk factor for postoperative complications in spinal deformity surgery. In the present study focusing on pediatric patients, most patients with diabetes were thought to be insulin dependent, and also most frequent postoperative complication was SSI. Thus diabetes may have been eventually identified as a predictive factor for postoperative complications.

The risk of allogeneic blood transfusion is controversial. Minhas et al<sup>[29]</sup> identified that total transfusion volume of 20 mL/kg or more was associated with higher complication rates in patients with adolescent idiopathic scoliosis. Kelly et al<sup>[30]</sup> reported that allogeneic blood transfusion was not associated with postoperative infectious complications in adult spinal deformity patients. In the present study, allogeneic blood transfusion was identified as an independent risk factor for postoperative complications. Further studies are required to confirm the risk of allogeneic blood transfusion.

There are several limitations to this study. First, the etiology of scoliosis was not specified in the database. Therefore, the study included idiopathic, neuromuscular, congenital, and infantile patients, although the risks for postoperative complications were reported to differ among these groups.<sup>[10]</sup> Second, recorded diagnoses in retrospective studies are generally less well-validated than those in planned prospective studies. For example, neurological complications following surgery cannot be adequately identified in the database.

In conclusion, we investigated for the first time the mortality and morbidity of pediatric scoliosis surgery in an area other than North America, utilizing a Japanese national inpatient database. Among 1703 patients, there were no in-hospital deaths, and postoperative complications were identified in 49 patients (2.9%). A multivariable logistic regression analysis revealed that male sex, comorbid diabetes, and use of allogeneic blood transfusion were independent risk factors for in-hospital postoperative complications.

### Author contributions

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