Perioperative complications of spine surgery in patients 80 years of age or older: a multicenter prospective cohort study

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OBJECTIVE The number of spine surgeries performed in elderly patients is consistently increasing. However, to date the prevalence of and risk factors for perioperative complications remain unclear, especially in patients 80 years of age or older. This study had two goals: 1) determine the perioperative complications of spine surgery associated with patients 80 years of age or older; and 2) investigate the risk factors for perioperative systemic complications.

METHODS In this paper, the authors describe a multicenter prospective cohort study. Seven spine centers with board-certified spine surgeons participated in this all-case investigation. A total of 270 consecutively enrolled patients (109 males and 161 females), 80 years of age or older, underwent spine surgery between January and December 2017. Patients with trauma, infection, or tumor were excluded in this cohort. Perioperative complications were defined as adverse events that occurred intraoperatively or within 30 days postoperatively. The patients' preoperative health status was determined using the following means of assessment: 1) the Charlson Comorbidity Index, 2) the American Society of Anesthesiologists Physical Status Classification System, 3) the Eastern Cooperative Oncology Group Performance Status (ECOG-PS), 4) the presence of sarcopenia, and 5) the Geriatric Nutritional Risk Index. Associations among patient age, preoperative health status, surgical factors (instrumentation surgery, operation time, number of spinal levels treated, and estimated blood loss), and perioperative systemic complications were analyzed.

RESULTS Overall perioperative, surgical site, and minor systemic complications were observed in 20.0%, 8.1%, and 14.8% of patients, respectively. Major systemic complications, on the other hand, were not observed. The reoperation rate was low—only 4.1%. Multivariate analysis revealed that the ECOG-PS ($p = 0.013$), instrumentation surgery ($p = 0.024$), and an operation time longer than 180 minutes ($p = 0.016$) were associated with minor systemic complications.

CONCLUSIONS To the best of the authors' knowledge, this is the first multicenter prospective all-case investigation of perioperative complications of spine surgery in elderly patients. Although decreased daily activity (ECOG-PS), instrumentation surgery, and longer operation time were associated with minor systemic complications, no major systemic complications were observed in these elderly patients. Thus, spine surgery can be safely performed in elderly patients 80 years of age or older.

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KEYWORDS spine surgery; elderly; perioperative complications; risk factor

ABBREVIATIONS ADL = activity of daily living; ASA-PS = American Society of Anesthesiologists Physical Status; BKP = balloon kyphoplasty; CCI = Charlson Comorbidity Index; CI = confidence interval; EBL = estimated blood loss; ECOG-PS = Eastern Cooperative Oncology Group Performance Status; GNRI = Geriatric Nutritional Risk Index; OR = odds ratio; UTI = urinary tract infection.

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THE number of people 60 years of age or older is increasing throughout the world: one in five individuals will be 60 years or older by 2050.³² The number of persons 80 years or older was 125 million in 2015; this number will reach 434 million in 2050.

Spinal degenerative diseases, such as lumbar spinal stenosis, cervical spondylotic myelopathy, degenerative spondylolisthesis, and osteoporotic vertebral fracture, generally develop with advancing age.¹⁰ Based on a Japanese nationwide cohort study,¹⁵ approximately 600 spine surgeries (3.8% of all surgeries) were performed in patients older than 80 years of age in 2001. In the following decade, this number significantly increased fivefold to 3000 or more (10% of all surgeries in 2011). Japan has the highest aging population in the world, and elderly patients requiring spine surgery may be recognized globally as a group in the future.

Spine surgery for elderly patients (defined as 65 years and older) is considered effective in improving quality of life;^{20,30} it is also cost-effective.⁸ Surgical treatment is considered beneficial for elderly patients 80 years or older as well as for patients younger than 80 years,²⁹ and the efficacy of surgical treatment in these age groups is well maintained even after long-term follow-up.^{12,19,29}

Nevertheless, one should pay careful attention to perioperative complications in elderly patients. Hamel et al. showed that 20% of patients 80 years of age or older who underwent major noncardiac surgery experienced one or more postoperative complications.¹³ These authors also mentioned that mortality rates were higher in elderly patients than in younger patients (8.2% vs 2.8%). The rate of perioperative complications in spine surgery has been reported to range from 5.6% to 35% in patients 80 years of age or older.^{12,16,18,19,21,24,26,28,34}

The majority of earlier studies on perioperative complications were retrospective. One systematic review showed that the incidence of complications was higher in prospective studies than in retrospective studies (19.9% vs 16.1%).²² Previous studies revealed several risk factors, such as older age, presence of comorbidities, estimated blood loss (EBL), and the number of spinal levels that were treated, to be associated with perioperative complications of spine surgery in elderly patients.^{3,4,14,33} Some recent studies showed an association between perioperative complications of spine surgery and frailty, sarcopenia, or malnutrition,^{1,27,35} whereas other studies did not reveal any association between these factors.⁵ Given the disagreement, the association between perioperative complications of spine surgery and frailty, sarcopenia, and malnutrition remains unclear.

Surgeons are reluctant to perform spine surgery in elderly patients because of the high risk of perioperative complications due to the patient's advanced age. Moreover, the prevalence and risk factors of perioperative complications remain unclear, specifically for elderly patients who are 80 years or older. Spine surgeons therefore need more reliable data on which to determine the indications for surgical treatment. For that reason, we conducted a prospective all-case investigation. The study had two goals: 1) determine the perioperative complications of spine surgery associated with patients 80 years of age or older; and

2) investigate the risk factors for perioperative systemic complications.

Methods

Seven spine centers staffed with board-certified spine surgeons participated in this multicenter prospective cohort study in Hokkaido, Japan. The current study protocol was fully approved by the local institutional review board, and informed consent was obtained from the study participants. A total of 2847 spine surgeries were performed in 2017. Surgical treatment was indicated in patients who experienced disabilities that impacted their daily living due to pain after ineffective nonoperative treatment and/or neurological deficit: all participants were willing to undergo surgery and had sufficient knowledge of the potential risks of the surgery. In this study, we analyzed data from 270 consecutively enrolled patients who had undergone an elective spine surgery when 80 years or older (9.5% of the entire patient population); patients with trauma, infection, or tumor were excluded. Surgical interventions for pathological disorders related to osteoporosis were included in this study. Apart from balloon kyphoplasty (BKP), all posterior lumbar surgeries were performed by open procedures at our spine centers, and there were no cases of endoscopic surgery in the current study. A total of 109 males and 161 females with a mean age of 83.2 years (range 80–99 years) were included in the study (Fig. 1). Perioperative complications and potential risk factors were assessed by prospective observation. In this population, 213 patients (78.9%) were discharged home, and 57 patients (21.1%) were discharged to a facility other than home.

Surgical Factors

Surgical factors analyzed included the following: operative level (cervical, thoracic, and thoracolumbar–lumbosacral spine), surgical procedure (decompression, instrumentation surgery, and BKP), operation time, number of spinal levels treated, and EBL.

Perioperative Complications

Perioperative complications were defined as adverse events that occurred intraoperatively or within 30 days postoperatively. We divided all complications into three categories: surgical site complications, major systemic complications, and minor systemic complications. Surgical site complications included dural tear, hematoma requiring surgery, surgical wound disruption, and surgical site infection. Complications specific to instrumentation surgery or BKP were also investigated. Major systemic complications were defined as complications that were potentially life-threatening or that led to prolonged hospitalization. Complications that we routinely investigated are listed in Table 1.

Preoperative Health Status

The patients' preoperative health status was determined using the following means of assessment: 1) the Charlson Comorbidity Index (CCI),⁶ 2) the American Society of Anesthesiologists Physical Status (ASA-PS) Clas-

FIG. 1. Bar graph demonstrating the patient distribution by age. The y-axis represents the number of patients and the x-axis represents patients' ages in years.

sification System,⁹ 3) the Eastern Cooperative Oncology Group Performance Status (ECOG-PS),²³ 4) the presence of sarcopenia, and 5) the Geriatric Nutritional Risk Index (GNRI).²

The CCI is a method that assesses comorbidity. The total score is obtained by adding the relative weight of each comorbidity. For example, myocardial infarction, congestive heart failure, cerebrovascular disease, asthma, diabetes, and hypertension are each given a score of 1; renal disease, mild liver disease, and cancer, a score of 2; severe liver disease, a score of 3; and metastatic solid tumor or human immunodeficiency virus, a score of 6.

The ASA-PS Classification System aids in the assessment of the general condition of patients before surgery. Class I indicates a normal healthy patient; class II, a patient with mild systemic disease; class III, a patient with severe systemic disease; class IV, a patient with a severe and life-threatening systemic disease; class V, a moribund patient who is not expected to survive without the operation; and class VI, a patient who has been declared brain dead and whose organs will be removed for donation. As a matter of course, patients 80 years of age or older were assigned to class II or greater.

The ECOG-PS is a measurement of activities of daily living (ADLs) in patients with cancer (Table 2). We find this assessment useful in all patients regardless of whether they have cancer.

Sarcopenia is a syndrome characterized by the loss of muscle mass and strength.⁷ We assessed sarcopenia by using a simplified method reported by Shimokata and Ando.³¹ Patients with a grip strength less than 25 kg in males or less than 20 kg in females, and a body mass index less than 18.5 kg/m² or a calf girth less than 30 cm were diagnosed with sarcopenia by using this method.

The GNRI is an index of the nutrition condition of el-

derly patients; it is used to predict the risk of morbidity and mortality in hospitalized elderly patients. This index is calculated from the patient's serum albumin, weight, and ideal weight. The GNRI has the following grading system: > 98 = absence of nutrition-related risk; 92 to ≤ 98 = low risk; 82 to < 92 = moderate risk; and < 82 = major risk.

All these scores were assessed after patients decided to undergo surgical treatment. No patients were excluded from surgical consideration based on these scores.

Statistical Analyses

Associations among patients' age (80–84, 85–89, or ≥ 90 years), patients' preoperative health status (CCI, ASA-PS, and ECOG-PS grades, presence or absence of sarcopenia; and nutritional risk assessed by the GNRI [no risk, low risk, moderate risk, or major risk]), surgical factors (surgery involved instrumentation or not, operation time > 180 minutes, number of spinal levels treated ≥ 3, and EBL > 500 ml), and systemic perioperative complications were analyzed using Pearson's chi-square test and logistic regression analysis for the univariate analysis. A multivariate logistic regression model was constructed for the multivariate analysis by using explanatory variables selected by stepwise multiple regression. All statistical analyses were performed using JMP Pro 13 (SAS). A p value < 0.05 was considered statistically significant.

Results

Surgical Factors

Surgical factors are listed in Table 3. The operative spine level was cervical in 32 patients, thoracic in nine patients, and thoracolumbar–lumbosacral in 231 patients (two patients underwent cervical and thoracolumbar–lum-

TABLE 1. Perioperative complications in 270 patients, 80 years of age or older, who underwent spine surgery

Complication	No. of Patients (%)	Reop Required (%)
Total	54 (20.0)*	—
Surgical site complication		
Total	22 (8.1)†	11 (4.1)
Dural tear	6 (2.2)	1
Hematoma	2 (0.7)	2
Surgical wound disruption	2 (0.7)	1
Superficial wound infection	5 (1.9)	1
Deep wound infection	1 (0.4)	1
Complication specific to instrumentation (132 patients)		
Total	6 (4.5)	4
Fracture of lower instrumented vertebra	3 (2.3)	2
Pedicle screw back-out after surgery	2 (1.5)	2
Pedicle fracture	1 (0.8)	0
Pedicle screw deviation	0 (0.0)	0
Cage back-out after surgery	0 (0.0)	0
Complication specific to BKP (32 patients)		
Adjacent-level fracture	1 (3.1)	1
Major systemic complication		
Total	0 (0.0)	—
Acute coronary syndrome	0 (0.0)	—
Cardiac failure	0 (0.0)	—
Cerebrovascular disease	0 (0.0)	—
Pneumonia	0 (0.0)	—
Venous thrombosis	0 (0.0)	—
Renal failure requiring dialysis	0 (0.0)	—
Peptic ulcer	0 (0.0)	—
Ileus	0 (0.0)	—
Cholangitis	0 (0.0)	—
Cholecystitis	0 (0.0)	—
Minor systemic complication		
Total	40 (14.8)‡	—
Anemia requiring transfusion	20 (7.4)	—
Delirium	17 (6.3)	—
UTI	7 (2.6)	—

— = not applicable.

* In eight patients both a surgical site complication and a minor systemic complication developed.

† A dural tear and a pedicle fracture occurred in the same patient.

‡ In two patients both anemia and a UTI developed; in one patient both delirium and anemia developed; and in another patient both delirium and a UTI developed.

bosacral surgery simultaneously). The surgical procedure performed was posterior decompression in 106 patients, instrumentation surgery in 132 patients, and BKP in 32 patients. The mean duration of the operation was 119.8 minutes (range 25–678 minutes). The mean number of operative spine levels that were treated was 1.87 (range 0–9 levels). The average EBL was 146.2 ml (range 0–1160 ml).

Perioperative Complications

The rate of all perioperative complications was 20.0% (67 complications were observed in 54 of 270 patients [Ta-

ble 1]). Complications based on the type of procedures are shown in Fig. 2. Surgical site complications were observed in 22 patients (8.1%): specifically, in six (5.7%) of the 106 patients who underwent decompression, 15 (11.4%) of the 132 patients who underwent instrumentation surgery, and one (3.1%) of the 32 patients who underwent BKP. Dural tears were observed in six patients (2.2%), and hematoma and surgical wound disruption in two patients each (0.7%). Surgical site infections were observed in six patients (2.2%): five patients (1.9%) had superficial wound infections and one (0.4%) had a deep infection. Six (4.5%) of

TABLE 2. Eastern Cooperative Oncology Group Performance Status*

Grade	Activity of Daily Living
0	Fully active, able to carry on all pre-disease performance w/o restriction
1	Restricted in physically strenuous activity but ambulatory & able to carry out work of a light or sedentary nature, e.g., light house work, office work
2	Ambulatory & capable of all self-care but unable to carry out any work activities; up & about >50% of waking hours
3	Capable of only limited self-care; confined to bed or chair >50% of waking hours
4	Completely disabled; cannot carry on any self-care; totally confined to bed or chair
5	Dead

* Based on Oken MM et al: Toxicity and response criteria of the Eastern Cooperative Oncology Group. *Am J Clin Oncol* 5:649–655, 1982.

the 132 patients who underwent instrumentation surgery experienced complications specific to the instrumentation: three fractures in the lower instrumented vertebra (2.3%), two cases of pedicle screw back-out after surgery (1.5%), and one pedicle fracture (0.8%). An adjacent-level fracture, a complication specific to BKP, was experienced by one (3.1%) of the 32 patients who underwent that procedure. Repeated operations were required in 11 patients (4.1%).

No patient experienced major systemic complications, which would include acute coronary syndrome, cardiac failure, cerebrovascular disease, pneumonia, venous thrombosis, renal failure requiring dialysis, peptic ulcer, ileus, cholangitis, or cholecystitis. There were no perioperative deaths in this series.

Minor systemic complications developed in 40 patients (14.8%): seven of the 106 patients who underwent decompression, 31 of the 132 patients who underwent instrumentation surgery, and two of the 32 patients who underwent BKP. These complications included anemia requiring transfusion in 20 patients (7.4%), delirium in 17 patients (6.3%), and urinary tract infection (UTI) in seven patients (2.6%). With regard to patient age, minor systemic complications were observed in 32 (16.1%) of the 199 patients who were 80–84 years of age, six (10.3%) of the 58 patients who were 85–89 years of age, and two (15.4%) of the 13 patients who were in their 90s.

Preoperative Health Status

Patient demographics and preoperative health status are shown in Table 4. Assessments of preoperative general health status showed that the majority of patients were in good condition. The CCI was less than 5 in 242 cases, the ASA-PS was class II in 248 cases, and the ECOG-PS grade was less than 3 in 184 cases. The prevalence of sarcopenia was 24.4% (60/246 patients; there was insufficient data in 24 patients and, hence, those patients could not be assessed for sarcopenia). The GNRI in 203 patients was higher than 98, which means absence of nutritional risk.

TABLE 3. Surgical factors

Procedure	Value (range)
Operative level	
Cervical	
Decompression*	21
Instrumentation surgery	11
Thoracic	
Decompression	3
Instrumentation surgery	3
BKP	3
Thoracolumbar–lumbosacral	
Decompression*	84
Instrumentation surgery	118
BKP	29
Mean op time, mins	119.8 (25–678)
Mean no. of spinal levels treated	1.87 (0–9)
Mean EBL, ml	146.2 (0–1160)

Unless otherwise specified, values represent number of patients.

* Two patients underwent cervical and thoracolumbar decompression simultaneously.

Statistical Analyses

The univariate analysis showed that the ECOG-PS ($p = 0.011$) and nutritional risk ($p = 0.010$) were significantly associated with minor systemic complications. Patient age ($p = 0.556$), CCI ($p = 0.169$), ASA-PS ($p = 0.094$), and the presence of sarcopenia ($p = 0.125$) were not deemed risk factors. Instrumentation surgery, operation time longer than 180 minutes, three or more operative spinal levels, and an EBL greater than 500 ml were also associated with minor systemic complications ($p < 0.0001$, < 0.0001 , 0.005 , and 0.001 , respectively). The stepwise multiple regression selected the ECOG-PS, instrumentation surgery, operation time longer than 180 minutes, and three or more spinal levels treated as explanatory variables. In the multivariate logistic regression, ECOG-PS (unit odds ratio [OR] 1.6, 95% confidence interval [CI] 1.106–2.385, $p = 0.013$), instrumentation surgery (OR 2.9, 95% CI 1.148–7.235, $p = 0.024$), and operation time longer than 180 minutes (OR 2.9, 95% CI 1.220–7.009, $p = 0.016$) were significantly associated with minor systemic complications. The details of the statistical analysis are shown in Table 5.

In patients with lower ADL scores (ECOG-PS grades 2, 3, and 4) the rate of minor systemic complications was 18.9% (31/164), whereas in those with higher ADL scores (ECOG-PS grades 0 and 1), the rate was 8.5% (9/106). The rate of complications in patients who underwent instrumentation surgery was 23.5% (31/132); in patients who underwent posterior decompression or BKP, the rate was 6.5% (9/138). Similarly, the rate of complications was 37.0% (20/54) in patients in whom there was a longer operation time and 9.3% (20/216) in patients whose surgery lasted a shorter time. The complication rate in patients with a nutritional risk of “no” or “low” was 12.1% (29/239) and the rate in those with a nutritional risk of “moderate” or “major” was 35.5% (11/31).

FIG. 2. Pie chart demonstrating perioperative complications based on the type of operative procedure. Anemia and delirium were observed in all procedures.

Discussion

Although several studies have been published on perioperative complications of spine surgery in the elderly, there have been limited studies that focused on patients 80 years of age or older. Moreover, those studies focusing on that age group have been retrospective studies with small sample sizes^{21,24,28,29,34} or large sample sizes based on databases lacking in patients' individual factors.^{18,26} Kobayashi et al. conducted a multicenter retrospective study of 262 spine surgeries performed in patients 80 years of age or older and identified a high complication rate (29%).¹⁶ Nasser and colleagues found a higher complication rate associated with spine surgery in prospective studies than in retrospective studies.²² To the best of our knowledge, a multicenter prospective all-case investigation of perioperative complications of spine surgery in patients 80 years of age or older has not previously been conducted, and the results of our current study are potentially able to determine the perioperative complications of spine surgery.

The majority of previous studies have shown high rates of perioperative complications in patients 80 years or older, ranging from 18.9% to 35%.^{16,18,21,24,28,34} The complication rate of overall spine surgery was reported to be 16.4%.²² In the current study, we have also demonstrated a higher complication rate of 20.0%; however, we did not observe any major systemic complications in our study.

Earlier studies revealed several risk factors for perioperative complications associated with spine surgery in patients 80 years of age or older. In addition, age older than 85 years, EBL greater than 500 ml, and operation time longer than 180 minutes are considered risk factors.^{16,34}

On the contrary, the association between patients' preoperative general health status and perioperative complications remains unclear. In patients 85 years or older, Li et al. demonstrated that complications are more likely to occur in patients with three or more comorbidities than in patients with no comorbidities (18.9% vs 14.7%).¹⁸ Wang et al. reported that the CCI and ASA-PS, which reflect a patient's comorbidities and general condition, were not associated with complications.³⁴ In our current study, we reviewed both CCI and ASA-PS scores and found no association between those scores and perioperative complications. Our result is consistent with that of Wang's study.

Several studies have been performed to examine the association between frailty, sarcopenia, or nutrition status and perioperative complications.^{1,5,27,35} Zakaria et al. showed that patients with frailty or sarcopenia are more likely to develop postoperative complications (OR 1.70).³⁵ Bokshan et al. demonstrated that patients with sarcopenia have a high incidence of postoperative complications.¹ However, Charest-Morin and colleagues found that frailty or sarcopenia did not predict the occurrence of postoperative complications in elderly patients older than 65 years of age.⁵ Puvanesarajah et al. demonstrated an association between postoperative complications and preoperative malnutrition, which contributed to frailty or sarcopenia. Those authors reported that malnutrition significantly increased the complication rate for the first 90 days postoperatively (OR 4.24) as well as the mortality rate as of the 1-year follow-up (OR 6.16).²⁷ These findings on the effect of frailty, sarcopenia, or malnutrition on the occurrence of perioperative complications were not specific to pa-

TABLE 4. Demographics and preoperative health status

Item	Value (range)
Demographics	
Age, yrs	83.2 (80–99)
Sex, M/F	109/161
Body mass index, kg/m ²	23.7 (14.4–37)
Preop health status	
CCI score	
0	22
1	62
2	56
3	57
4	45
5	16
6	8
7	3
8	1
ASA-PS class	
II	248
III	22
ECOG-PS grade	
0	4
1	102
2	78
3	72
4	14
Sarcopenia*	
Present	60
Absent	186
GNRI score	
>98 (no risk)	203
92 to ≤98 (low risk)	36
82 to <92 (moderate risk)	25
<82 (major risk)	6

Unless otherwise specified, values represent number of patients.

* Data in 24 patients were insufficient, and thus those patients could not be assessed for sarcopenia.

tients 80 years of age or older. Furthermore, in the current study we showed that both sarcopenia and malnutrition were considered insignificant risk factors for perioperative complications, which is consistent with the result found by Charest-Morin and colleagues. Complication rates in patients with a nutritional risk of “no” or “low” were 12.1%, and those in patients with a nutrition risk of “moderate” or “major” were 35.5%. Our results suggest that nutritional counseling may not be required, especially for patients with lower nutritional risks.

The ECOG-PS is a simple index of ADLs, but it is rarely used to assess ADLs in patients without cancer who require spine surgery. This investigation revealed that a low grade in the ECOG-PS was considered a significant risk factor of perioperative minor complications.

TABLE 5. Statistical analysis of risk for minor systemic complications

Variable	p Value
Univariate analysis	
Patient age	0.556
CCI	0.169
ASA-PS	0.094
ECOG-PS	0.011
Sarcopenia	0.125
Nutritional risk	0.010
Instrumentation surgery	<0.0001
Op time >180 mins	<0.0001
No. of spinal levels treated ≥3	0.005
EBL >500 ml	0.001
Multivariate analysis	
ECOG-PS	0.013 (unit OR = 1.6)
Instrumentation surgery	0.024 (OR = 2.9)
Op time >180 mins	0.016 (OR = 2.9)
No. of spinal levels treated ≥3	0.166

Boldface type indicates statistical significance at $p < 0.05$.

Hence, the ECOG-PS should be assessed before surgery in the future.

There have been few articles that mention an association between the type of spinal procedure undertaken and perioperative complications in patients older than 80 years of age. Onda et al. demonstrated no difference in the perioperative complication rate between patients older than 85 years of age who underwent decompression only and patients of similar ages who underwent instrumentation surgery (21.0% vs 28.5%, $p = 0.374$).²⁴ Puvanesarajah et al. demonstrated that longer spinal fusions were associated with increased rates of complications: patients who underwent fusions extending over more than eight spinal levels had a significantly higher chance of developing perioperative complications.²⁵ In the current study, instrumentation surgery was significantly associated with minor perioperative complications. Spine surgeries for the elderly are generally safe, but surgeons should pay careful attention when instrumentation surgery is involved.

Regarding the types of complications, anemia requiring transfusion, delirium, and a UTI were likely to develop, which is consistent with the findings of previous studies.^{16,21,26} Fineberg et al. revealed that older patient age (≥ 65 years old), alcohol/drug abuse, depression, psychotic disorders, neurological disorders, iron deficiency anemia, fluid/electrolyte disorders, and weight loss are risk factors for delirium.¹¹ Kobayashi et al. identified that cervical lesion surgery and an EBL greater than 300 ml were significantly associated with postoperative delirium in patients 80 years or older.¹⁷ Surgeons should pay careful attention when performing surgery in elderly patients who cannot accept a transfusion due to religious reasons and in patients with risk factors for postoperative delirium.

In the current study we observed perioperative complications in 20.0% of patients, surgical site complications

in 8.1%, and minor systemic complications in 14.8% of patients, but no major systemic complications. We also found a low reoperation rate of 4.1%, and no perioperative deaths. The ECOG-PS, instrumentation surgery, and an operation time longer than 180 minutes were considered significant risk factors of minor systemic complications. A one-grade increase in the ECOG-PS resulted in a 1.6-fold risk of developing minor systemic complications. In patients with lower ADL scores (ECOG-PS grades 2, 3, and 4), the rate of minor systemic complications was 18.9%; the rate was half as much, 8.5%, in patients with higher ADL scores (ECOG-PS grades 0 and 1). Instrumentation surgery and an operation time exceeding 180 minutes were both 2.9 times more likely to cause the development of minor systemic complications. The complication rate was 23.5% in patients who underwent instrumentation surgery and 6.5% in those who underwent posterior decompression or BKP. Similarly, the complication rate was 37.0% in patients whose surgeries exceeded 180 minutes and 9.3% in patients whose surgeries took less time. Surgeons should recognize these factors as risks of minor systemic complications such as anemia, delirium, or a UTI. Although decreased daily activity, instrumentation surgery, and longer operation time were recognized as risk factors of perioperative minor systemic complications, older age, comorbidity, and a poor nutrition condition were not considered risk factors. More importantly, no severe complications were observed in our study; hence, spine surgery for elderly patients can be safely performed. Galiano et al.¹² and Liao and colleagues¹⁹ reported good long-term outcomes of spine surgery in patients 80 years of age or older. Nanjo et al. identified similar benefits and risks of decompression surgery for lumbar spinal stenosis between patients older than 80 years and those younger than 80 years.²¹ Therefore, surgeons should not be reluctant to perform spine surgery on the basis of the advanced age of the patient.

The current study has several limitations that must be addressed. Clinical outcomes were not evaluated. The 30-day follow-up period was insufficient to assess long-term complications such as pseudarthrosis or adjacent segment disease. However, the current study aimed to determine the perioperative complications of spine surgery for elderly patients, not to verify the efficacy or long-term results of spine surgery. In elderly patients, long-term follow-up may not be beneficial and may lead to difficulty in distinguishing surgery-related complications from increasing age-related pathologies.

Despite these limitations, this is a prospective multicenter cohort study including a relatively large number of patients, and the findings provide important estimates about the safety of spine surgery.

Conclusions

We conducted a multicenter prospective cohort study of perioperative complications in spine surgery for patients aged 80 years or older. Perioperative complications were observed in 20.0%, surgical site complications in 8.1%, and minor systemic complications in 14.8% of patients; no major systemic complications were observed. Although

lower ADLs before surgery, instrumentation surgery, and longer operation time were considered significant risk factors for minor systemic complications, spine surgery can be performed safely, even in elderly patients.

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Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: Watanabe, Kanayama, Takahata. Acquisition of data: Watanabe, Takahata, Oda, Suda, Abe, Okumura, Hojo. Analysis and interpretation of data: Watanabe. Drafting the article: Watanabe. Critically revising the article: Kanayama. Reviewed submitted version of manuscript: Kanayama, Takahata. Approved the final version of the manuscript on behalf of all authors: Watanabe. Study supervision: Iwasaki.

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