Efficacy of Intervention for Prevention of Postoperative Delirium after Spine Surgery

Fumihiro Arizumi, Keishi Maruo, Kazuki Kusuyama, Kazuya Kishima and Toshiya Tachibana

Department of Orthopaedic Surgery, Hyogo College of Medicine, Nishinomiya, Japan

Abstract:

   Introduction: Delirium after spine surgery is an important complication; identification of risk factors associated with postoperative delirium (PD) is essential for reducing its incidence. Prophylactic intervention for PD has been reported to be effective. This study aimed to identify risk factors for PD and determine the efficacy of a prevention program using a delirium risk scoring system for PD after spine surgery.

   Methods: This study was conducted in two stages. First, 294 patients (167 males, 127 females) who underwent spine surgery from 2013 to 2014 were assessed to examine the incidence and risk factors of PD and to establish a novel PD screening tool (Group A). Second, preoperative intervention was performed on 265 patients who underwent surgery from 2016 to 2017 (Group B) for the purpose of preventing PD using a delirium risk scoring system. Outcomes, including PD incidence and rates of adverse events, were compared between Group A and Group B.

   Results: A logistic regression analysis revealed that psychiatric disorders (odds ratio [OR] = 10.3, P < 0.001), benzodiazepine use (OR = 4.9, P < 0.001), age > 70 years (OR = 4.2, P < 0.001), hearing loss (OR = 3.7, P = 0.001), and admission to intensive care unit (ICU) (OR = 3.7, P = 0.006) were independent risk factors associated with PD. Based on these results, we established a novel delirium screening tool after spine surgery. PD incidence was significantly higher in Group A than in Group B (22% vs. 13%, P = 0.0008). The occurrence of dangerous behavioral symptoms was significantly higher in Group A than in Group B (66% vs. 40%, P = 0.02). The catheter problem tended to be higher in Group A than in Group B (19% vs. 9%, P = 0.245).

   Conclusions: In this study, psychiatric disorders, benzodiazepine use, age > 70 years, hearing loss, and admission to ICU were independent risk factors associated with PD. With the introduction of the delirium risk score, the onset of delirium was delayed, and adverse outcomes of delirium were reduced.

   Keywords:

   post operative delirium, spine surgery, risk factor, delirium risk scoring system, intervention program

Introduction

   Postoperative delirium (PD) is a common and serious complication after surgery[1]. PD causes many problems and has been associated with increased length of hospital stay. In a study by Glennie et al., the presence of neurological injury and the need for operative fixation of thoracic or lumbar injuries lead to a greater risk of adverse events, and only pneumonia and delirium consistently increase length of stay in the hospital[2]. Patients who develop delirium have been associated with increased risk of death[3]. Furthermore, PD can be related to increased health care costs[4]. The incidence of delirium after spine surgery has been widely reported with a range from 1% to 21%, depending on the study population[5]. The incidence of PD is high in the elderly after spinal surgery. Brown et al. reported that 40.5% of >70-year-old patients undergoing spine surgery developed delirium[6]. Furthermore, Oe et al. reported undernutrition-related PD after adult spinal deformity surgery[7]. Spinal surgery is associated with higher rates of PD than those of other orthopedic surgeries, including total joint arthroplasty[8]. The reason for this may be issues associated with the prone position during surgery[9]. A large number of risk factors for PD have been reported[10-18]. To reduce the incidence of PD, it is im-
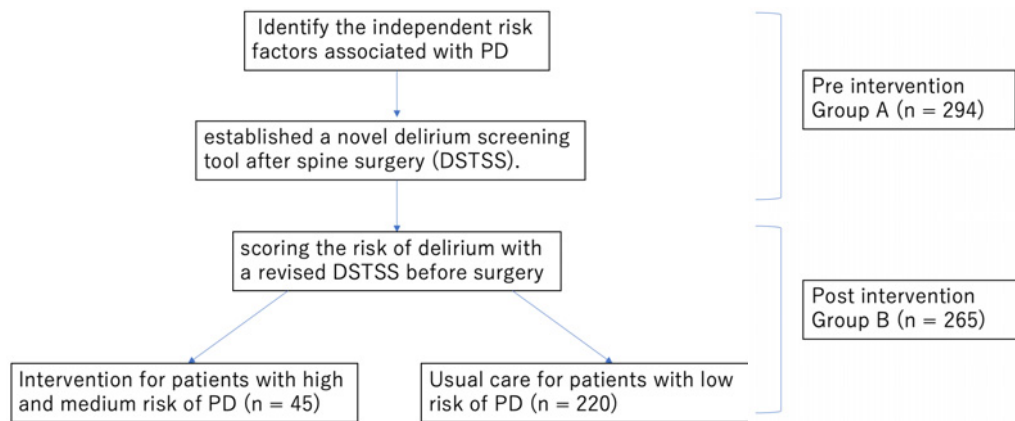
Figure 1. Flow diagram for the interventional study.
PD, postoperative delirium; DSTSS, delirium screening tool after spine surgery

portant to identify the risk factors associated with PD. If the possibility of delirium can be determined before surgery, PD may be prevented.

There are few reports on the prevention of PD in spine surgery[10], and there is no preoperative screening tool. The purpose of this study was to examine the incidence and risk factors associated with PD, to establish a novel PD screening tool and to determine the efficacy of intervention for prevention of PD after spine surgery.

Materials and Methods

1) Retrospective study to identify risk factors for PD

This study was a consecutive single-center retrospective case review of 294 (167 males and 127 females) patients who underwent spine surgery from 2013 to 2014, with an average age of 65.3 ± 15.6 years (Group A). PD was diagnosed using the Confusion Assessment Method (CAM)[19]. We assessed patient factors (age, sex, height, body weight, serum hemoglobin [Hb], and hematocrit [Ht] levels, serum sodium and albumin [Alb] levels, American Society of Anesthesiologists [ASA] grade, smoking, alcohol abuse, and hearing loss), surgical factors (operative time, estimated blood loss [EBL], cervical, instrumentation use, emergency, blood transfusion, and admission to intensive care unit [ICU]), and comorbidities (Charlson Comorbidity Index[20], diabetes mellitus [DM], neoplasm, central nervous system disorder, collagen disease, psychiatric disorder and hemodialysis) steroid use, benzodiazepine use as potential risk factors of delirium.

Statistical analysis

We compared the groups with and without delirium. The statistical software used was SPSS (version 17.0, SPSS Inc., Chicago, IL, USA). A t-test and a chi-squared test were used for comparison between the two groups, and a P value less than 5% was considered statistically significant. A logistic regression analysis was used to identify the independent risk factors associated with PD. We established a novel de-

lirium screening tool after spine surgery (DSTSS). The cut-off value was analyzed using a receiver operating characteristic (ROC) curve and the area under the curve (AUC).

2) Efficacy of intervention for prevention of PD

A prospective study was conducted to evaluate the effectiveness of intervention for prevention of PD. Preoperative intervention was performed for the purpose of preventing PD using DSTSS on 265 patients (151 men and 114 women, age: 68.7 ± 14.4 years) who underwent surgery at our hospital from 2016 to 2017 (Group B). The intervention consisted of preoperative patient education (reduction of stress by regularly speaking to patients, establishment of sleep and circadian rhythm, insertion of a catheter into the leg to prevent removal a catheter into the arm), change of medical protocol (change from benzodiazepine to risperidone), early removal of vascular and urinary catheters (within postoperative 2 days), and consultation with the psychiatric liaison team before surgery. The delirium risk scoring system was divided into three groups (low risk: 0 to 4 points, medium risk: 5 to 9 points, and high risk: ≥10 points). An interventional prevention program was implemented for medium- and high-risk groups. Outcomes were compared, including PD incidence and rates of adverse outcomes in Group A and Group B. The adverse outcomes of delirium included dangerous behavioral symptoms, self-removal of vascular or urinary catheters, and perception disturbance (Fig. 1).

Statistical analysis

For statistical analysis, differences between the two groups were analyzed using Fisher's exact test or Student's t-test. The statistical analyses were performed using EZR software (Saitama Medical Center, Jichi Medical University, Saitama, Japan), which is the graphical user interface for R (The R Foundation for Statistical Computing, Vienna, Austria). The significance level was set at $p < 0.05$.

Table 1. Association between Factors of Categorical Variables and Postoperative Delirium.

Variables	Delirium (+) n=64	Delirium (−) n=230	P
Patient factors			
Age (year)	72.2±13.3	63.3±16.2	<0.001
Height (cm)	157.9±8.6	160.6±9.8	0.053
Body weight (kg)	60.0±11.3	60.5±13.2	0.637
Hb (g/dl)	12.4±1.8	13.1±2.1	0.01
Ht (%)	36.4±6.0	39.0±5.6	0.001
Na (mEq/l)	140.1±3.2	140.0±2.8	0.884
Alb (g/dl)	3.7±0.6	4.0±0.6	<0.001
ASA grade	2.5±0.5	2.2±0.6	0.003
Gender (female)	26 (40%)	101 (44%)	0.574
Age>70	47 (72%)	92 (40%)	<0.001
Smoker	13 (20%)	42 (18%)	0.723
Alcohol abuse	12 (19%)	38 (17%)	0.711
Hearing loss	15 (23%)	13 (6%)	<0.001
Surgical factors			
Op time (min)	189.1±91.8	183.1±89.8	0.637
EBL (ml)	305.4±502.8	348.5±707.4	0.647
Cervical	21 (32%)	57 (25%)	0.265
Instrumentation use	35 (54%)	136 (59%)	0.477
Emergency	11 (17%)	32 (14%)	0.554
Blood transfusion	13 (20%)	38 (17%)	0.578
ICU	31 (48%)	43 (19%)	<0.001
Op>5h	5 (8%)	24 (11%)	0.64
EBL (>1000 ml)	14 (16%)	21 (9%)	0.615
Comorbid disease			
Charlson score	1.2±1.0	1.0±1.4	0.275
DM	18 (28%)	43 (19%)	0.122
Neoplasm	1 (8.3%)	11 (4.8%)	0.214
Central nervous system disorder	9 (53%)	8 (4%)	0.004
Steroid use	2 (3%)	25 (11%)	0.054
Collagen disease	2 (3%)	24 (11%)	0.082
Psychiatric disorder	16 (25%)	5 (2%)	<0.001
Hemodialysis patient	3 (5%)	16 (7%)	0.775
Benzodiazepines use	32 (49%)	27 (12%)	<0.001

Hb, hemoglobin; Ht, hematocrit; Na, natrium; Alb, albumin; ASA, American Society of Anesthesiologists; Op time, operative time; EBL, estimated blood loss; DM, diabetes mellitus

Table 2. Multivariate Risk Factors of Postoperative Delirium.

Variables	Odds ratio	95% CI	P value
Psychiatric disorder	10.307	2.824–37.619	<0.001
Benzodiazepines use	4.866	2.231–10.616	<0.001
Age>70 rears	4.262	1.884–9.640	0.001
Hearing loss	3.738	1.464–9.546	0.001
ICU	3.494	1.711–7.134	0.006

ICU, intensive care unit

Table 3. Delirium Screening Tool after Spine Surgery (DSTSS).

Factors	Score
Psychiatric disorder	10
Age: >84 years	5
75−84 years	3
65−74 years	2
Hearing loss	3
ICU or HCU	3
Benzodiazepines use	3
Central nervous system disorder	3
ASA grade 3	2
grade 2	1
Preop Alb<3.5 g/dl	2
Preop Hb<11 g/dl	2
Cervical	1
DM	1
H2 blocker	1

ICU indicates intensive care unit; ASA, American Society of Anesthesiologists; Alb, albumin; Hb, hemoglobin; and DM, diabetes mellitus.

Results

Pre-intervention

Delirium after spine surgery was found in 64 patients (22%). Surgical sites were as follows: cervical (27%) and thoracolumbar (73%). Intraoperative EBL was 338.9 ± 666.9 ml. Comorbidities were as follows: DM, 61 patients (21%); malignant disease, 12 patients (4%); psychiatric disorders, 21 patients (7%); central nervous system disorders, 17 patients (6%); collagen disease, 26 patients (9%); hemodialysis patients, 19 patients (6%); benzodiazepine use, 59 patients (20%); and steroid use, 27 patients (20%). Age-specific rates were as follows: under 65 years, 12%; 65 to 74 years, 16%; 75 to 84 years, 38%; and over 86 years, 67%. Advancing

age, ASA grade, anemia, low Alb levels, admission to ICU, and hearing loss were identified as patient- and surgery-related risk factors associated with PD. Central nervous system disorders, psychiatric disorders, and benzodiazepine use were identified as comorbidity-related risk factors associated with PD (Table 1). The logistic regression analysis revealed that psychiatric disorders (odds ratio [OR] = 10.3, P < 0.001), benzodiazepine use (OR = 4.9, P < 0.001), age > 70 years (OR = 4.2, P < 0.001), hearing loss (OR = 3.7, P = 0.001), and admission to ICU (OR = 3.7, P = 0.006) were the independent risk factors associated with PD (Table 2). DSTSS was established based on the outcome of univariate and multivariate regression analysis (Table 3). For score weighting, factors with high OR were assigned high scores, and factors that were significantly different in the univariate analysis were assigned low scores. DM that were not significantly different and H2 blockers that were not included in this study were also added to the score. These items have been reported as risk factors for PD, and we considered that they were necessary to create a more discriminating scoring system[12,21]. The ROC curve analysis indicated that the optimal cut-off value of DSTSS was ≥10 points (AUC = 0.838, sensitivity = 72%, and specificity = 84%) (Fig. 2).
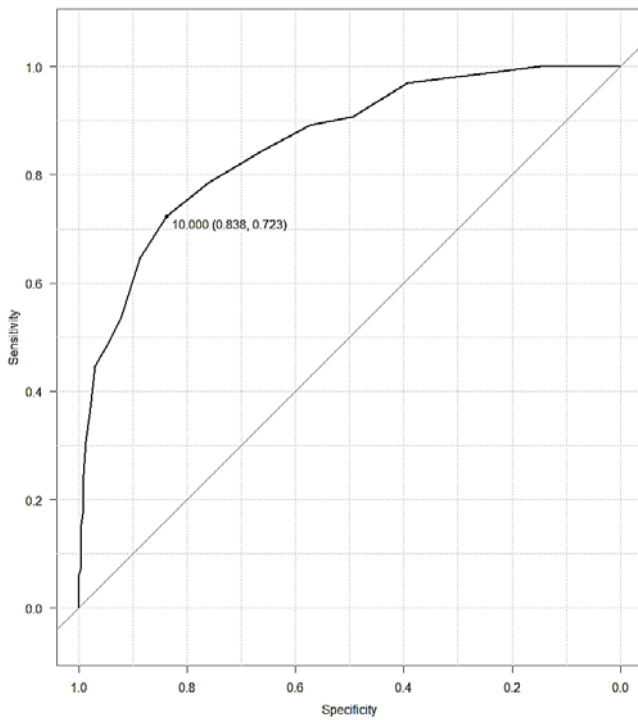
Figure 2. ROC curve analysis.
ROC, receiver operating characteristic

Table 4. Incidence of Delirium.

	Group A (n=294)	Group B (n=265)	P
Delirium (+)	64 (22%)	35 (13%)	0.0008

Table 5. Association between Risk Score of DSTSS and Postoperative Delirium.

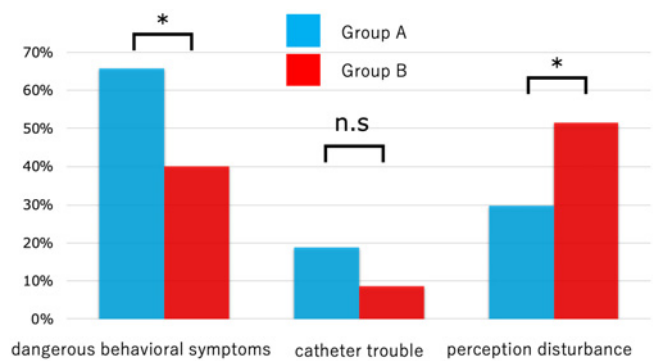| Risk score	Delirium (+) (n=35)
<5 (low risk)	0
5-9 (medium risk)	12 (34%)
≥10 (high risk)	23 (66%)

DSTSS, delirium screening tool after spine surgery

Figure 3. Comparison of the delirium severity between Groups A and B.
* statistically significant

Post-intervention

After interventions, the incidence of PD was significantly higher in Group A (22%) compared to that in Group B (13%) (P = 0.0008) (Table 4). Surgical sites were as follows: cervical (26%) and thoracolumbar (74%). Intraoperative blood loss was 147 ± 261.1 ml. Age-specific rates were as follows: under 65 years, 0%; 65 to 74 years, 10%; 75 to 84 years, 23%; and over 86 years, 42%. The incidence of delirium was 0% in the low-risk group (0 to 4 points), 34% (n = 12) in the medium-risk group (5 to 9 points), and 66% (n = 23) in the high-risk group (≥10 points) on the DSTSS (Table 5). The occurrence of dangerous behavioral symptoms was significantly higher in Group A (66%) compared to that in Group B (40%) (P = 0.02). The catheter trouble tended to be higher in Group A (19%) compared to Group B (9%); however, the difference was not significant (P = 0.245). However, perception disturbance was significantly higher in Group B (51%) compared to that in Group A (30%) (P = 0.0498) (Fig. 3).

Discussion

Incidence of postoperative delirium

Reported rates of PD were between 0.84% and 21.3% in a recent meta-analysis[5]. In the field of orthopedic surgery, the incidence of PD has been reported to be relatively high (24%) for femoral neck fractures in a meta-analysis[22], and 5% to 14.3% for total joint arthroplasty, which is lower than that for spinal surgery[8]. The reason why PD tends to be higher in spine surgery than in total joint arthroplasty has been reported to be the cerebral desaturation that is related to the prone position[9], and cerebral desaturation is considered to be a cause of delirium. In this study, the incidence of PD was 22%, which was higher than that in the meta-analysis. The reason is thought to be that the average age was higher than that in previous reports and that there were more patients with complications.

Risk factors for postoperative delirium

The risk factors for PD are multifactorial. In a meta-analysis of PD in spine surgery extracted from six articles, an age > 65 years, female sex, the number of medications, low preoperative Ht, low preoperative Alb, longer duration of surgery, more intraoperative blood loss, low postoperative Ht, Hb and sodium, and postoperative fever were reported as risk factors[5]. Fineberg et al. found that independent predictors of delirium included older age, alcohol/drug abuse, depression, psychotic disorders, neurological disorders, deficiency anemia, fluid/electrolyte disorders, and weight loss, and delirium was found to be associated with increased length of hospital stay, higher costs, and higher mortality rates[11]. In this study, as in previous reports, psychiatric dis-

orders, benzodiazepine use, an age > 70 years, hearing loss, and admission to ICU were independent risk factors associated with PD.

Efficacy of a prevention program using the delirium risk scoring system

Prophylactic intervention for PD has been reported to be effective after gastrointestinal surgery[23] and after hip fracture surgery[24]. Inouye et al. targeted six risk factors closely related to delirium: cognitive impairment, sleep deprivation, immobility, visual impairment, hearing impairment, and dehydration and reported that delirium decreased significantly because of reduction in these risk factors[25].

The purpose of this study was to establish a novel PD screening tool to reduce future rates of PD following surgery. It has been reported that even non-psychiatrists can easily predict the risk of delirium using a delirium scoring tool in the field of cardiovascular surgery[26]. In this study, orthopedic surgeons and nurses who are not specialized in psychiatry used screening tools to assess the risk of delirium preoperatively, and for high-risk patients, consulted with a psychiatric liaison team regarding the possibility of post-surgery delirium. Even in the absence of psychiatry, findings suggest that the risk of delirium can be prevented by discontinuing benzodiazepines, reducing stress levels of patients and removing catheters early for high-risk patients. An advantage of our scoring system is that medical staff can share information on preventing PD. As a result, it may be possible for one to detect delirium early and reduce line troubles and falls.

Limitations

Our study had certain limitations. First, the rate of delirium diagnosis may be questionable as although we reviewed electronic medical records, mainly nursing records, the possibility remains that hypoactive delirium was missed. Breitbart et al. reported that patients with hypoactive delirium were as distressed as patients with hyperactive delirium[27]; however, this is one of the limitations of this research as specialists were not available to diagnose hypoactive delirium. Second, psychiatric disorders included schizophrenia, severe mental illness, and dementia. Although nurses and orthopedic surgeons were aware of patients with these disorders, it may have been difficult to differentiate behaviors associated with these mental illnesses and behaviors associated with delirium. Third, in this study, we were able to evaluate the efficacy of intervention for the prevention of PD after spine surgery. However, the DSTSS could not be validated because of the use of Group A data. A prospective study without intervention must be performed to validate the scoring system. Fourth, this single-center study may have had patient selection bias. In particular, patients with schizophrenia were mostly referred from other hospitals, suggesting that the patient selection may have been biased. Future prospective studies at multiple centers are desirable.

In conclusion, psychiatric disorders, benzodiazepine use,

age > 70 years, hearing loss, and admission to the ICU were identified as independent risk factors for PD. Through the introduction of the delirium risk score, the onset and severity of delirium were reduced. Our scoring system helps medical staff to find and prevent delirium after spinal surgery.

Conflicts of Interest: The authors declare that there are no relevant conflicts of interest.

Ethical Approval: Ethical approval was obtained from the Hyogo College of Medicine's institutional ethics committee (IRB approval no.: 2471).

Author Contributions: Fumihiro Arizumi wrote and prepared the manuscript, and Keishi Maruo participated in the study design and analysis of the data. All authors reviewed and approved the manuscript.

Informed Consent: Informed consent was obtained from all participants in this study.

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