Incidence and Risk Factors for Hyponatremia in Postoperative Spinal Surgery Patients

Masato Sanada, Hiroyuki Tominaga, Ichiro Kawamura, Hiroto Tokumoto, Takuma Ogura and Noboru Taniguchi

Department of Orthopaedic Surgery, Kagoshima University, Kagoshima, Japan

Abstract:

Introduction: The incidence of hyponatremia after orthopedic surgery is high. Hyponatremia may prolong hospitalization and increase mortality, but few reports have identified risk factors for hyponatremia after spinal surgery. This study aims to determine the incidence and risk factors for hyponatremia after spinal surgery.

Methods: A total of 200 patients aged 20 years or older who underwent spinal surgery at our hospital from 2020-2021 were recruited. Data on age, sex, height, weight, body mass index, operation duration, blood loss, albumin level, the geriatric nutritional risk index (GNRI), potassium level, the estimated glomerular filtration rate (eGFR), sodium level, length of hospital stay, history of hypertension, dialysis status, the occurrence of delirium during hospital stay, and oral medication use were collected. Comparisons between the postoperative hyponatremia group and the postoperative normonatremia group were conducted to evaluate the impact of hyponatremia on clinical outcomes.

Results: Postoperative hyponatremia was observed in 56 (28%) of the 200 patients after spinal surgery. Comparison between the postoperative hyponatremia group with the postoperative normonatremia group revealed that the patients in the postoperative hyponatremia group were significantly older (72 versus 68.5 years, $p<0.01$). Postoperative hyponatremia was significantly associated with low GNRI values (100.8 versus 109.3, $p<0.01$), low eGFR values (59.2 versus 70.8 mL/min/1.73 m^2, $p<0.01$), preoperative hyponatremia (138.5 vs. 141 mEq/L, $p<0.01$), and a high incidence of delirium (12.5% versus 2.7%, $p=0.01$). Older age (odds ratio=1.04, $p=0.01$) and preoperative hyponatremia (odds ratio=0.66, p value<0.01) were risk factors for postoperative hyponatremia.

Conclusions: In addition to older age and preoperative hyponatremia, the study identified new risk factors for postoperative hyponatremia, which are preoperative undernutrition and impaired renal function. The incidence of delirium was significantly higher in the postoperative hyponatremia group, suggesting that correcting preoperative hyponatremia and ensuring good nutrition may prevent delirium and thereby shorten hospital stays.

Keywords:

Hyponatremia, spinal surgery, delirium

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Introduction

Hyponatremia is a common electrolyte abnormality in clinical practice commonly seen in elderly patients. Hyponatremia, even when mild, is associated with increased mortality during hospitalization and at 1 and 5 years after hospitalization[1]. For each 1 mEq/L decrease in sodium levels below 135 mEq/L, mortality increases by 23%[2]. If hyponatremia is corrected, the risks of short- and long-term mortality are reduced[1]. It remains unclear whether hyponatremia predicts disease severity and whether it is itself a cause of death[3,4]. Severe hyponatremia can lead to seizures and other symptoms of cerebral edema[5]. Hyponatremia occurs more frequently after orthopedic surgery[6], and even mild hyponatremia in the elderly is associated with an increased risk of falls leading to fractures[7]. Hyponatremia has also been reported to prolong hospitalization and increase mortality[1]. The mechanisms linking hyponatremia to poor outcomes remain unclear, although several studies have reported that hyponatremia may occur after spinal surgery[8,9]. Hyponatremia is a common electrolyte abnormality in clinical practice and its incidence has been reported after surgery and dialysis

Corresponding author: Hiroyuki Tominaga, hiro-tom@m2.kufm.kagoshima-u.ac.jp

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Table 1. Demographic and Clinical Characteristics of the Patients.

Variable	Value
Postoperative hyponatremia	56 (28%)
Age (years)	69 (59–76)
Male sex	106 (53%)
Height (cm)	158.5 (150–165)
Body weight (kg)	59 (49.5–65.4)
BMI (kg/m^2)	23.4 (21.2–26.1)
Operation duration (min)	231 (170–326)
Blood loss (mL)	170 (80–370)
Preoperative albumin level (g/dL)	4.2 (3.9–4.4)
Preoperative total protein (g/dL)	7.1 (6.7–7.4)
GNRI	107.9 (100.0–113.3)
Preoperative potassium level (mEq/L)	4.2 (4.0–4.5)
eGFR (mL/min/1.73 m^2)	68.1 (53.1–86.8)
Preoperative sodium level (mEq/L)	140 (139–142)
Length of hospital stay (days)	18 (15–24)
Hypertension	70 (35%)
Diabetes mellitus	38 (19%)
Dialysis	13 (6.5%)
Delirium	11 (5.5%)
Duloxetine use	18 (9%)
Diuretic use	3 (1.5%)

Data are presented as n (%) or the median (1st quartile–3rd quartile).
Abbreviations: BMI, body mass index; GNRI, geriatric nutritional risk index; eGFR, estimated glomerular filtration rate

treatment, but there are few reports on the risk factors for hyponatremia after spinal surgery. Thus, this study aims to determine the incidence and risk factors for hyponatremia after spinal surgery.

Materials and Methods

This study was a single-center retrospective case review of 200 consecutive patients aged 20 years or older who underwent spinal surgery from January 2020 to December 2021. We retrospectively reviewed the electronic medical and operating room records. Age, sex, body mass index (BMI), operation duration, blood loss, preoperative albumin level, total protein level, the geriatric nutritional risk index (GNRI), potassium level, the estimated glomerular filtration rate (eGFR), preoperative sodium level, postoperative sodium levels (on postoperative days 1, 3, 7, and 14), hospital length of stay, history of hypertension, dialysis status, presence of delirium, use of oral duloxetine, and use of oral diuretics were evaluated. Delirium was defined according to the Diagnostic and Statistical Manual of Mental Disorders, Fifth edition, published by the American Psychiatric Association[10]. Patients with serum sodium levels below 135 mEq/L were diagnosed with hyponatremia, and those with serum sodium levels between 135 and 145 mEq/L were considered to have normal sodium levels (normonatremia). The postoperative hyponatremia and normonatremia groups were compared using the Wilcoxon test or Fisher's exact test. We performed a multivariate logistic regression analysis to identify the risk factors for postoperative hyponatremia. All analyses were conducted using JMP software (version 16; SAS Institute, Cary, NC, USA). We defined $p<0.05$ as indicating a significant difference.

Results

Hyponatremia after spinal surgery was detected in 56 patients (28%). Among the 200 included patients, the median age was 69 years (Table 1), with 106 male patients and 94 female patients. The median operation duration was 231 minutes, and the median blood loss was 170 mL. The median preoperative sodium level was 140 mEq/L, and the median hospital stay was 18 days. Of the patients, 70 had hypertension, and 13 were on dialysis. Delirium was detected in 11 patients during the hospitalization period. The postoperative hyponatremia group and the postoperative normonatremia group were compared. Older age was associated with a higher incidence of postoperative hyponatremia (72 versus 68.5 years, $p<0.01$) (Table 2), and no significant differences in sex, height, or weight were found. A lower preoperative BMI was associated with an increased likelihood of postoperative hyponatremia (22.4 versus 23.8 kg/m^2, $p<0.01$). There were no significant group differences regarding the duration of the surgery or blood loss volume. Low preoperative albumin levels (3.9 versus 4.3 g/dL, $p<0.01$), low GNRI values (100.8 versus 109.3, $p<0.01$), high preoperative potassium levels (4.4 versus 4.2 mEq/L, $p<0.05$), and low eGFR values (59.2 versus 70.8 mL/min/1.73 m^2, $p<0.01$)

Table 2. Demographic and Clinical Characteristics of the Postoperative Hyponatremia and Postoperative Normonatremia Groups.

Variable	Postoperative hyponatremia group	Postoperative normonatremia group	P value
Number of patients	56	144	
Age (years)	72 (67.3–79.3)	68.5 (57.0–74.8)	<0.01
Male sex	33 (58.9%)	73 (50.7%)	0.29
Height (cm)	159 (150–164)	158 (149–166)	0.65
Body weight (kg)	58.1 (45.9–63.4)	59.5 (50.2–65.7)	0.09
BMI (kg/m^2)	22.4 (20.0–25.6)	23.8 (21.5–26.4)	0.04
Operation duration (min)	242 (184–329)	223 (158–326)	0.39
Blood loss (mL)	237.5 (85.3–421.3)	159 (76.3–357.5)	0.68
Preoperative albumin level (g/dL)	3.9 (3.5–4.2)	4.3 (4.0–4.5)	<0.01
Preoperative total protein (g/dL)	7 (6.6–7.4)	7.1 (6.8–7.4)	0.13
GNRI	100.8 (93.3–108)	109.3 (102.6–114.6)	<0.01
Preoperative potassium level (mEq/L)	4.4 (4.0–4.7)	4.2 (4.0–4.4)	0.04
eGFR (mL/min/1.73 m^2)	59.2 (41.8–74.4)	70.8 (59.8–89)	<0.01
Preoperative sodium level (mEq/L)	138.5 (136–140)	141 (139–143)	<0.01
Preoperative hyponatremia group	12 (21.4%)	1 (0.7%)	<0.01
Length of hospital stay (days)	23 (17–30)	16.5 (14–21)	<0.01
Hypertension	22 (39%)	48 (33%)	0.5
Diabetes mellitus	16 (28.6%)	22 (15.2%)	0.03
Dialysis	5 (8.9%)	8 (5.5%)	0.3
Delirium	7 (12.5%)	4 (2.7%)	0.01
Duloxetine use	5 (8.9%)	13 (9%)	0.99
Diuretic use	1 (1.7%)	2 (1.3%)	0.99
Cervical	21 (37.5%)	53 (36.8%)	0.9
Thoracic	16 (28.5%)	33 (22.9%)	0.4
Lumbar	23 (41%)	65 (45.1%)	0.6
Tumor	5 (8.9%)	23 (15.9%)	0.19
Spinal deformity	7 (12.5%)	11 (7.6%)	0.28
Spinal fusion	38 (67.8%)	76 (52.7%)	0.05

Data are presented as n (%) or the median (1st quartile–3rd quartile).

Abbreviations: BMI, body mass index; GNRI, geriatric nutritional risk index; eGFR, estimated glomerular filtration rate

Table 3. Risk Factors for Postoperative Hyponatremia.

Variable	Odds ratio	95% CI	p value
Age	1.04	1.01–1.07	0.01
Male	1.09	0.51–2.34	0.82
Diabetes mellitus	2.01	0.85–4.76	0.11
Spinal fusion	2.00	0.93–4.29	0.08
Preoperative sodium level	0.66	0.56–0.78	<0.01

were associated with postoperative hyponatremia, along with low preoperative sodium levels (138.5 versus 141 mEq/L, p <0.01). The postoperative hyponatremia group had a significantly longer hospital stay than the normonatremia group (23 days versus 16.5 days, p<0.01). Thus, hyponatremia was associated with less favorable clinical outcomes. There was no significant difference between groups in terms of the presence or absence of preexisting hypertension or dialysis. Delirium during hospitalization was significantly more common in the postoperative hyponatremia group (12.5% versus 2.7%, p=0.01). No significant difference in the use of oral duloxetine or diuretics was found, as well as no significant differences were found in terms of the surgical sites, including the cervical, thoracic, and lumbar spine, and terms of diseases (Table 2).

Multivariate regression analysis showed that age (odds ratio=1.04, p=0.01) and preoperative sodium levels (odds ratio =0.66, p<0.01) were risk factors for postoperative hyponatremia (Table 3).

Discussion

There are few reports on the risk factors for hyponatremia after spinal surgery. However, in this study, older age and preoperative hyponatremia were identified as risk factors for hyponatremia after spinal surgery. Low nutritional status and

poor renal function were not previously linked with hyponatremia; we are the first to reveal that preoperative undernutrition and impaired renal function are risk factors for postoperative hyponatremia. In hospitalized patients, the prevalence of hyponatremia, a common electrolyte abnormality, is 15%-30%[11]. Consistent with previous findings, 56 patients (28%) in this study presented with hyponatremia[12]. Preoperative hyponatremia may increase mortality and prolong hospital stays[1]. In addition to postoperative hyponatremia, older age is also a risk factor for preoperative hyponatremia. Aside from older age, spinal fusion and hip arthroplasty were also reported to be risk factors for hyponatremia[6]. Further, elderly patients are at risk of hyponatremia due to changes in physiology and various complications[13]. Additionally, older age and higher BMI were reported to be risk factors for thiazide diuretic-induced hyponatremia[14]. The syndrome of inappropriate antidiuretic hormone secretion (SIADH) causes hyponatremia, with reports stating that hyponatremia and delirium are associated with the use of duloxetine and that SIADH is more likely to occur after spinal surgery[15]. However, we did not find an association between hyponatremia and the use of duloxetine or oral diuretics in the present study.

Some patients with preoperative hyponatremia may develop chronic hyponatremia, as some cases of hyponatremia remain after surgery. Notably, hyperglycemia has been reported to decrease serum sodium levels[16]. In our study, the characteristics of the patients with diabetes in the postoperative hyponatremia group were significantly different. The increased frequency of comorbidities such as diabetes mellitus and diuretic medications that predispose elderly patients to hyponatremia led to the present results. Hyponatremia was previously found to be associated with a higher incidence of delirium and a longer hospital stay[17]. This may be partially due to the association of hyponatremia with impaired attention and cognition[17]. Delirium associated with nutritional deficiencies has also been reported after adult spinal deformity surgery[18]. In this study, the incidence of delirium was also significantly higher in the postoperative hyponatremia group, suggesting that sodium level and nutritional correction may prevent delirium and reduce the length of hospital stay. Nutritional management includes the use of protein supplements; the age-related recommendation for daily protein intake for patients with sarcopenia who are 65 years of age and older is 1-1.2 g/kg/day. Intake of protein and other nutrients and exercise are important for maintaining health[19]. Aside from nutritional deficiencies, psychiatric disorders, benzodiazepine use, age >70 years, and hearing loss are reportedly risk factors for delirium[20]. Patients with the aforementioned risk factors as well as undernutrition and preoperative hyponatremia require careful inpatient management.

Limitations

This study has some limitations. First, this study involved a single-center retrospective analysis of hospital records. Second, we evaluated blood loss and duration of the surgery but did not evaluate infusion volume, drinking water volume, or perioperative water in-out balance. The use of isotonic saline in pediatric surgery has been reported to reduce the risk of postoperative hyponatremia[21], which has been reported to be significantly associated with the total dose of lactate Ringer's solution[6]. Finally, all surgeries were performed under general anesthesia with motor-evoked potential (MEP) monitoring. Compared with intravenous anesthetics, inhaled anesthetics are less suitable for MEP monitoring[22]; therefore, they are not used for maintaining anesthesia. Short-acting analgesics and muscle relaxants were used during the induction of anesthesia, and intravenous anesthetics were used during its maintenance. The use of different anesthesia methods and drugs may affect the results.

Conclusions

Hyponatremia was present in 28% of postoperative spinal surgery patients in this study. The risk factors for postoperative hyponatremia included older age, preoperative hyponatremia, poor nutrition, and impaired renal function. Hyponatremia was associated with a longer hospital stay and an increased incidence of delirium. Therefore, it is important to correct preoperative hyponatremia and improve patients' nutritional status. Preoperative correction is cost-effective and may lead to better patient outcomes; thus, it merits investigation in future prospective studies.

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

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Author Contributions: Hiroyuki Tominaga designed the study.

Masato Sanada and Hiroyuki Tominaga collected and analyzed the data. Ichiro Kawamura, Hiroto Tokumoto, Takuma Ogura, and Noboru Taniguchi supervised the experiments. Masato Sanada and Hiroyuki Tominaga wrote the manuscript. All authors participated in interpreting the results, drafting the report, and approving the final version. Masato Sanada and Hiroyuki Tominaga contributed equally to this study.

Ethical Approval: Kagoshima University approved the study (IRB approval number is 220278).

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