Perioperative Complications of Open Spine Surgery in Older Adults over 90 Years of Age

Takeru Tsujimoto[1)], Masahiro Kanayama[1)], Kota Suda[2)], Fumihiro Oha[1)], Miki Komatsu[2)], Yukitoshi Shimamura[1)], Masaru Tanaka[1)], Daisuke Ukeba[1)], Yuichi Hasegawa[1)], Tomoyuki Hashimoto[1)], Masahiko Takahata[3)] and Norimasa Iwasaki[3)]

1) Spine Center, Hakodate Central General Hospital, Hakodate, Hokkaido, Japan
2) Department of Orthopedic Surgery, Hokkaido Spinal Cord Injury Center, Bibai, Hokkaido, Japan
3) Department of Orthopaedic Surgery, Hokkaido University Graduate School of Medicine, Sapporo, Hokkaido, Japan

Abstract:

Introduction: Despite perioperative risks in nonagenarian patients who undergo open spine surgery for degeneration disorder or spinal trauma being of great interest, the prevalence of complications in this group remains unclear. This study aims to examine the perioperative complications of open spine surgery in the elderly over 90 years of age.

Methods: Preoperative and intraoperative characteristics including the American Society of Anesthesiologists Physical Status (ASA-PS) class, type of surgery, and complications within 30 postoperative days were retrospectively collected from the medical records of nonagenarians who underwent open spine surgery between April 2004 and July 2019 at our spine centers.

Results: A total of 48 patients met the inclusion criteria of this study. All belong to ASA-PS class 2 (69%) or 3. Preoperative American Spinal Injury Association Impairment Scale grades in trauma group were grade A in 4 cases, B in 1 case, C in 5 cases, D in 11 cases, and E in 1 case. Major complications (deep surgical site infection, cardiac event, respiratory disorder, gastrointestinal hemorrhage, and renal failure) occurred in 13 cases, and the rate of overall perioperative complications was 45.8%. One patient who underwent cervical stabilization for cervical fracture dislocation died at postoperative 13 days due to respiratory disorder. The rates of major complications and overall perioperative complications were 3.6% and 14.3% in the degenerative group and 45.5% and 81.8% in the trauma group, respectively. Especially in the trauma group, respiratory disorder occurred in 7 cases, delirium in 11 cases, and urinary tract infection in 5 cases.

Conclusions: Although the perioperative complication rate reached 81.8% in spinal trauma cases, the complication rate in degenerative disorders was relatively low as 14.3%. Open spine surgery for degenerative disorders can be relatively safe even in nonagenarians, whereas the risks of perioperative complications, including respiratory disorder and delirium, were high in spinal trauma cases.

Keywords:

older adults, spine surgery, perioperative complication, nonagenarian

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Introduction

With a continuously increasing global life expectancy, most countries face significant healthcare problems relating to aging populations. This demographic change will continue to progress over time. Consequently, nearly half of the world's population will live in relatively aged countries, with at least 20% of the global population aged 60 years or over by 2050[1)]. In Japan, the population over 65 years old accounts to 28.4%, and the mean life expectancy for females was 87.5% in 2019[2)]. Hence, surgical indications for spinal disorders in elderly patients, including octogenarians and nonagenarians, are becoming more common[3,4)]. Although the risks of spine surgery in octogenarians are well-known[4-11)], there is a lack of information for nonagenarian patients who undergo spine surgery. To the best of our knowledge, only two previous studies have reported complications in nonagenarians following spine surgery[3,12)]. According to these stud-

Corresponding author: Takeru Tsujimoto, t.1105.tsujimoto@gmail.com
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ies, the short-term major complication rate in nonagenarians after spine surgery ranged from 7% to 26%, and the in-hospital mortality rate ranged from 1.7% to 2.9%.

Previous studies investigating the complications in nonagenarians did not distinguish between open and percutaneous surgeries, such as percutaneous stabilization without fusion, full endoscopic spine surgery (FESS), or balloon kyphoplasty (BKP). Percutaneous procedures are associated with fewer complications and infections, lower estimated blood loss, and shorter hospital stays and recovery times[13-15]. Therefore, they are considered favorable procedures for older adults. Nevertheless, open spine surgery is still a common procedure for patients requiring spinal decompression or fusion due to its well-established and safe procedure. Postoperative risks in nonagenarians undergoing open spine surgery for degenerative disorders or spinal trauma are of great interest, but the prevalence of complications in this group remains unclear. This study aims to examine the perioperative complications of open spine surgery in older adult patients aged ≥90 years. In addition, the differences in perioperative complications between degenerative disorders and spinal trauma were assessed.

Materials and Methods

Patients

This study was approved by the institutional review board and was conducted in accordance with the principles laid down in the Declaration of Helsinki. The medical records of patients over 90 years of age who underwent open spine surgery at two spine centers between April 2004 and July 2019 were retrospectively reviewed. The exclusion criteria were (1) percutaneous spine surgery including percutaneous stabilization, FESS, and BKP, (2) surgery for spinal infection or tumor, (3) patients with multiple injury, and (4) patients who were referred to other hospitals within 30 days postoperatively. Of the 12,380 patients who underwent spine surgeries, 48 (0.4%) met the inclusion criteria for this study. These included 27 men and 21 women with a mean age of 91.7 years (range, 90-98 years) at the time of surgery. All patients were allowed to walk or transfer to a wheelchair from the first postoperative day.

Pre- and intra-operative factors

Preoperative comorbidities included hypertension, cardiovascular disease, chronic kidney disease, diabetes mellitus, history of malignant tumors, previous cerebral infarction, and chronic obstructive pulmonary disease. The American Society of Anesthesiologists Physical Status (ASA-PS) classification system was used to determine the patients' preoperative health status. Surgical factors included operative level (cervical, thoracic, and thoracolumbar-lumbosacral spine), surgical procedure (decompression or instrumentation surgery), setting of surgery (elective or emergency surgery), operation time, and estimated blood loss (EBL).

Perioperative complications

Perioperative complications were defined as adverse events that occurred intraoperatively or within 30 days postoperatively. All complications were divided into major and minor complications. Major complications were defined as deep surgical site infections (SSI), respiratory disorders, cardiac events, renal failure, and gastrointestinal hemorrhages. Minor complications were defined as decubitus, urinary tract infection (UTI), and delirium, which are more likely to occur among older patients[16,17]. Similarly, the patient's death within postoperative 30 days was investigated. Furthermore, the patients were divided into two groups, i.e., the degeneration group and the trauma group, and the data of the two groups were statistically compared. Pathogenesis in the degeneration group included cervical spondylotic myelopathy, cervical spondylolisthesis, thoracic myelopathy, lumbar spinal stenosis, and lumbar spondylolisthesis. Pathogenesis in the trauma group included cervical spinal cord injury, thoracolumbar vertebral fracture with or without ankylotic spine, thoracolumbar osteoporotic vertebral collapse, and lumbar burst fracture. The rates of major, minor, and overall complications in each group were examined. When multiple complications occurred in a patient, it was as one complication to calculate the overall complication rate.

Statistical analysis

Statistical analyses of the categorical variables between groups were performed using Fisher's exact test. Further, analyses of the continuous variables were performed using an unpaired Student's t-test or Welch's test for two-group comparisons. Statistical analyses were performed using JMP Pro version 13.0, statistical software (SAS Institute, NC, USA). Statistical significance was set at $P<0.05$.

Results

Table 1 lists the characteristics of these 48 cases. All patients belong to ASA-PS classification II or III, with 33 patients (68.8%) classified as class II. The preoperative comorbidities included hypertension in 32 patients (66.7%), cardiovascular disease in 17 patients (35.4%), chronic kidney disease in 13 patients (27.1%), diabetes mellitus in 9 patients (18.8%), a history of malignant tumors in 7 patients (14.6%), previous cerebral infarction in 6 patients (12.5%), and chronic obstructive pulmonary disease in 3 patients (6.3%). The mean operation time was 130 min (range, 36-284 min), and the average EBL was 161 ml (range, 5-941 ml). Thirty patients (62.5%) underwent instrumentation surgery.

Fig. 1 shows the preoperative pathogenesis based on the spinal level. The pathogenesis was trauma in 22 cases (45.8%), lumbar spinal stenosis in 18 cases (37.5%), cervical spondylotic myelopathy in 4 cases (8.3%), degenerative lumbar spondylolisthesis in 2 cases (4.2%), thoracic myelopathy in 1 case (2.1%), and degenerative cervical spondy-

Table 1. Characteristics of the 48 Cases.

Item	Value (Range)
Demographic	
Age (years)	91.7 (90–98)
Sex, male/female (n)	27/21
Body mass index (kg/m^2)	21.3 (14–31)
ASA-PS class, II/III (n)	33/15
Smoker (n)	2 (4.2%)
Comorbidity	
Hypertension	32 (66.7%)
Cardiovascular disease	17 (35.4%)
Chronic kidney disease	13 (27.1%)
Diabetes mellitus	9 (18.8%)
History of malignant tumors	7 (14.6%)
Previous cerebral infarction	6 (12.5%)
Chronic obstructive pulmonary disease	3 (6.3%)
Surgical factor	
Operative time (minutes)	130 (36–284)
Estimated blood loss (mL)	161 (5–941)
Need of instrumentation (n)	30 (62.5%)

Abbreviations: ASA-PS, American Society of Anesthesiologists Physical Status

lolisthesis in 1 case (2.1%). The operative spine level was cervical in 15 patients and thoracolumbar-lumbosacral in 33 patients. Ten of 15 cervical spine patients underwent surgeries for trauma, while 21 of 33 thoracolumbar-lumbosacral spine patients underwent surgeries for degeneration disorders.

A total of 38 cases of perioperative complications occurred, and 22 of 48 patients (45.8%) had at least one complication. Major complications occurred in 13 cases (27.1%), and minor complications occurred in 25 (52.1%). Major complications were respiratory disorders in seven cases (14.6%), deep SSI in two cases (4.2%), cardiac events in two cases (4.2%), renal failure in one case (2.1%), and gastrointestinal hemorrhage in one case (2.1%). Minor complications included delirium in 13 cases (27.1%), UTIs in 7 cases (14.6%), and decubitus in 4 cases (8.3%). One patient who had severe paralysis and underwent cervical stabilization for cervical fracture dislocation died on day 13 postoperatively due to respiratory disorders (Table 2).

Demographics were statistically compared between the degeneration and trauma groups. No significant differences were found in age, sex, body mass index, and ASA-PS class, whereas the proportion of emergency surgery, operative time, EBL, and rate of instrumentation surgery was greater in the trauma group than in the degeneration group (Table 3). Preoperative American Spinal Injury Association Impairment Scale (AIS) grades in trauma group were grade A in 4 cases, grade B in 1 case, grade C in 5 cases, grade D in 11 cases, and grade E in 1 case. Elective surgeries occurred in 24 of 26 cases (92.3%) in the degeneration group and only 3 of 22 (13.6%) patients in the trauma group. The rates of major and minor complications were 3.6% and 10.7%, respectively, in the degenerative group and 45.5% and 63.6%, respectively, in the trauma group (Fig. 2). The overall complication rate was 14.3% in the degeneration group and 81.8% in the trauma group, and the difference was deemed statistically significant (P<0.001). Table 4 presents the incidence of individual complications in the degeneration and trauma groups. Major complications in the degeneration group involved a deep SSI in one patient (3.6%), while those in the trauma group were respiratory disorders in seven patients (31.8%), cardiac events in two patients (9.1%), a deep SSI in one patient (4.5%), renal failure in one patient (4.5%), and gastrointestinal hemorrhage in one patient (4.5%). Similarly, minor complications in the degeneration group included delirium in 2 patients (7.1%), UTIs in 2 patients (7.1%), and decubitus in 2 patients (7.1%), while those in the trauma group included delirium in 11 patients (50.0%), UTIs in 5 patients (22.7%), and decubitus in 2 patients (9.1%). All 5 patients with AIS grades A or B in the trauma group had at least one major complications, whereas only 5 of 17 other patients had major complications.

Discussion

In the past century, global life expectancy has continuously increased, and Japan already faces a "super-aging" society in which those aged 65 years or older occupy over 21% of the population[18,19]. Consequently, a nationwide survey for spine surgery in Japan in 2011 indicated that patients aged 80 years or older accounted for over 10% of all spine surgeries[20]. Nevertheless, the risks of spine surgery for nonagenarians remain unclear. Previously, Oichi et al. reported that the 90-day mortality rate of elective spine surgery for nonagenarians was 1.7%, and the major complication rate was 7.4%[3]. Rychen et al. reported that the overall complication rate, including elective and emergency surgeries for 6 weeks after surgery, was 66%[12]. We showed that perioperative complications occurred in 45.8% of nonagenarian patients. The rate of major complications was 27.1%, and the mortality rate was 2.1% within 30 days postoperatively. Here, we showed that the complication and mortality rates of open spine surgery were within the range of the previous two studies.

Furthermore, the major complication and overall perioperative complication rates were 3.6% and 14.3% in the degenerative group, respectively, and 45.5% and 81.8% in the trauma group, respectively. Thus, the major complication rate in the degenerative group was relatively lower than that in the previous two studies investigating perioperative complications of spine surgery in nonagenarians, but that in the trauma group was extremely high. These results suggest that open spine surgery for degenerative disorders can safely be performed even in patients aged 90 years or older. On the other hand, when it is unavoidable to perform open surgery in patients with spinal trauma, the risk of perioperative complications should be explained elaborately in advance.

The difference in surgical settings may have influenced

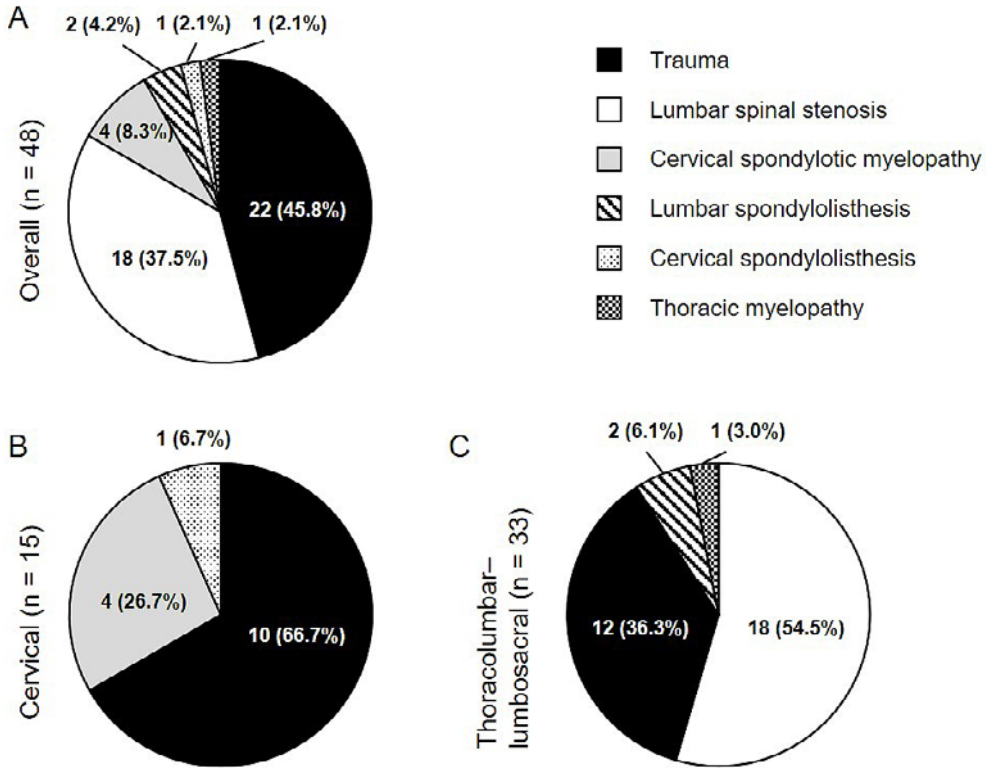

Figure 1. Pie chart demonstrating preoperative pathogenesis based on the spinal level. The breakdown of spinal disorders in overall patients (A), cervical spine (B), and thoracolumbar-lumbosacral spine (C).

Table 2. Details of Peri-operative Complications (n=38).

Complication	No. with complications
Major complications (n=13)	
Respiratory disorder	7 (14.6%)
Deep surgical site infection	2 (4.2%)
Cardiac event	2 (4.2%)
Renal failure	1 (2.1%)
Gastrointestinal hemorrhage	1 (2.1%)
Minor complications (n=25)	
Delirium	13 (27.1%)
Urinary tract infection	7 (14.6%)
Decubitus	4 (8.3%)
Death	1 (2.1%)

the higher perioperative complication rate in the trauma group than the degeneration group. A previous study reported that emergent spine surgery was an independent risk factor for a high incidence of perioperative complications and in-hospital mortality[21-23]. Furthermore, other studies reported a higher incidence of cardiac, infection-related, and genitourinary events or deep vein thrombosis after emergent spine surgery than after elective spine surgery[23-25]. Indeed, a previous study investigating spine surgery in nonagenarians found that the complication rate in the emergency surgery group was significantly higher than that in the elective surgery group[12]. Cases of emergent surgical procedures in the current study accounted for 86.4% of the trauma group and only 7.7% of the degeneration group. Consequently, the high proportion of emergent surgical settings in the trauma group may increase the risk of perioperative complications.

Additionally, all patients with severe paralysis in the trauma group had major complication, while only less than one-third patients with milder paralysis had major complication. Moreover, one patient who had severe paralysis died after cervical stabilization for cervical fracture dislocation. These results suggest that patients with severe paralysis have greater risk than patients with milder neurological deficit after open spine surgery in nonagenarians for spinal trauma.

In the current study, operative time and EBL in the trauma group were greater than those in the degeneration group. Previous studies indicated that an operative time longer than 180 min and EBL greater than 500 ml are considered risk factors in spine surgery[7,26]. Wang et al. reported that the operative time for patients with a complication was 196.8 min versus 176.9 min in those without a complication after lumbar spine surgery for the elderly[26]. However, the operative time and EBL of both degeneration and trauma groups in the current study were less than 180 min and 500 ml, respectively. This suggests that these operative factors did not cause an increase in perioperative complications in our study.

Among perioperative complications, respiratory disorders, UTI, and delirium have high rates in the current population[3,10,11,27-29]. Previous studies investigating perioperative complications in various types of spine surgery reported that

Table 3. Characteristics of Degeneration and Trauma Group.

	Degeneration group (n=26)	Trauma group (n=22)	*P* value
Demographic			
Age (years)	91.9±2.3*	91.5±2.2*	0.647
Sex, male/female (n)	14/12	13/9	0.715
Body mass index (kg/m^2)	22.5±2.7*	20.3±4.5*	0.072
ASA-PS class, II/III (n)	20/6	15/7	0.184
Surgical factor			
Setting of surgery, elective/emergency (n)	24/2	3/19	<0.001
Operative time (min)	104.6±50.9*	157.8±57.3*	0.002
Estimated blood loss (mL)	97.8±105.7*	233.0±222.0*	0.014
Instrumentation surgery (n)	9 (34.6%)	21 (95.5%)	<0.001

Abbreviations: ASA-PS, American Society of Anesthesiologists Physical Status

*: The values are expressed as mean and standard deviation.

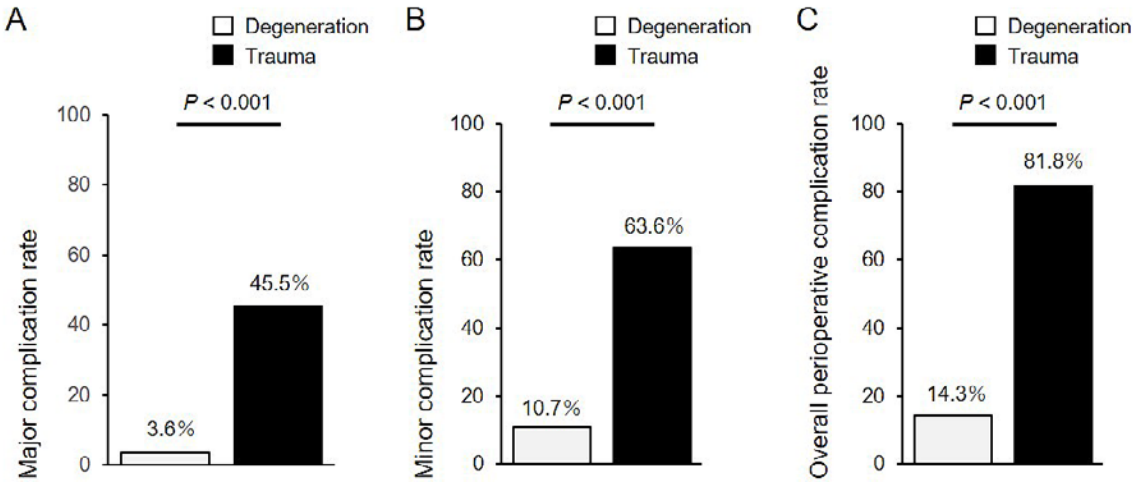

Figure 2. Complication rate in the degeneration and trauma group. The rates of major complications (A), minor complications (B), and overall perioperative complications (C).

the rates of perioperative respiratory disorders, UTIs, and delirium in older adults were 1.9%-14.6%[3,10,11,27,29], 1.8%-16.1%[3,16,27,29], and 3.3%-40.5%[3,29-32], respectively. In the current study, the complication rates of respiratory disorders, UTIs, and delirium in the trauma group were higher than those reported in previous studies, whereas those in the degeneration group were equal to the previously reported rates. Generally, older adult trauma patients are prone to protracted bed rest, oropharyngeal dysphagia due to oropharyngeal muscular weakness, and long-term detainment of indwelling catheters, which are related to respiratory disorders, UTIs, and delirium[33,34]. Therefore, early recognition of these problems and their potential prevention (with measures such as reduction of time spent in bed, swallowing rehabilitation, removal of indwelling catheters, and postoperative neurologic consultation) should be conducted to reduce perioperative morbidity.

This study focused on perioperative complications after open spine surgery in older adult patients over 90 years of age and provided three important findings. First, the overall perioperative complication rate in nonagenarians was 45.8%. Second, the perioperative complication rate in patients with degenerative disorders was 14.3%, while the rate in those with spinal trauma reached 81.8%. Finally, among perioperative complications, rates of respiratory disorders, UTIs, and delirium were high.

The main strength of this study is that it investigated nonagenarians who underwent open spine surgery, a well-established and safe procedure. To the best of our knowledge, only two published studies have investigated the perioperative complications of nonagenarians undergoing spine surgery[3,12]. The current investigation is the first to focus on open spine surgery. The results of this study may be helpful in explaining the risk of spine surgery to nonagenarian patients and deciding on a treatment policy.

The primary limitation of this study was its retrospective design. A previous systematic review reported that the incidence of complications was lower in retrospective studies than in prospective studies[35]. Therefore, the results of this current study cannot be used to determine the actual perioperative complication rate in nonagenarians. Moreover, previous studies have found that instrumented fusion surgery

Table 4. Incidence of Individual Complications in the Degeneration and Trauma Groups.

	Degeneration group		Trauma group	
	No. with complications	%	No. with complications	%
Major complications				
Respiratory disorder	0	0	7	31.8
Cardiac event	0	0	2	9.1
Deep surgical site infection	1	3.6	1	4.5
Renal failure	0	0	1	4.5
Gastrointestinal hemorrhage	0	0	1	4.5
Minor complications				
Delirium	2	7.1	11	50.0
Urinary tract infection	2	7.1	5	22.7
Decubitus	2	7.1	2	9.1
Death	0	0	1	4.5

increases the risk of perioperative complications in elderly patients[4,36]. Given that the proportion of instrumentation surgery in the current study was remarkably divergent between the degeneration and trauma groups, this deflection was related to a significant difference in the perioperative complication rate between the two groups. Furthermore, because patients in our cohort had undergone multiple types of spine surgery at different spinal levels, different functional outcomes would be predicted after each surgery. Therefore, evaluating the postoperative clinical outcomes is a challenge. However, this study would be more meaningful if the information on postoperative symptomatic improvements, such as pain or neurological deficit, was available for our cohort, and further study will be required.

Conclusion

Although the perioperative complication rate was 45.8% in all patients and 81.8% in spinal trauma cases, the complication rate in degenerative disorders was relatively low at 14.3%. Open spine surgery for degenerative disorders is relatively safe even in patients aged 90 years or older. On the other hand, the risks of perioperative complications, including respiratory disorders, UTIs, and delirium, were high in spinal trauma cases.

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

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Author Contributions: T.T., M.K, and K.S. designed the study. T.T. performed and analyzed the data. T.T., M.K., K.S., F.O., M.K., Y.S., M.T., D.U., and Y.H. collected the data. T.T. and M.K. wrote the manuscript. T.H., M.T., and N.I. supervised the study. All authors have read, reviewed, and approved the article.

Ethical Approval: The Institutional Review Board of Hakodate Central General Hospital approved the protocol followed in this study (approval code: 2021-31).

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

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