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Clinical Research

Analysis of the characteristics of unplanned admission to the intensive care unit after general surgery

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Background: Unplanned intensive care unit admission (UIA) is associated with perioperative morbidity and mortality, and can be used as a surrogate marker for patient safety. This study aimed to compare the characteristics of planned and unplanned intensive care unit (ICU) admission groups.

Methods: We retrospectively reviewed the electronic medical records of adult patients admitted to the ICU after abdominal and thyroid surgery under general anesthesia between 2016 and 2017. Preoperative, intraoperative, and postoperative information of enrolled patients was recorded. We compared patients' characteristics and outcomes between the unplanned and planned admission groups.

Results: In the total cohort, the proportion of UIA was 82.8% (202/244). In the unplanned admission group, total hospital stay was significantly shorter and ICU stay longer than that in the planned admission group (19.0 and 3.0 days, respectively vs. 28.5 and 2.0 days, respectively). In-hospital mortality rates were 21.3% and 7.1% in the unplanned and planned groups, respectively (P = 0.055). Patients in the UIA group showed higher Acute Physiology And Chronic Health Evaluation II scores, higher American Society of Anesthesiologist physical status class, and more co-morbidities than those in the planned group. There were significant differences in the incidence of UIA among surgery types.

Conclusions: The UIA group had a relatively high mortality rate and longer ICU stay. More critically ill patients tended to be admitted to the ICU without planning.

Keywords: Anesthesia; Critical care; General surgery; Intensive care units; Perioperative care.

INTRODUCTION

Perioperative morbidity and mortality are usually related to patients' co-morbidities, or intraoperative events such as hypotension or massive bleeding. Identifying and analyzing such relationships may help improve surgical outcomes. Indicators that predict patients' safety may help anesthetists to manage patients well. The concept of 'unplanned intensive care unit admission' (UIA) was first used in the US as a surrogate marker for patient safety and has potential for use in other countries [1,2]. Several studies indicated that UIA was associated with higher incidence of intraoperative adverse events such as cardiac arrest and hemodynamic instability; moreover, it was related to increased risk of respiratory fail-

ure and mortality, and prolonged hospital stay [3,4]. Previous studies reported that American Society of Anesthesiologist physical status classification (ASA PS class), male sex, advanced age, and surgery duration contributed significantly to UIA [4,5]. The limited information about the characteristics of patients with UIA in Korea and elsewhere suggests that further analyses of the risk factors for UIA may improve anesthesia care and reduce UIA. This study aimed to identify patient and surgical characteristics associated with unplanned intensive care unit (ICU) admissions immediately after surgery.

MATERIALS AND METHODS

This study reviewed the electronic medical records of 244 adult patients admitted to the ICU immediately after surgery and was approved by the Institutional Review Board of the Sanggye Paik Hospital (IRB no. SGPAIK 2016-09-014). The database comprises patients 19 years or older who underwent abdominal (esophageal, stomach, colorectal, hepatobiliary, vascular, or breast and thyroid) surgery under general anesthesia, and were admitted to the ICU postoperatively between January 1, 2016 and December 31, 2017. For patients who underwent operations more than twice during the study period, data from only the first surgery was included in the study.

'Planned ICU admission' was defined as a surgical case in which the ICU reservation was made on the day before surgery itself; 'unplanned ICU admission' as a surgical case in which ICU admission was determined intra- or postoperatively.

Patients' demographics (age, sex, height, and weight), social history (type, amount, frequency and duration of alcohol intake and frequency and duration of smoking), and ASA PS class were recorded. Preoperative coexisting medical diseases (cardiovascular: hypertension, heart failure, angina, atrial fibrillation and coronary artery occlusive disease; respiratory: asthma and chronic obstructive pulmonary disease: hepatic: liver cirrhosis, renal: acute or chronic kidney disease, end-stage renal disease, neurologic: cerebrovascular accident, delirium and dementia, and endocrinology: diabetes mellitus [DM] and thyroid disease) were recorded. In cases with past disease or treatment at other hospitals, information was obtained through electronic medical records of patient interviews. For patients that were being treated at our hospital, information was retrieved from admission or outpatient records. Duration of anesthesia and surgery (min), intraoperative hypotensive events, blood transfusion (whether conducted or not, and amount), and estimated blood loss during surgery (amount, ml) were recorded. An intraoperative hypotensive event was defined as hypotension with an indication for vasopressor administration during surgery. Duration of total hospital stay (number of days), duration of hospital stay after surgery (number of days), duration of ICU stay (number of days), Acute Physiology And Chronic Health Evaluation II (APACHE-II) scores [6], cardiovascular drugs such as dopamine, dobutamine, norepinephrine, and epinephrine (whether used or not), mechanical ventilator care in ICU (whether performed or not), and mortality rate (hospital death and death within 24 h after surgery) were also recorded.

All data are expressed as number of patients (%) or median (interquartile range) based on the results of the Shapiro–Wilk normality test. Continuous variables (e.g., duration of hospital stay, age, body weight, height, APACHE-II score, or transfusion/bleeding volume) were compared between the two groups using the Student's *t*-test or Mann–Whitney *U* test, depending on normality of the data. Incidence of mortality, co-morbidities, and surgery type were compared between groups using the chi-squared test. Statistical analysis was performed with R software (ver. 3.5.0, R Foundation for Statistical Computing, Austria) [7], with $P < 0.05$ considered statistically significant.

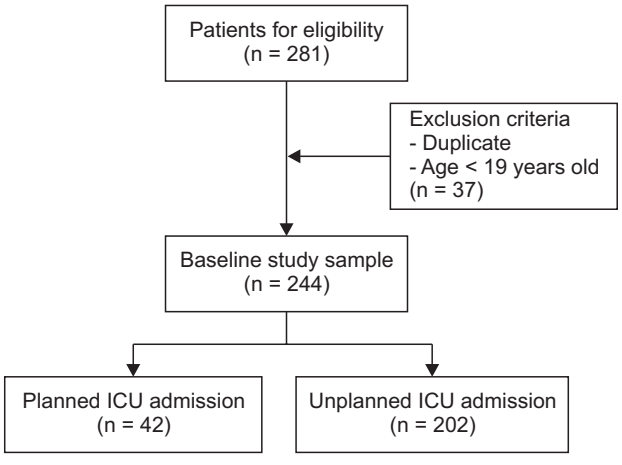

Fig. 1. Study design and flow graph. ICU: intensive care unit.

RESULTS

Of the patients who underwent abdominal (colorectal, hepatobiliary, stomach, vascular, breast and thyroid surgery) by general surgeons from January 1, 2016 to December 31, 2017, a total of 244 patients were admitted to the surgical ICU after surgery. Of these, 42 patients (17.2%) were of the planned ICU admission group, and 202 patients (82.8%) were of the unplanned ICU admission group (Fig. 1).

We present the characteristics of the two groups in Table 1. ASA PS class distribution differed significantly between groups. In the planned group, ASA PS class II patients accounted for almost half the patients (47.6%); in the unplanned group, ASA PS class III accounted for the majority (70.8%) and ASA PS class IV and V also occurred. The ASA PS class score of the unplanned group was higher than that of

Table 1. Characteristics of Patients and Information Related to Anesthesia and Surgery

Variable	Planned group (n = 42)	Unplanned group (n = 202)	P value
Age (yr)	65.0 (63.0, 74.0)	70.5 (56.0, 79.0)	0.487
Sex			0.440
Male	26 (61.9)	109 (54.0)	
Female	16 (38.1)	93 (46.0)	
Height (cm)	163.9 (156.8, 167.7)	162.0 (155.0, 170.0)	0.766
Weight (kg)	59.9 (57.0, 64.0)	58.6 (50.0, 67.0)	0.259
Alcohol	14 (33.3)	60 (29.7)	0.779
Smoking	11 (26.2)	51 (25.2)	1.000
ASA PS class			< 0.001
II	20 (47.6)	35 (17.3)	
III	22 (52.4)	143 (70.8)	
IV	0 (0.0)	20 (9.9)	
V	0 (0.0)	4 (2.0)	
Comorbidity			
Cardiovascular	27 (64.3)	87 (43.1)	0.019
Respiratory	4 (9.5)	9 (4.5)	0.341
DM	19 (45.2)	41 (20.3)	0.001
CKD	3 (7.1)	17 (8.4)	1.000
Neurologic	4 (9.5)	24 (11.9)	0.865
Type of surgery			< 0.001
Stomach	1 (2.4)	23 (11.4)	
Colorectal	2 (4.8)	64 (31.7)	
Hepatobiliary	34 (81.0)	33 (16.3)	
Vascular	2 (4.8)	30 (14.9)	
Breast and thyroid	3 (7.1)	52 (25.7)	
Emergency surgery	0 (0.0)	191 (94.6)	< 0.001
Anesthetic time (min)	542.5 (415.0, 660.0)	200.0 (145.0, 265.0)	< 0.001
Surgery time (min)	497.5 (365.0, 615.0)	150.0 (105.0, 210.0)	< 0.001
Intraoperative hypotensive event	37 (88.1)	172 (85.1)	0.800
Transfusion during surgery	27 (64.3)	78 (38.6)	0.004
Estimated blood loss during surgery (ml)	500.0 (300.0, 1,500.0)	50.0 (20.0, 150.0)	< 0.001
Duration of total hospital stay (d)	28.5 (20.0, 41.0)	19.0 (12.0. 36.0)	0.003
Duration of hospital stay after surgery* (d)	20.0 (15.0, 29.0)	16.0 (10.0, 30.0)	0.099
Duration of ICU stay (d)	2.0 (2.0, 3.0)	3.0 (2.0, 5.0)	< 0.001
APACHE-II score	21.0 (11.0, 26.0)	25.0 (17.0, 31.0)	0.004
Use of cardiovascular drugs in ICU	3 (7.1)	50 (24.8)	0.021
Use of ventilators in ICU	2 (4.8)	49 (27.1)	0.009
Death within 24 hours	0 (0.0)	7 (3.5)	0.474
Death in-hospital	3 (7.1)	43 (21.3)	0.055

Values are presented as median (1Q, 3Q) or number (%). ASA PS: American Society of Anesthesiologists physical status, DM: diabetes mellitus, CKD: chronic kidney disease, ICU: intensive care unit, APACHE: Acute Physiology and Chronic Health Evaluation. *Hospital day after surgery means duration from operation to discharge.

the planned group.

Comorbidities also differed between groups, with a significantly greater proportion of patients in the planned group presenting with cardiovascular diseases and diabetes mellitus. The proportions of respiratory, renal and neurologic diseases did not differ between groups.

Surgical characteristics differed between groups. First, surgery type was different, with almost 80% of the planned group undergoing hepatobiliary surgery (34/42 patients), a significantly higher proportion than that of other surgery types. Second, the rate of emergency surgery within the unplanned group was much higher than that of the planned group (94.6% vs. 0.0%, P < 0.001).

APACHE-II scores within the unplanned group at the time of ICU admission were significantly higher than those of the planned group (25.0 vs. 21.0, P = 0.004). In the ICU, the incidence of cardiovascular drug use, e.g. dopamine, dobutamine, norepinephrine, and epinephrine, was significantly higher in the unplanned than in the planned group (24.8% vs. 7.1%, P = 0.021), as was the rate of ventilator therapy (27.1% vs. 4.8%, P = 0.009).

In contrast, average durations of surgery and anesthesia were significantly longer in the planned group (497.5 min and 542.5 min, respectively, P < 0.001) than in the unplanned group (150.0 min and 200.0 min, respectively). Estimated intraoperative blood loss in the planned group was higher than that in the unplanned group (500.0 ml vs. 50.0 ml, P < 0.001), as was the rate of transfusion (64.3% vs. 38.6%, P = 0.004).

The difference in duration of ICU stay between the two groups was 1.0 day, with patients of the unplanned group staying longer in the ICU. However, the duration of total hospital stay in the unplanned group was less than that in the planned group by 9.5 days. In addition, the duration of hospital stay after surgery in the unplanned group was shorter than that in the planned group (16.0 days vs. 20.0 days, P = 0.099), but the difference was not significant. The mortality rate in the unplanned group was 14.2% higher than that in the planned group, but the difference was not significant (P = 0.055).

DISCUSSION

Previous studies have shown that unplanned ICU admission had a negative impact on patients' safety, such as increased mortality and longer hospital stay [3,8]. Reducing or preventing the factors contributing to UIA might help to improve patients' safety [9].

Unplanned ICU admission has been studied largely in the postoperative period, and for emergency hospitalization. Despite study-based differences, generally, time to admittance to ICU is 1–2 days after surgery or leaving the emergency room [4,10,11]. Here, we aimed to identify patient and surgical characteristics associated with unplanned ICU admissions immediately after surgery, because a delay before ICU admission may result in situations that anesthesiologists cannot control and may introduce factors unrelated to perioperative periods.

Clinical experience suggests that older patients and those with poor health status are more likely to have unintentional ICU admission, and our findings support this hypothesis well. The ASA PS scores in the unplanned group were higher than those in the planned group. This is in line with the results of another study showing that the ASA PS class, old age, and surgery duration were risk factors related to unplanned ICU admission [4]. In addition, APACHE-II score, and frequency of cardiovascular drug use and ventilator therapy in the ICU, were significantly higher within the unplanned group, suggesting that this group comprised relatively more complicated cases. However, the incidence of intraoperative hypotension did not differ between groups. It is likely that the incidence of intraoperative hypotension was relatively low. Moreover, the incidence of respiratory failure was not significantly different between groups, in contrast to the findings of the aforementioned studies [3,4].

Meanwhile, the rate of presence of comorbidities of cardiovascular disease and DM was lower in the unplanned than the planned group, probably because clinical experience leads anesthesiologists to predict increased risks of postoperative complications for patients with a history of cardiovascular disease, and accordingly to prepare for ICU admissions with such patients.

The rate of unplanned ICU admission differed among surgeons, because some surgeons prefer to prepare the ICU preoperatively and make the decision regarding ICU admission intraoperatively. Moreover, preoperative preparation of the ICU depends on the type of surgery (e.g., stomach, colon, liver, or thyroid surgery). For instance, liver surgery is long and massive bleeding is expected, therefore is followed

by a high proportion of planned admissions relative to other surgery types. In addition, analysis of patient characteristics within each group showed that total surgery and anesthesia durations, amount of bleeding during surgery, and frequency of transfusion were significantly higher in the planned group than in the unplanned group. This may be due to the tendency to prepare the ICU before surgery in case of certain operations such as Whipple's operation, lobectomy of the liver, liver tumor resection, and other liver-related surgeries which are usually related with prolonged surgical time or large estimated bleeding volume.

The patients of the unplanned group had longer ICU stays but shorter total hospital stays than those of the planned group. This may be explained by several hypotheses. First, the higher mortality rate in the unplanned group, particularly within the first 24 h, may have reduced the duration of hospital stay. Secondly, the rate of emergency surgery within the unplanned group was higher than that of the planned group, leading to shorter pre-operative hospital stays because of omission of many pre-operative screenings and evaluations.

The in-hospital mortality rate in the unplanned group was higher than that in the planned group (21.3% vs. 7.1%), but not significantly so; and mortality rates for both groups were higher than those reported by other studies including patients with unplanned ICU admission. For example, for 2,910,738 patients from the National Anesthesia Clinical Outcomes Registry, among whom were 3,479 with UIA, the UIA-associate mortality rate was very low (0.64%) [4]. Among 46,539 patients from 498 hospitals across 28 European countries, in-ICU mortality of UIA patients was 8% for elective surgery, and 16% and 22% for urgent and emergency surgery, respectively [12]. We report in-hospital mortality of approximately 21%, similar to that reported by Pearse et al. [12]. Swann et al. [13] studied 265 patients who were admitted to the ICU postoperatively in Canada, excluding those who underwent neurosurgical operations; of these, 34 were of the UIA group and the in-hospital mortality rate was 8.8%. However, the mortality rate within 24 h after surgery was 3.5% in the unplanned group and 0% in the planned group, which was similar to or lower than that reported in other studies. Low mortality rate within the first 24 h compared to high mortality rate during hospital stay may be due to the patient's underlying disease or complications other than the effect of surgery and anesthesia.

Like ours, most institutes have established criteria for ICU admission. However, the practical decision for ICU admission is generally made by medical staff, such as surgeons and anesthesiologists, rather than being based on objective criteria. This may have affected the results of this study.

Our analysis does not establish cause and effect, as it was a retrospective rather than prospective randomized study. To explore the reasons why individual patients need ICU admission, a prospective study is needed.

In this retrospective review, we identified that patients with UIA show a higher ASA PS class, more prolonged ICU stays and greater mortality than patients with planned ICU admission. UIA patients have poorer health status, higher APACHE scores, and need more cardiovascular pharmacologic support and respiratory ventilatory care in the ICU. Unplanned ICU admissions differ among surgery types. We expect an improved understanding of these characteristics of patients with UIA to be helpful in analyses of the factors contributing to unplanned ICU admission that aim to improve patients' safety.

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CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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