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Effect of Rapid Response System on Unplanned Intensive Care Unit Admission after Elective Surgery

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Abstract

Objective: The purpose of this study was to clarify whether initiation of a rapid response system (RRS) affected the incidence of unplanned intensive care unit (ICU) admissions (UIAs) for treatment of organ dysfunction in the early postoperative period.

Methods: We retrospectively identified patients admitted unexpectedly to the ICU from general wards within the first 72 h after surgery between January 2006 and December 2017. Patients with UIAs were divided into two groups: a pre-RRS group (January 2006-May 2013); and a post-RRS group (June 2013-December 2017). We extracted data on the patients' characteristics, intraoperative status, and postoperative conditions. Student's t-test and Fisher's exact test were used to compare the patients' characteristics and incidences of UIA in the pre- and post-RRS groups.

Results: Thirty-nine patients (0.06%) underwent UIAs from general wards within the first 72 h after surgery. Pre-anesthetic condition as evaluated by ASA-physical status (ASA-PS) was ≥ 2, showing that most patients displayed some form of pre-anesthetic complication. The most frequent reasons for UIA were hypoxia in 19 patients (48.7%), shock in 12 patients (30.8%), and disturbance of consciousness in 4 patients (10.3%). The mortality rate in the pre-RRS group was 11.5%. SOFA score was significantly lower in the post-RRS group than in the pre-RRS group. The odds ratio for UIA between the pre- and post-RRS groups was 0.756 (95% confidence interval: 0.388-1.471). This result was not significant, but introduction of an RRS may be associated with an up to 25% reduction in UIA.

Conclusion: Introduction of an RRS did not reduce the incidence of UIA significantly, but severity of organ failure in patients with UIA decreased, resulting in lower UIA-associated mortality. Introduction of an RRS and careful observation of respiration-associated vital signs are therefore crucial to prevent UIA and UIA-related mortality after elective surgery.

Keywords: Rapid response system; Unplanned ICU admission; Postoperative organ failure; Vital signs; Outcome

Introduction

Due to advances in anesthetic management and the development of less invasive surgical procedures, the incidence of postoperative complications requiring treatment in the intensive care unit (ICU) appears to be decreasing [1-3]. On the other hand, thanks to minimally invasive surgical procedures and advances in perioperative care such as Enhanced Recovery after Surgery (ERAS), patients with severe and multiple comorbidities can now meet the indications for surgery. The risk of complications developing in the early postoperative period has thus been increasing. Postoperative complications such as hypoxemia, circulatory derangement and acute kidney injury can prove fatal when medical staff does not recognize changes in vital signs at an early stage. To prevent the risk of developing such fatal conditions, the rapid response system (RSS) has been widely introduced to many hospitals and countries. Bellomo et al. [4] reported that introduction of an RRS resulted in a 36.6% reduction in the postoperative mortality rate.

However, few studies have examined the beneficial effects of the RRS in terms of reducing unplanned ICU admissions (UIAs) in the early postoperative period.

We conducted this study to clarify whether the initiation of an RRS affects the incidence of UIAs for the treatment of organ dysfunction in the early postoperative period.

Patients and Methods

This study was approved by the institutional review board at Sapporo Medical University (approval number 302-53).

Patients

Subjects were patients who underwent UIA from a general ward within the first 72 h after surgery during the period from January 2006 to December 2017 at Sapporo Medical University Hospital. In our hospital, RSS was introduced in June 2013. Patients with UIA were divided into two groups: a pre-RRS group (January 2006-May 2013); and a post-RRS group (June 2013-December 2017).

Data collection

A retrospective cohort study was performed using anesthetic recordings and medical charts. The number of elective surgeries in each year and the number of elective ICU admissions in each year were recorded from the medical database.

Patients' characteristics, intraoperative status and postoperative conditions were collected from medical charts and records.

Patients' characteristics: Age, sex, and body mass index (BMI) were collected from the medical records. Pre-anesthetic comorbidities were evaluated using the Charlson comorbidity index [5]. Data on surgical site and operative procedures were collected from medical charts.

Intraoperative status: Site of surgical procedure, American Society of Anesthesiologist physical status (ASA-PS) classification, duration of operation and anesthesia, hemorrhage volume, fluid balance and dose of fentanyl administered were obtained from anesthetic records.

Postoperative conditions (demographic conditions in the ICU): Reasons for admission to the ICU, interval from return to general ward after surgery to admission to the ICU, acute physiology and chronic healthcare evaluation (APACHE) II score, sequential organ failure assessment (SOFA) score on admission to the ICU, 28-day ventilator-free days, 28-day ICU-free days, 28-day mortality rate and cause of death were collected from medical charts.

Statistical analysis

Continuous variables are expressed as mean ± standard deviation (SD) and categorical variables as numbers and percentages. Patients' characteristics were compared between the pre- and post-RRS groups using Student's t-test. Incidences of UIA in the pre- and post-RRS groups were compared by Fisher's exact test and odds ratios were calculated. Values less than 0.05 were considered statistically significant. All analyses were performed using Prism 5 software (GraphPad Software, San Diego, CA).

Results

Characteristics of UIA patients receiving elective surgery

Table 1 shows the demographic characteristics of patients. A total of 68,760 patients underwent elective surgery during the study period. Ninety-four percent (n=64,889) were directly transferred from the operating room to a general ward, and the others were electively admitted to the ICU. Thirty-nine patients (0.060%) were admitted to the ICU unexpectedly from a general ward within the first 72 h after surgery. Pre-anesthetic comorbidities were slightly high according to the Charlson comorbidity index. Pre-anesthetic condition as evaluated by ASA-PS was ≥ 2 in all except one case, showing that patients typically had some pre-anesthetic complications. Among the entire survey population, 18 patients (46.2%) underwent abdominal surgery, 9 (23.1%) underwent neck surgery, and 6 (15.4%) underwent orthopedic surgery. The most frequent reasons for ICU admission were hypoxia in 19 patients (48.7%), shock in 12 patients (30.8%), and disturbance of consciousness in 4 patients (10.3%). The mean interval from transfer to the general ward to UIA was 37.2 h.

Effect of RRS introduction on UIA

Numbers of elective surgeries during the periods from January 2006 to May 2013 and from June 2013 to December 2017 were 40,987 and 27,773, respectively. Of the 39,049 elective surgery patients transferred to a general ward, 26 patients (pre-RRS group) were admitted to the ICU unexpectedly during the period from January 2006 to May 2013 within the first 72 h after surgery. After the introduction of the RRS in our hospital, 13 patients (post-RRS group) were admitted to the ICU unexpectedly during the period from June 2013 to December 2017 within the first 72 h after surgery. Table 1 shows the patients' characteristics, perioperative conditions and conditions in the ICU obtained from anesthesia and medical records for the two groups. No significant differences in the patients' characteristics and perioperative conditions were seen between the two groups. No significant difference in APACHE II score was evident between the two groups. However, SOFA score was significantly lower in the post-RRS group than in the pre-RRS group. The odds ratio for UIA between the pre-RRS and post-RRS groups was 0.756 (95% confidence intervals: 0.388-1.471). This result was not significant, but introduction of the RRS may be associated with a 25% reduction in UIA.

The main reason for the ICU admission was hypoxemia in the two groups (53.8% in the pre-RRS group and 38.5% in the post-RRS group). Overall, 71.8% of patients required mechanical ventilation. Mortality rate in the pre-RRS group was 11.5%; two patients died of septic shock and one patient died of non-occlusive mesenteric ischemia (NOMI), whereas no patients died in the post-RRS group.

Discussion

We evaluated the backgrounds of UIA patients who underwent elective surgery and the effects of the implementation of introducing an RRS on the incidence of postoperative UIA. The results from the present study indicated that the number of UIAs from a general ward within the first 72 h after surgery was 6 per 10,000 operations (0.06%) in our hospital.

The incidence of UIA has been reported to vary from 0.12% to 0.79% [6-8]. These varying incidences of UIA among the literature were considered to be a result of differences in methods of data collection; prospective or retrospective design of the study; inclusion criteria; sample size; and definition of UIA as described by Meziane et al. [6].

Our result (0.06%) was markedly lower than in previous reports. In our study, subjects were patients who underwent elective surgery, excluding patients who underwent emergency, cardiac or vascular surgery. In addition, in our study, UIA was defined as admission to the ICU within 72 h after elective surgery. The reason for choosing 72 h after elective surgery in our study was supported by the report by Ramachandran et al. [9]. They showed postoperative hypoxemia as a major complication after surgery and unexpected intubation was required within the first 72 h after surgery. This study protocol may have resulted in the extremely low incidence of UIA after elective surgery.

On the other hand, most patients with the complication of hypoxemia showed a PaO_2/FiO_2 ratio <300 and 70% required mechanical ventilation, as demonstrated by Ramachandran et al. [9].

Respiratory complications such as atelectasis and pneumonia have been shown to frequently occur in patients who underwent upper abdominal surgery [10].

	Over all	Pre-RRS group	Post-RRS group	p value
Year	**2006-2017**	**2006-2013.5**	**2013.6-2017**	
Total number of elective surgery	68760	40987	27773	
Unplanned ICU admission, n (%)	39 (0.060)	26 (0.067)	13 (0.050)	0.507
I characteristics of patients				
Age (year-old)	69.8 ± 13.3	69.8 ± 13.4	70.0 ± 13.6	0.924
Gender (Male/Female)	2/14	15/11	10/3	0.304
Body mass index	21.5 ± 2.9	20.8 ± 2.9	22.7 ± 2.4	0.072
II perioperative conditions				
Charlson comorbidity index	4.7 ± 2.0	4.5 ± 1.8	5.1 ± 2.3	0.334
Surgical lesions Head Neck Thorax Abdomen Extremities Urogenital	2 9 3 18 6 1	1 7 3 11 3 1	1 2 0 7 3 0	
ASA-PS 1 2 3 Mean ± SD	1 25 13 2.3 ± 0.5	0 19 7 2.2 ± 0.4	1 6 6 2.4 ± 0.7	0.362
Operation time (min)	369 ± 246	378 ± 239	350± 268	0.665
Anesthesia time (min)	451 ± 257	461 ± 244	432 ± 289	0.843
Fluid balance during surgery (ml)	2248 ± 1617	2081 ± 1720	2581 ± 1391	0.157
III Conditions in the ICU				
Reasons for ICU admission Respiratory Circulatory Renal Central nervous system Miscellaneous	19 12 3 4 1	14 7 3 1 1	5 5 0 3 0	
MET activation, n (%)		-	6 (46.2)	
APACHE II score	20.3 ± 4.2	20.7 ± 3.9	19.7 ± 4.9	0.611
SOFA score on ICU admission	7.8 ± 3.9	8.9 ± 4.0	6.4 ± 2.9	0.046
Time from surgery to ICU admission (min)	37.2 ± 22.8	36.0 ± 22.3	39.5 ± 24.5	0.686
Length of ICU stay (day)	5.7 ± 6.6	6.2 ± 7.7	4.8 ± 3.2	0.748
Ventilator free days (day)	23.5 ± 7.4	22.3 ± 8.7	25.9 ± 2.3	0.33
28-day mortality rate, n (%)	3 (7.7)	3 (11.5)	0 (0)	0.202

Table 1: Patient's characteristics-Effect of rapid response system on unplanned intensive care unit admission.

Evacuation of expectoration is likely to be difficult in these patients because of inadequate analgesia, increased tracheobronchial secretion and elevated abdominal pressure due to swelling of the gastrointestinal tract.

Actually, the present results show abdominal surgery and respiratory abnormalities as possible factors contributing to UIA. We should therefore pay attention to changes in respiratory function such as changes in SpO_2 and respiratory rate for preventing deterioration of a patient's condition.

RRS services have been reported to significantly reduce the incidence of ICU admissions due to cardiac arrest, but not to improve mortality from medical emergencies [11]. However, some reports have suggested that RRS demands are particularly high in the surgical ward and the RRS might impact improvements in outcome for postoperative patients [12].

Alternatively, a before-and-after trial of RRS introduction showed improvements in long-term mortality not only for medical emergency patients, but also for postoperative patients [13].

The present results concerning the effects of the RRS on UIA were not significant in our hospital, which is compatible with the above-mentioned results. However, SOFA score on ICU admission was significantly decreased after RRS introduction in our study. This may be associated with the introduction of the RRS making medical staff (including attending nurses and attending physicians) pay closer attention to avoiding the development of organ dysfunction in the early postoperative period. Moreover, immaturity and delayed RRS activation have been demonstrated to be associated with poor prognosis [14,15]. To prevent development of organ failure, early detection of changes in vital signs and appropriate RRS activation are crucial points for improving postoperative mortality and morbidity. While our study found no significant difference in the mortality rate between the two groups, all patients after the introduction of the RRS survived. This favorable outcome may be associated with RRS-induced early detection, early recognition and early intervention. The introduction of an RRS thus appears meaningful for preventing unplanned ICU admission in the early postoperative period.

Limitations

This study has several limitations that must be considered. First, the results were obtained using retrospective data from a single-center cohort. Moreover, criteria for discharge from the operating room and admission to the ICU differ between hospitals and might change if the hospital has a post-anesthesia care unit, high care unit or RRS. Multicenter comparisons are needed to clarify which notable features are most relevant to unexpected ICU admissions, including postoperative discharge criteria and RRS activation criteria. Second, the sample size of UIAs was small compared to patients with uneventful postoperative outcomes. Multivariable-adjusted analysis was needed to compare postoperative mortality and morbidity. Further study is required to integrate fragmentary properties after surgery and to establish RRS activation criteria.

Conclusion

We investigated the background of elective surgery patients admitted to the ICU unexpectedly within the first 72 h after returning to a general ward, and the effect of introducing a rapid response system on the incidence of UIA after elective surgery. Abdominal surgery and hypoxemia were the main causes of UIA, consistent with other reports. While introduction of the RRS did not reduce the incidence of UIA, the severity of organ failure in patients with UIA decreased, resulting in an absence of UIA-associated mortality. Introduction of an RRS and careful observation of respiration-associated vital signs are crucial points to prevent UIA and UIA-related deaths after elective surgery.

Interests

The authors declare no conflicts of interest associated with this manuscript.

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