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Changes in Physiological Indices Before and After Nursing Care of Postoperative Patients With Esophageal Cancer in the ICU

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Abstract

Introduction: Various stressors have been identified in patients in the intensive care unit (ICU), including postoperative pain, ventilatory management, and nursing care. However, sedated patients are less responsive, and nurses have difficulty capturing their stressors.

Objective: To investigate patient stress caused by nursing care performed in the ICU on sedated patients based on changes in physiological indices.

Methods: We observed nursing care performed on patients with postoperative esophageal cancer under sedation in the ICU. This included endotracheal suctioning and turning, the time required for the care, and the patients' behavioral responses. Information on arousal levels, autonomic nervous system indices, and vital signs were also obtained. The changes in indicators before and after care were then compared and analyzed.

Results: There were 14 patients in the study. The mean age of the patients was 68 years. Ninety-nine scenes of nursing care were observed, and in six of these, additional bolus sedation was administered because of the patient's significant body movements. In endotracheal suctioning, no significant changes were observed in all indicators. In turning, vital signs changed significantly, and when both were continued, all indicators changed significantly.

Conclusion: Our study found that different types and combinations of nursing care may cause different stresses to the patients. Moreover, the autonomic nervous system indices may be more likely to react to stresses in a variety of nursing care, while arousal levels may be more likely to react to burdensome stresses. If the characteristics of these physiological indicators can be understood and effectively utilized during care, it may be possible to better identify and reduce patient stress during sedation management.

Keywords

intensive care unit, critical care, patient positioning, suction, stress, physiological

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Introduction

With the rapid development of intensive care medicine, more patients are recovering from critical conditions (Imanaka et al., 2010). Some intensive care unit (ICU) patients suffer from physical, cognitive, and mental dysfunctions that persist past the acute phase, known as post-intensive care syndrome (PICS). (Needham et al., 2012). PICS is accompanied by a decrease in patients' quality of life (Briegel et al., 2013).

In Japan, PICS can also occur in patients who have undergone selective surgery for diseases such as esophageal cancer and acute myocardial infarction (Ohbe et al., 2021; Unoki et al., 2021)

One of the factors contributing to PICS is the stress associated with treatment, nursing care, the special environment of the ICU, and the stress of being under sedation with a

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ventilator (Hweidi, 2007; Needham et al., 2012; Pang & Suen, 2008; Puntillo et al., 2016; Yava et al., 2011).

To improve the long-term prognosis of patients, including their quality of life, the American Society of Intensive Care Medicine published a revised version of its "Clinical Practice Guidelines for the Management of Pain, Agitation, and Delirium in Adult Patients in the Intensive Care Unit" (Barr et al., 2013; Devlin et al., 2018). The guidelines include recommendations for types of sedatives, management of shallow sedation, and early rehabilitation.

It has been reported that following the guidelines can reduce the duration of ventilator placement (Kress et al., 2000), reduce ICU and hospital stay (Girard et al., 2008), improve patient mobility (Pohlman et al., 2010), and is beneficial in terms of healthcare costs (Dasta et al., 2010). The guidelines also mention nursing care; routine nursing care performed under sedation control, such as turning and endotracheal suctioning, can contribute to patient stress (Aslanidis et al., 2018; Gelinas et al., 2019; Grap et al., 2014; Siffleet et al., 2007).

Review of Literature

Turning and endotracheal suctioning are the most common aspects of nursing care performed on patients in the ICU. These are frequently performed as essential care for pressure ulcer prevention and respiratory drainage but can be stressful for the patient (Puntillo et al., 2014, 2018; Siffleet et al., 2007).

The assessment of stress and pain is based on patient complaints and self-reports. As a measurement of stress associated with nursing care, the behavioral pain scale and the critical-care pain observation tool are utilized (Gélinas, 2016). However, because most patients are sedated immediately after surgery, their responses to stimuli are suppressed (Shehabi et al., 2018); thus, it is difficult to communicate their stress verbally or through reactions (Devlin et al., 2018; Gélinas, 2016; Puntillo et al., 2017).

Other non-verbal and observable measures include serum biomarkers such as cortisol, epinephrine (Chlan et al., 2007), and salivary amylase (Grap et al., 2014). However, these are difficult to use to determine the stress associated with nursing care.

Other physiological indices such as vital signs (Arbour & Gélinas, 2010), level of arousal (Coleman et al., 2013; Gélinas et al., 2011), and autonomic nervous system indices (Bourgault et al., 2006; Chanques et al., 2017; Devlin et al., 2018) have also been reported as measures of stress in patients under sedation management. They are non-invasive and easy to use in unstable postoperative patients when assessing stress. They can also capture and measure trivial changes promptly, even in sedative patients who are slow to respond to stimuli (Chanques et al., 2017; Devlin et al., 2018).

This study aims to investigate patient stress caused by turning and endotracheal suctioning, routine nursing care performed in the ICU on sedated patients with esophageal cancer immediately after surgery, based on changes in physiological indices such as arousal level, autonomic nervous system indices, and vital signs.

Methods

Design

Observational Study Design. Research Question

We set the following research question prior to our investigation:

- How is the stress associated with nursing care reflected in physiological indices in ICU patients with esophageal cancer whose responses to stimuli are suppressed by sedation?

Sample. Postoperative patients with esophageal cancer who were admitted to the ICU and underwent ventilator management from September to December 2019 were included in the study.

Inclusion Criteria. Postoperative patients with esophageal cancer admitted to the ICU who are under sedation management.

Exclusion Criteria. Patients with persistent preoperative arrhythmias, pacemakers, and anticholinergic medications were excluded because they would have precluded accurate data analysis when analyzing heart rate variability (HRV).

Definitions of Terms. This study defined stress as the physiological fluctuations in arousal level, autonomic nervous system indices, and vital signs resulting from the burden of endotracheal suctioning and turning. We also defined mean bispectral index (BIS) as the arousal level index, HRV as the autonomic nervous system index, mean blood pressure (MAP) and heart rate (HR) as the cardiovascular system index, and the central venous blood oxygen saturation ($ScvO_2$) as the respiratory system index.

Collected Data Items. Patient age and sex were obtained from their health records. MAP, HR, and $ScvO_2$ were obtained from the monitors worn (CSM-1702) (NIHON KOHDEN, Japan) for therapeutic management purposes. These data can be continuously extracted without new invasive procedures.

BIS was obtained from EEG data through its sensors (A-3200) (NIHON KOHDEN, Japan), and RR interval data was obtained from the wireless sensor RF-ECG2 and MemCalc/BonalyLight. All data were obtained via USB in Excel data files.

The data on the presence or absence of changes in the patient's facial expression and body movements during endotracheal suctioning and turning and the frequency of additional bolus sedation as a measure to reduce the burden of care were obtained by the researcher at the bedside and recorded in the field notes.

Calculation of Parasympathetic/Sympathetic Nervous System Indices

Frequency analysis was performed on the RR interval data using MemCalc software (GMS, Japan) to calculate the following HRV parameters: low frequency (LF; 0.04–0.15 Hz) and high frequency (HF; 0.15–0.40 Hz). HF was calculated as a parasympathetic index, and the ratio of LF to HF (LF/HF) as a sympathetic index (Task Force of The European Society of Cardiology and The North American Society of Pacing and Electrophysiology, 1996).

Data Collection Procedure

The investigators stayed at the patient's bedside without intervention from when the patients entered the ICU after surgery until they were extubated the next day. The investigators observed clinical nurses providing care to patients. Nursing care was classified into three patterns: turning and endotracheal suctioning, each performed separately and combined. The time required for these procedures was measured with a stopwatch, and care lists and patient behavioral indicators were recorded in field nodes. Instruments used to extract physiological index data were set to a predetermined date and time. For instruments whose date and time could not be changed, the date and time displayed on the screen were recorded and adjusted when analyzing the data.

In addition, since the HRV analysis devices needed to be newly attached to the patient, investigators confirmed that an environment was available for observation and obtained consent from the nurse in charge. Since the accurate analysis of HRV is not possible with HRV analysis, we excluded some supraventricular extrasystoles and artifacts from the data after confirming the electrocardiogram waveforms with the research collaborator, who is a physician.

Statistical Analysis

The results were averaged for each of the four points (1 min before, during, 1 min immediately after, and 5 min after). When averaging, we ensured the patient rested for at least 10 min before and after care. Multiple comparisons were made using the Wilcoxon signed rank test after performing the Friedman test for turning and endotracheal suctioning. The Shaffer method was used for correction. Due to the small sample size, we chose the Shaffer method, which allows for controlling Type II errors (Shaffer, 1995). The statistical significance level was set at 5%. Statistical analysis was performed using IBM SPSS Statistics (version 26).

Results

Sample Characteristics

Consent to participate in the study was obtained from 15 patients. One participant was excluded because it was difficult to accurately analyze the HRV owing to the persistent appearance of arrhythmia after surgery; thus, fourteen participants were analyzed. Ninety-nine scenes of nursing care were observed.

The participants were nine men and five women, with a mean age of 68 ± 8.9 years. The participants were controlled sedated from −4 to −5 on the Richmond Agitation-Sedation Scale (RASS). The sedatives used were propofol and dexmedetomidine.

During endotracheal suctioning and turning, the patients showed changes in behavioral indicators, such as facial expressions and movements of the upper and lower limbs, in 30 out of 99 scenes.

We observed six scenes in which a medical professional promptly administered additional bolus sedation to the patient during or after nursing care.

Single care: Endotracheal suctioning (Table 1)

Endotracheal suctioning was performed in 20 scenes. Of these, facial expression changes and coughing were observed in five scenes; no additional bolus sedation was administered in those five scenes. The average time required to perform endotracheal suctioning was 44.6 ± 5.4 s per session. No significant differences were found in all indices. However, LF/HF showed an increasing trend from before to during care in 14 of the 20 situations.

Single care: Turning (Table 2)

Turning was performed in 34 scenes. Of these, facial expression changes, upper and lower limb movements, and attempts to get up were observed during turning on two scenes; additional bolus sedation was performed on both of these scenes. Excluding those, 32 scenes were analyzed. The average time required for turning was 235.3 ± 24.3 s per change. Significant differences were observed in MAP, HR, and LF/HF, respectively. No significant differences were observed in BIS, $ScvO_2$, and HF.

Combined care: Turning and endotracheal suctioning in succession (Table 3)

Turning and endotracheal suctioning were performed in 51 scenes. Of these, facial expression changes, coughing, and upper and lower limb movements were observed in 23 scenes; additional bolus sedation was administered in four of those scenes. Excluding those, 47 scenes were analyzed. The average time required to perform turning and

Table 1. Effects of Endotracheal Suctioning at Different Time Points: Wilcoxon's Signed Rank Test With Shaffer Correction.

Endotracheal suction		Frequency	Median (IQR)	Mean ± SD	Comparison by scene		*p*-value
BIS	Before	12	61.0 (45.3–72.8)	60.3 ± 14.7	Before	During	n.s.
	During	12	59.8 (47.7–77.7)	60.3 ± 17		1 min after	n.s.
	1 min after	12	63.0 (51.3–74.8)	64.7 ± 16.8		5 min after	n.s.
	5 min after	11	66.0 (49.0–73.0)	63.8 ± 15.6	During	1 min after	n.s.
						5 min after	n.s.
					1 min after	5 min after	n.s.
MAP	Before	11	73.7 (67.3–96.7)	78.5 ± 17.8	Before	During	n.s.
	During	12	67.6 (62.8–94.5)	77.3 ± 21.7		1 min after	n.s.
	1 min after	12	68.5 (61.9–99.3)	79.1 ± 22.9		5 min after	n.s.
	5 min after	10	69.5 (64.4–89.0)	76.8 ± 19	During	1 min after	n.s.
						5 min after	n.s.
					1 min after	5 min after	n.s.
HR	Before	11	75.3 (61.0–92.7)	77.1 ± 17.2	Before	During	n.s.
	During	12	78.1 (60.6–93.8)	78 ± 17.1		1 min after	n.s.
	1 min after	12	79.2 (61.2–94.3)	77.9 ± 16.7		5 min after	n.s.
	5 min after	10	73.8 (59.6–87.1)	74.6 ± 14.7	During	1 min after	n.s.
						5 min after	n.s.
					1 min after	5 min after	n.s.
$ScvO_2$	Before	10	72.8 (57.0–77.5)	68.9 ± 10.4	Before	During	n.s.
	During	11	72.0 (60.0–77.0)	69.7 ± 10		1 min after	n.s.
	1 min after	11	72.0 (59.3–76.7)	69.5 ± 10		5 min after	n.s.
	5 min after	9	73.7 (62.7–81.3)	72.6 ± 9.9	During	1 min after	n.s.
						5 min after	n.s.
					1 min after	5 min after	n.s.
HF	Before	20	6.0 (3.0–14.7)	12.8 ± 15.5	Before	During	n.s.
	During	20	7.4 (3.5–22.5)	15.0 ± 17.6		1 min after	n.s.
	1 min after	20	7.4 (2.8–16.6)	12.9 ± 15.7		5 min after	n.s.
	5 min after	12	7.5 (1.6–24.5)	14.2 ± 15.6	During	1 min after	n.s.
						5 min after	n.s.
					1 min after	5 min after	n.s.
LF/HF	Before	20	1.2 (0.4–2.7)	1.9 ± 2.1	Before	During	n.s.
	During	20	2.4 (0.9–5.1)	3.0 ± 2.3		1 min after	n.s.
	1 min after	20	0.9 (0.6–4.1)	2.3 ± 2.4		5 min after	n.s.
	5 min after	13	0.7 (0.2–4.1)	1.9 ± 2.4	During	1 min after	n.s.
						5 min after	n.s.
					1 min after	5 min after	n.s.

Note. BIS = biospectral index; MAP = mean blood pressure; HR = heart rate; $ScvO_2$ = central venous blood oxygen saturation; LF = low frequency; HF = high frequency; IQR = interquartile range; SD = standard deviation.
** $p < .01$; * $p < .05$.

endotracheal suctioning was 315.6 ± 20.0 s per session. Significant differences were observed in BIS, HR, $ScvO_2$, and LF/HF, respectively. No significant differences were observed in MAP and HF.

Discussion

Type of Care and Magnitude of Stress

When turning and endotracheal suctioning were performed consecutively, significant changes were observed in all indicators except MAP, but when turning was performed alone, no change in arousal level was observed. Furthermore, when endotracheal suctioning was performed alone, no significant changes were observed in all indicators. These results suggest differences in the amount of stress applied to patients depending on the type and combination of care.

Endotracheal suctioning is perceived to be stressful care because an awake patient can recognize that the nurse is about to attempt endotracheal suctioning (Puntillo et al., 2014, 2018). Under sedation, the patient's inability to anticipate the onset of distress or the suppression of the cough reflex caused decreased stress. The respiratory index, $ScvO_2$, was also unchanged, indicating that the stress caused by endotracheal suctioning was relatively small.

Turning is characterized by the dynamic effects of moving the patient's body. Patients in the acute postoperative period have an unstable cardiovascular status and are easily affected

Table 2. Effects of Turning at Different Time Points: Wilcoxon's Signed Rank Test with Shaffer Correction.

Turning		Frequency	Median (IQR)	Mean ± SD	Comparison by scene		p-value
BIS	Before	25	56.0 (50.5–65.0)	57.3 ± 11	Before	During	n.s.
	During	25	58.3 (52.8–67.1)	60.9 ± 10.7		1 min after	n.s.
	1 min after	25	63.0 (52.5–72.0)	62.2 ± 12.4		5 min after	n.s.
	5 min after	25	63.0 (56.0–71.0)	63.0 ± 10.3	During	1 min after	n.s.
						5 min after	n.s.
					1 min after	5 min after	n.s.
MAP	Before	25	66.0 (61.8–82.0)	72.5 ± 15	Before	During	<.001**
	During	25	69.1 (64.8–86.5)	75.9 ± 16.7		1 min after	.003**
	1 min after	25	73.3 (64.7–85.7)	77.7 ± 16.4		5 min after	n.s.
	5 min after	25	70.3 (63.8–85.0)	75.1 ± 15.5	During	1 min after	n.s.
						5 min after	n.s.
					1 min after	5 min after	.009**
HR	Before	25	68.0 (57.8–79.5)	70.9 ± 15.2	Before	During	n.s.
	During	25	69.0 (60.0–78.1)	71.8 ± 14.9		1 min after	.018*
	1 min after	25	67.7 (60.8–79.2)	72.1 ± 15.1		5 min after	n.s.
	5 min after	25	66.3 (59.3–77.2)	70.7 ± 15.2	During	1 min after	n.s.
						5 min after	.042*
					1 min after	5 min after	.012*
$ScvO_2$	Before	21	74.3 (67.0–80.2)	73.5 ± 9.1	Before	During	n.s.
	During	21	73.2 (70.0–78.3)	72.4 ± 8.5		1 min after	n.s.
	1 min after	21	72.0 (69.5–76.3)	71.5 ± 7.8		5 min after	n.s.
	5 min after	21	75.3 (68.5–78.3)	73.0 ± 8.4	During	1 min after	n.s.
						5 min after	n.s.
					1 min after	5 min after	n.s.
HF	Before	32	10.3 (2.3–19.6)	12.9 ± 11.9	Before	During	n.s.
	During	32	10.4 (3.7–26.2)	16.2 ± 16.9		1 min after	n.s.
	1 min after	32	11.6 (3.1–20.4)	14.3 ± 13.4		5 min after	n.s.
	5 min after	30	8.6 (3.1–20.6)	15.0 ± 15.1	During	1 min after	n.s.
						5 min after	n.s.
					1 min after	5 min after	n.s.
LF/HF	Before	32	1.3 (0.5–2.7)	2.6 ± 4	Before	During	.012*
	During	32	2.3 (0.9–5.2)	3.9 ± 4.7		1 min after	n.s.
	1 min after	32	1.2 (0.6–2.9)	2.7 ± 5.2		5 min after	n.s.
	5 min after	30	1.5 (0.6–2.8)	2.2 ± 2.6	During	1 min after	.003**
						5 min after	.006**
					1 min after	5 min after	n.s.

Note. BIS = biospectral index; MAP = mean blood pressure; HR = heart rate; $ScvO_2$ = central venous blood oxygen saturation; LF = low frequency; HF = high frequency; IQR = interquartile range; SD = standard deviation.
** $p < .01$; * $p < .05$.

by changes in positioning (Brindle et al., 2013). Therefore, cardiovascular system indices such as MAP and HR may have changed.

This study showed that performing combined care may be more stressful than single care. This may be because the total care time was longer as it was 1 min longer than for turning alone. This longer care time may have induced greater stress on the sedated patient (Puntillo et al., 2014). To reduce patient stress, it may be necessary to consider performing them independently and shortening the time of care if not urgent and possible.

Contrary to expectations, no significant difference in MAP was observed when turning and endotracheal suctioning were performed consecutively. The result may be due to the order of turning and endotracheal suctioning. In this study, the combined care had a mix of patterns of endotracheal suctioning after turning and vice versa. The effect of endotracheal suctioning after turning may have mitigated the effect of hemodynamic changes on blood pressure, making it more difficult to detect significant changes.

Type of Index and Their Usefulness

Autonomic nervous system indices showed an increasing trend in 14 of 20 situations during endotracheal suctioning. Significant changes were observed in other care, suggesting that they are more sensitive than other indices (Broucqsault et al., 2016; Devlin et al., 2018; Chanques et al., 2018).

Table 3. Effects of Turning and Endotracheal Suctioning at Different Time Points: Wilcoxon's Signed Rank Test With Shaffer Correction.

Turning and endotracheal suctioning		Frequency	Median (IQR)	Mean ± SD	Comparison by scene		*p*-value
BIS	Before	42	57.5 (50.0–68.0)	59.7 ± 13.8	Before	During	.003**
	During	42	67.9 (54.8–73.5)	66.2 ± 12.4		1 min after	<.001**
	1 min after	40	72.5 (62.3–78.8)	71.1 ± 11.7		5 min after	<.001**
	5 min after	41	68.0 (58.0–76.0)	68.5 ± 13.7	During	1 min after	.009**
						5 min after	n.s.
					1 min after	5 min after	n.s.
MAP	Before	46	69.2 (62.9–81.8)	73.1 ± 14.2	Before	During	n.s.
	During	46	69.7 (64.0–83.4)	74.3 ± 14.6		1 min after	n.s.
	1 min after	46	70.7 (64.1–83.8)	74.5 ± 15.7		5 min after	n.s.
	5 min after	46	67.5 (63.6–80.8)	72.9 ± 14.6	During	1 min after	n.s.
						5 min after	n.s.
					1 min after	5 min after	n.s.
HR	Before	46	69.2 (57.9–81.8)	70.3 ± 14	Before	During	n.s.
	During	46	70.4 (59.5–79.6)	71.3 ± 13.1		1 min after	.03*
	1 min after	46	70.5 (58.9–81.4)	71.9 ± 13.8		5 min after	n.s.
	5 min after	46	69.0 (58.8–81.0)	71.2 ± 13.6	During	1 min after	n.s.
						5 min after	n.s.
					1 min after	5 min after	n.s.
$ScvO_2$	Before	44	71.7 (62.8–80.3)	70.4 ± 12.2	Before	During	n.s.
	During	44	71.0 (64.4–79.9)	70.1 ± 12.3		1 min after	.015*
	1 min after	44	69.0 (63.4–79.9)	69.2 ± 12.5		5 min after	n.s.
	5 min after	44	70.2 (62.8–78.8)	69.6 ± 12.2	During	1 min after	.012*
						5 min after	n.s.
					1 min after	5 min after	n.s.
HF	Before	47	15.0 (7.1–28)	29.3 ± 48.9	Before	During	n.s.
	During	47	12.6 (5.6–30.3)	26.6 ± 36.7		1 min after	n.s.
	1 min after	47	9.0 (5.1–21.9)	17.0 ± 19.4		5 min after	n.s.
	5 min after	42	14.2 (5.9–28.2)	20.5 ± 26.6	During	1 min after	n.s.
						5 min after	n.s.
					1 min after	5 min after	n.s.
LF/HF	Before	47	1.2 (0.8–2.7)	1.9 ± 2.1	Before	During	<.001**
	During	47	2.1 (1.0–5.2)	3.2 ± 3		1 min after	n.s.
	1 min after	47	1.2 (0.5–3.0)	1.9 ± 2.2		5 min after	n.s.
	5 min after	42	1.2 (0.4–2.1)	1.4 ± 1.3	During	1 min after	<.001**
						5 min after	<.001**
					1 min after	5 min after	n.s.

Note. BIS = biospectral index; MAP = mean blood pressure; HR = heart rate; $ScvO_2$ = central venous blood oxygen saturation; LF = low frequency; HF = high frequency; IQR = interquartile range; SD = standard deviation.
** $p < .01$; * $p < .05$.

Conversely, the arousal level index showed significant changes only when combined care was performed. This is consistent with increased arousal levels in nursing care, as shown in previous studies (Gelinas et al., 2011; Li et al., 2009), suggesting that the index had low sensitivity but high specificity for major stress (Arbour et al., 2015; Gelinas, 2016; Gelinas et al., 2011). Therefore, the care that causes fluctuations in arousal level has a high risk of causing significant stress to the patient and is recommended to be more carefully applied.

Vital signs may be used as an index to infer what specific stresses are occurring in the patient by evaluating a composite of several indicators. For example, when combined care was performed, BIS and HR began to increase during care, and $ScvO_2$ changed after the end of care. It has been reported that shallower sedation increases oxygen consumption and increases the tendency to arousal (Terao et al., 2003). This could indicate that the care load stimulated the sympathetic nervous system, increasing arousal level and HR and ultimately increasing oxygen consumption. The cardiovascular system index may reflect stress quickly, while the respiratory system index may lag behind changes in cardiovascular indicators and reflect stress. Paying attention to which vital signs are changing and at what time may help identify the specific stresses occurring in the patient.

Measures to Reduce Stress

Typically, when a patient is determined to be experiencing stress, a drug intervention is used in the ICU to reduce the patient's stress (Devlin et al., 2018). The criterion for nurses to implement measures to reduce patient stress from care is often whether there is a change in the patient's behavioral indicators (Gélinas et al., 2019). This study also administered a bolus dose of sedatives as a stress reduction measure. However, only six doses were administered in the 30 cases in which patients showed changes in facial expression or limb movements. The BIS of the six patients who received the additional dose was more than 10 higher than the remaining 24 patients who did not receive the additional dose. This means that patients may have been more responsive to the stress imposed by nursing care, and the behavioral changes in patients may have been more evident. The 24 cases in which no additional doses were given may have been less responsive, and the changes may have been less noticeable to the nurses who were focused on nursing care.

Previous studies have reported changes in vital signs such as HR, MAP, and SvO2 due to turning (Arbour and Gélinas, 2010; Li et al., 2009; Payen et al., 2001; Shively, 1988; Winslow et al., 1990). These studies were conducted on awake patients with higher values of change in vital signs compared to the present study. Patients under sedation management are generally reported to have suppressed responses to stimuli (Gelinas, 2016; Li et al., 2009; Payen et al., 2001). Since the participants in this study were under sedation management of RASS −5 to −4, the sedative drugs might suppress the fluctuations in vital signs. While this is a beneficial phenomenon in postoperative management (Devlin et al., 2018), it may be difficult to detect stress, including pain, associated with nursing care (Aissaoui et al., 2005; Robleda et al., 2016). Moreover, changes in arousal levels and vital signs continued during and after nursing care. This is similar to previous studies (Arbour & Gélinas, 2010; Erden et al., 2018; Li et al., 2009; Winslow et al., 1990). Nursing care is generally addressed to improve the patient's condition, so the damage accompanying nursing care is not often recognized. Physiological indicators may be useful in catching such potentially existing stresses. If we can focus our attention not only on behavioral indicators but also on physiological indicators and use them effectively, we may be able to better identify the occurrence of stress added to the patient and provide mitigating measures.

Strengths and Limitations

This study was conducted at a single institution. Moreover, it was a small number of participants and did not consider individual backgrounds such as the stage of esophageal cancer, drugs used, medical history, pain, respiratory control, noise, and illumination, which are considered to be related to the results. Furthermore, since this was an observational, field-based study, the techniques and order of turning and endotracheal suctioning were inconsistent. Therefore, the generalization of the findings is limited. In the future, it is necessary to increase the number of cases, paying attention to the types of diseases, individual backgrounds, and uniformity of techniques. Conversely, this study provides important insights into how nursing care provided to patients under sedation management may affect physiological indicators. This is a fundamental finding for future consideration of the management of pain, agitation, and delirium in the ICU.

Implications for Practice

This study suggests that routine nursing care for patients under sedation immediately after surgery may be stressful for patients. The distress and stress in patients under sedation control are controlled to some degree but not eliminated. Proactive recognition by nurses using these indicators of potentially occurring stress and providing more considerate care will improve the quality of life of postoperative patients.

Conclusions

This study examined changes in arousal level, autonomic nervous system indices, and vital signs associated with turning and endotracheal suctioning, which are essential care provided by nurses to sedated patients in the postoperative ICU.

The results revealed that different types and combinations of nursing care might cause different patient stress. Moreover, the autonomic nervous system indices may be more likely to react to stresses in a variety of nursing care, while arousal levels may be more likely to react to burdensome stresses. If the characteristics of these physiological indicators can be effectively utilized with behavioral indicators, it may be possible to accurately identify stress in patients with suppressed responses to stimuli and provide mitigating measures.

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Declaration of Conflicting Interests

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Ethical Consideration

This study was approved by the Ethical Review Board of Osaka University Hospital (number: 19156). During the investigation, the patients' physical condition was considered first, and their treatment and care were prioritized.

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References

Aissaoui, Y., Zeggwagh, A. A., Zekraoui, A., Abidi, K., & Abouqal, R. (2005). Validation of a behavioral pain scale in critically ill, sedated, and mechanically ventilated patients. *Anesthesia and Analgesia*, *101*(5), 1470–1476. https://doi-org.osaka-u.idm.oclc.org/10.1213/01.ane.0000182331.68722.ff

Arbour, C., & Gelinas, C. (2010). Are vital signs valid indicators for the assessment of pain in postoperative cardiac surgery ICU. *Intensive and Critical Care Nursing*, *26*(2), 83–90. https://doi-org.osaka-u.idm.oclc.org/10.1016/j.iccn.2009.11.003

Arbour, C., Gelinas, C., Loiselle, C. G., & Bourgault, P. (2015). An exploratory study of the bilateral bispectral index for pain detection in traumatic-brain-injured patients with altered level of consciousness. *Journal of Neuroscience Nursing*, *47*(3), 166–177. https://doi-org.osaka-u.idm.oclc.org/10.1097/jnn.0000000000000137

Aslanidis, T., Grosomanidis, V., Karakoulas, K., & Chatzisotiriou, A. (2018). Electrodermal activity monitoring during endotracheal suction in sedated adult intensive care unit patients. *Folia Med*, *60*(1), 92–101. doi: 10.1515/folmed-2017-0063.

Barr, J., Fraser, G. L., Puntillo, K., Ely, E. W., Gelinas, C., Dasta, J. F., & Jaeschke, R. (2013). Clinical practice guidelines for the management of pain, agitation, and delirium in adult patients in the intensive care unit. *Critical Care Medicine*, *41*(1), 263–306. https://doi-org.osaka-u.idm.oclc.org/10.1097/CCM.0b013e3182783b72

Bourgault, A. M., Brown, C. A., Hains, S. M. J., & Parlow, J. L. (2006). Effects of endotracheal tube suctioning on arterial oxygen tension and heart rate variability. *Biological Research for Nursing*, *7*(4), 268–278. https://doi-org.osaka-u.idm.oclc.org/10.1177/1099800405285258

Briegel, I., Dolch, M., Irlbeck, M., Hauer, D., Kaufmann, I., & Schelling, G. (2013). Quality of of acute respiratory failure. Changes over a period of two decades. *Anaesthesist*, *62*(4), 261. https://doi-org.osaka-u.idm.oclc.org/10.1007/s00101-013-2156-z

Brindle, C. T., Malhotra, R., O'Rourke, S., Currie, L., Chadwik, D., Falls, P., & Creehan, S. (2013). Turning and repositioning the critically ill patient with hemodynamic instability a literature review and consensus recommendations. *Journal of Wound Ostomy and Continence Nursing*, *40*(3), 254–267. https://doi-org.osaka-u.idm.oclc.org/10.1097/WON.0b013e318290448f

Broucqsault-Dedrie, C., De Jonckheere, J., Jeanne, M., & Nseir, S. (2016). Measurement of heart rate variability to assess pain in sedated critically ill patients: A prospective observational study. *Plos One*, *11*(1), 11, Article e0147720. https://doi-org.osaka-u.idm.oclc.org/10.1371/journal.pone.0147720

Chanques, G., Delay, J. M., Garnier, O., Berra, J., Prades, A., Carr, J., & Jaber, S. (2018). Is there a single non-painful procedure in the intensive care unit? It depends!. *Intensive Care Medicine*, *44*(4), 528–530. https://doi-org.osaka-u.idm.oclc.org/10.1007/s00134-018-5051-x

Chanques, G., Tarri, T., Ride, A., Prades, A., De Jong, A., Carr, J., & Jaber, S. (2017). Analgesia nociception index for the assessment of pain in critically ill patients: A diagnostic accuracy study. *British Journal of Anaesthesia*, *119*(4), 812–820. https://doi-org.osaka-u.idm.oclc.org/10.1093/bja/aex210

Chlan, L. L., Engeland, W. C., Anthony, A., & Guttormson, J. (2007). Influence of music on the stress response in patients receiving mechanical ventilatory support: A pilot study. *American Journal of Critical Care*, *16*(2), 141–145. https://doi.org/10.4037/ajcc2007.16.2.141

Coleman, R. M., Tousignant-Laflamme, Y., Gélinas, C., Choinière, M., Atallah, M., Parenteau-Goudreault, E., & Bourgault, P. (2013). Changes in the bispectral index in response to experimental noxious stimuli in adults under general anesthesia. *ISRN Pain*, *2013*, 1–8. https://doi.org/10.1155/2013/583920.

Dasta, J. F., Kane-Gill, S. L., Pencina, M., Shehabi, Y., Bokesch, P. M., Wisernandle, W., & Riker, R. R. (2010). A cost-minimization analysis of dexmedetomidine compared with midazolam for long-term sedation in the intensive care unit. *Critical Care Medicine*, *38*(2), 497–503. https://doi-org.osaka-u.idm.oclc.org/10.1097/CCM.0b013e3181bc81c9

Devlin, J. W., Skrobik, Y., Gelinas, C., Needham, D. M., Slooter, A. J. C., Pandharipande, P. P., & Alhazzani, W. (2018). Clinical practice guidelines for the prevention and management of pain, agitation/sedation, delirium, immobility, and sleep disruption in adult patients in the ICU. *Critical Care Medicine*, *46*(9), E825–E873. https://doi-org.osaka-u.idm.oclc.org/10.1097/ccm.0000000000003299

Erden, S., Demir, N., Ugras, G. A., Arslan, U., & Arslan, S. (2018). Vital signs: Valid indicators to assess pain in intensive care unit patients? An observational, descriptive study. *Nursing & Health Sciences*, *20*(4), 502–508. https://doi-org.osaka-u.idm.oclc.org/10.1111/nhs.12543

Gelinas, C. (2016). Pain assessment in the critically ill adult: Recent evidence and new trends. *Intensive and Critical Care Nursing*, *34*, 1–11. https://doi-org.osaka-u.idm.oclc.org/10.1016/j.iccn.2016.03.001

Gelinas, C., Boitor, M., Puntillo, K. A., Arbour, C., Topolovec-Vranic, J., Cusimano, M. D., & Streiner, D. L. (2019). Behaviors indicative of pain in brain-injured adult patients with different levels of consciousness in the intensive care unit. *Journal of Pain and Symptom Management*, *57*(4), 761–773. https://doi-org.osaka-u.idm.oclc.org/10.1016/j.jpainsymman.2018.12.333

Gelinas, C., Joffe, A. M., Szumita, P. M., Payen, J. F., Berube, M., Shahiri, T. S., & Puntillo, K. A. (2019). A psychometric analysis update of behavioral pain assessment tools for noncommunicative, critically ill adults. *Aacn Advanced Critical Care*, *30*(4), 365. https://doi-org.osaka-u.idm.oclc.org/10.4037/aacnacc2019952

Gelinas, C., Tousignant-Laflamme, Y., Tanguay, A., & Bourgault, P. (2011). Exploring the validity of the bispectral index, the critical-care pain observation tool and vital signs for the detection of pain in sedated and mechanically ventilated critically ill adults: A pilot study. *Intensive & Critical Care Nursing*, *27*(1), 7. https://doi-org.osaka-u.idm.oclc.org/10.1016/j.iccn.2010.11.002

Girard, T. D., Kress, J. P., Fuchs, B. D., Thomason, J. W. W., Schweickert, W. D., Pun, B. T., & Ely, E. W. (2008). Efficacy and safety of a paired sedation and ventilator weaning protocol for mechanically ventilated patients in intensive care (awakening and breathing controlled trial): A randomised controlled trial. *Lancet*, *371*(9607), 126–134. https://doi-org.osaka-u.idm.oclc.org/10.1016/s0140-6736(08)60105-1

Grap, M. J., Munro, C. L., Wetzel, P. A., Ketchum, J. M., Hamilton, V. A., & Sessler, C. N. (2014). Responses to noxious stimuli in sedated mechanically ventilated adults. *Heart & Lung*, *43*(1), 6–12. https://doi-org.osaka-u.idm.oclc.org/10.1016/j.hrtlng.2013.10.012

Hweidi, I. M. (2007). Jordanian Patients' perception of stressors in critical care units: A questionnaire survey. *International Journal of Nursing Studies*, *44*(2), 227–235. https://doi-org.osaka-u.idm.oclc.org/10.1016/j.ijnurstu.2005.11.025

Imanaka, Y., Hayashida, K., Murakami, G., & Matsuda, S. (2010). Physician staffing and patient outcome in Japanese ICUs. *J Jpn Soc Intensive Care Med*, *17*(2), 227–232. https://doi.org/10.3918/jsicm.17.279

Kress, J. P., Pohlman, A. S., O'Connor, M. F., & Hall, J. B. (2000). Daily interruption of sedative infusions in critically ill patients undergoing mechanical ventilation. *New England Journal of Medicine*, *342*(20), 1471–1477. https://doi-org.osaka-u.idm.oclc.org/10.1056/nejm200005183422002

Li, D., Miaskowski, C., Burkhardt, D., & Puntillo, K. (2009). Evaluations of physiologic reactivity and reflexive behaviors during noxious procedures in sedated critically ill patients. *Journal of Critical Care*, *24*(3), 5, Article 472.e9. https://doi.org/10.1016/j.jcrc.2008.07.005

Needham, D. M., Davidson, J., Cohen, H., Hopkins, R. O., Weinert, C., Wunsch, H., & Harvey, M. A. (2012). Improving long-term outcomes after discharge from intensive care unit: Report from a stakeholders' conference. *Critical Care Medicine*, *40*(2), 502–509. https://doi-org.osaka-u.idm.oclc.org/10.1097/CCM.0b013e318232da75

Ohbe, H., Nakamura, K., Uda, K., Matsui, H., & Yasunaga, H. (2021). Effect of early rehabilitation on physical function in patients undergoing coronary artery bypass grafting: A nationwide inpatient database study. *Journal of Clinical Medicine*, *10*(4), 1–10. https://doi-org.osaka-u.idm.oclc.org/10.3390/jcm10040618

Pang, P. S. K., & Suen, L. K. P. (2008). Stressors in the ICU: A comparison of patients' and nurses' perceptions. *Journal of Clinical Nursing*, *17*(20), 2681–2689. https://doi-org.osaka-u.idm.oclc.org/10.1111/j.1365-2702.2008.02280.x

Payen, J. F., Bru, O., Bosson, J. L., Lagrasta, A., Novel, E., Deschaux, I., & Jacquot, C. (2001). Assessing pain in critically ill sedated patients by using a behavioral pain scale. *Critical Care Medicine*, *29*(12), 2258–2263. https://doi-org.osaka-u.idm.oclc.org/10.1097/00003246-200112000-00004

Pohlman, M. C., Schweickert, W. D., Pohlman, A. S., Nigos, C., Pawlik, A. J., Esbrook, C. L., & Kress, J. P. (2010). Feasibility of physical and occupational therapy beginning from initiation of mechanical ventilation. *Critical Care Medicine*, *38*(11), 2089–2094. https://doi-org.osaka-u.idm.oclc.org/10.1097/CCM.0b013e3181f270c3

Puntillo, K., Gelinas, C., & Chanques, G. (2017). Next steps in ICU pain research. *Intensive Care Medicine*, *43*(9), 1386–1388. https://doi-org.osaka-u.idm.oclc.org/10.1007/s00134-017-4694-3

Puntillo, K. A., Max, A., Chaize, M., Chanques, G., & Azoulay, E. (2016). Patient recollection of ICU procedural pain and post ICU burden: The memory study. *Critical Care Medicine*, *44*(11), 1988–1995. https://doi-org.osaka-u.idm.oclc.org/10.1097/ccm.0000000000001875

Puntillo, K. A., Max, A., Timsit, J. F., Ruckly, S., Chanques, G., Robleda, G., & Azoulay, E. (2018). Pain distress: The negative emotion associated with procedures in ICU patients. *Intensive Care Medicine*, *44*(9), 1493–1501. https://doi-org.osaka-u.idm.oclc.org/10.1007/s00134-018-5344-0

Puntillo, K. A., Max, A., Timsit, J. F., Vignoud, L., Chanques, G., Robleda, G., & Azoulay, E. (2014). Determinants of procedural pain intensity in the intensive care unit the Europain (R) study. *American Journal of Respiratory and Critical Care Medicine*, *189*(1), 39–47. https://doi-org.osaka-u.idm.oclc.org/10.1164/rccm.201306-1174OC

Robleda, G., Roche-Campo, F., Sendra, M. A., Navarro, M., Castillo, A., Rodriguez-Arias, A., & anos, J. E. (2016). Fentanyl as pre-emptive treatment of pain associated with turning mechanically ventilated patients: A randomized controlled feasibility study. *Intensive Care Medicine*, *42*(2), 183–191. https://doi-org.osaka-u.idm.oclc.org/10.1007/s00134-015-4112-7

Shaffer, J. P. (1995). Multiple hypothesis-testing. *Annual Review of Psychology*, *46*, 561–584. https://doi.org/10.1146/annurev.ps.46.020195.003021

Shehabi, Y., R Bellomo., S Kadiman., L. K Ti., B Howe., & M. C Reade., Australian New Zealand, I. (2018). Sedation intensity in the first 48 hours of mechanical ventilation and 180-day mortality: A multinational prospective longitudinal cohort study. *Critical Care Medicine*, *46*(6), 850–859. https://doi-org.osaka-u.idm.oclc.org/10.1097/ccm.0000000000003071

Shively, M. (1988). Effect of position change on mixed venous oxygen saturation in coronary artery bypass surgery patients. *Heart & Lung*, *17*(1), 51–59. https://pubmed.ncbi.nlm.nih.gov/3257482/.

Siffleet, J., Young, J., Nikoletti, S., & Shaw, T. (2007). Patients' self-report of procedural pain in the intensive care unit. *Journal of Clinical Nursing*, *16*(11), 2142–2148. https://doi-org.osaka-u.idm.oclc.org/10.1111/j.1365-2702.2006.01840.x

Terao, Y., Miura, K., Saito, M., Sekino, M., Fukusaki, M., & Sumikawa, K. (2003). Quantitative analysis of the relationship between sedation and resting energy expenditure in postoperative patients. *Critical Care Medicine*, *31*(3), 830–833. https://doi-org.osaka-u.idm.oclc.org/10.1097/01.ccm.0000054868.93459.e1

Unoki, T., Sakuramoto, H., Uemura, S., Tsujimoto, T., Yamaguchi, T., Shiba, Y., & Masuda, Y. (2021). Prevalence of and risk factors for post-intensive care syndrome: Multicenter study of patients living at home after treatment in 12 Japanese intensive care units, SMAP-HoPe study. *PLoS One*, *16*(5), e0252167. https://doi-org.osaka-u.idm.oclc.org/10.1371/journal.pone.0252167

Winslow, E. H., Clark, A. P., White, K. M., & Tyler, D. O. (1990). Effects of a lateral turn on mixed venous oxygen saturation and heart rate in critically ill adults. *Heart & Lung*, *19*(5), 557–561. https://pubmed.ncbi.nlm.nih.gov/2211167/

Yava, A., Tosun, N., Unver, V., & Cicek, H. (2011). Patient and nurse perceptions of stressors in the intensive care unit. *Stress and Health*, *27*(2), E36–E47. https://doi-org.osaka-u.idm.oclc.org/10.1002/smi.1333