



Original Article

Passive exercise of the lower limbs and trunk alleviates decreased intestinal motility in patients in the intensive care unit after cardiovascular surgery

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Abstract. [Purpose] The purpose of this study was to clarify the effects of passive exercise of the lower limbs and trunk (PELT) in ICU patients after cardiovascular surgery with decreased bowel motility. [Subjects and Methods] Ten ICU patients with clinically-apparent decreased bowel motility during the period of April to July 2016 were enrolled this study. Bowel sounds (BS) for 5 minutes at rest and 5 minutes after PELT were recorded through an electronic stethoscope. A frequency analysis was performed and the BS before and after PELT were compared. In addition, the percent change in BS before and after PELT was determined, and the relationship between the percent change in BS and individual parameters (invasiveness of surgery, inflammation, nutrition, renal function) was examined. [Results] Average BS (integral value) for 5 minutes before and after PELT were 63.1 ± 41.3 mVsec and 115.0 ± 57.8 mVsec, respectively; therefore, BS was significantly increased by PELT. When compared to patients at rest, a significant increase was found 0–4 minutes after PELT. None of the individual parameters was significantly correlated with the percent change. [Conclusion] PELT can increase the bowel motility of ICU patients with decreased bowel motility.

Key words: Passive exercise, Bowel motility, Bowel sounds

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INTRODUCTION

Critically ill patients in intensive care units (ICU) tend to have decreased bowel motility due to the use of anesthetic drugs¹⁾, mechanical ventilation²⁾, and increased activity in the sympathetic nerve³⁾. Particularly, postoperative cardiovascular patients tend to have reduced bowel motility due to various medical treatments such as sedative agents and catecholamine administration, mechanical ventilator, operative stress⁴⁾. Lowering of bowel motility could cause symptoms such as nutritional disorder, accumulation of gastrointestinal content and gas, feelings of nausea, and even ileus. Lowering of bowel motility is often a limiting factor of early ambulation.

In recent years, the ABCDE bundle (Awakening and Breathing Coordination, Delirium monitoring/management, and

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Early exercise/mobility bundle⁵⁾ has been firmly established in critical care settings, and early mobilization is actively performed in ICU. It has been reported that early mobilization significantly decreases the delirium period, mechanical ventilation period, the length of stay in ICU, and hospitalization period, and increases the ratio of ADL independence at the time of hospital discharge^{6, 7)}. Executing early mobilization also achieves systemic functional improvements in physical function, and respiratory circulatory function^{8, 9)}. However, very few reports have described the influence on bowel motility of early mobilization, even though some reports have described adverse effects due to early mobilization. Waldhausen et al.¹⁰⁾ reported that there was no significant difference in the activity of the digestive tract between an early ambulation group (initiation of walking on the day following surgery) and a control group (initiation of walking from the 4th day after surgery). Their report also indicated that there was no significant difference in the activity of the digestive tract between before and after walking. According to a comprehensive review of postoperative ileus treatment published in 2009, early ambulation has “no demonstrable benefit” and “the myth was dispelled that early mobilization could facilitate bowel motility”¹¹⁾. Early mobilization can be highly effective for improving the general health condition and should actively be utilized, but there is no evidence yet that early mobilization improves bowel motility; therefore, the development of a method to facilitate bowel motility in critical care settings is required.

Clinically, abdominal massage and thermal therapy are often used to facilitate method for bowel motility, but the effects of both methods have no clear scientific outcomes. In our previous studies, the effects of passive exercise of the lower limbs and trunk (PELT) on the bed as a facilitation method for bowel motility of normal subjects were investigated^{12, 13)}. It was our assumption that activation of the parasympathetic nervous system, which is necessary for promoting bowel motility, could be facilitated by PELT, and bowel motility would also be facilitated when an expansion effect was added to intestinal tract¹⁴⁾. An additional assumption was that articular movement, mainly of the lower limbs and trunk, would have a facilitation effect on bowel motility, even though transitive articular movement is regularly conducted on the bed for preventing articular contracture and deep-vein thrombosis. If an effect of PELT for ICU patients with decreased bowel motility as well as healthy persons were clearly established, it could be used as a bowel motility facilitation method for ICU patients with decreased bowel motility. Therefore, this study aimed to clarify how PELT influences ICU patients after cardiovascular surgery with decreased bowel motility.

SUBJECTS AND METHODS

Ten ICU patients after cardiovascular surgery [4 males, 6 females, average age: 70.5 (62–79) years old] with clinically-apparent decreased bowel motility at Hyogo College of Medicine Hospital were enrolled in this study during the period from April to July 2016. The inclusion and exclusion criteria are shown in Table 1. Patients with abdominal surgery were excluded, since such patients have decreased bowel motility after abdominal surgery due to various factors such as intestinal inflammation and edema as a result of operative stress. The underlying diseases of the study subjects were 5 cases of valvular disease, 2 cases of valvular disease and aortic aneurysm, 1 case of coronary heart disease, 1 case of chronic heart failure, and 1 case of aortic aneurysm. The basic characteristics of the study subjects are shown in Table 2.

Since patients in ICU are often managed in a semi-recumbent position to prevent ventilator-associated pneumonia, we conducted our study with the subjects in a semi-recumbent position. During PELT, one leg was passively flexed, and the full flexion position was maintained for five seconds. Each study subject was administered this passive exercise ten times for each leg. In addition to leg flexion, right and left trunk rotation was also alternately performed. Exercises involving flexion and extension of the lower limbs and rotation of the trunk were conducted for 10 minutes. However, articular movement was only conducted within the movable range when excessive rotation of the trunk or bending of hip flexion was undesirable to execute, because some subject patients received median sternotomy or had a line inserted in the groin. Since articular movement is normally conducted for approximately 10 minutes in an ICU, a PELT time of 10 minutes was adopted.

Table 1. Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
<ul style="list-style-type: none"> ·RASS scale -1~+1 ·Bowel gas and defecation are not recognized after a patient enters ICU room regardless of no apparent digestive disorder ·Bowel sound is clearly lowered or disappeared ·No enteral nutrition ·No administration of facilitation drug for bowel motility ·Patient who rests on the bed (before the program for leaving bed) ·Patient who agrees on study participation 	<ul style="list-style-type: none"> ·Ileus patient ·Patient after abdominal section ·Ventilated patient ·Use of sedation drugs ·When it is determined that a patient has unfavorable joint movement due to severe bone and joint disease, burn injury, or traumatic injury ·Abdominal aortic aneurysm with surgical indication ·Deep thrombophlebitis ·Severe patient with requirement of absolute rest ·Apparent septicemia or infectious disorder

RASS: Richmond Agitation Richmond Agitation-Sedation

Bowel sounds (BS) are used as a clinical index of bowel motility, as they are generated by contraction of the intestinal tract, and mixing of gas and liquid. A method that records BS with an electronic stethoscope and conducts PC analysis has frequently been used in recent years, since it is non-invasive and can conveniently evaluate bowel motility^{14–16}. This method was adopted to measure and analyze BS in this study^{12, 13}. A stethoscope with a data saving function (Fuji Iryoki) was used to record BS at the midpoint of the umbilical region above the right anterior superior iliac spine, since it is anatomically the same as the ileocecal region and the easiest region to auscultate BS with the exclusion of heartbeat and breathing sounds. A stethoscope was closely attached to the skin with medical tape to prevent frictional noise. The acquired BS were amplified, digitally sampled, and saved on a PC, then analyzed with Lab Chart Pro (analysis software). For the analysis of BS, frequency analysis of the BS data was conducted in the 100–500 Hz frequency range, and the integrated value per second of the acquired BS was calculated. In addition, the number of BS auscultated with a stethoscope was counted for 5 min before and 5 min after PELT to serve as the bowel sound count (BSC). When abdominal auscultation is conducted in an ICU environment, it often records surrounding noises such as alarm sounds from medical equipment or conversations between medical staff and patients. In addition, it also auscultates other noises, such as coughing and body motion of the patient at the time of BS measurement. Since we attempted to record the actual BS in the ICU environment, we and the ICU specialists checked the BS at the time of analysis, and only the data of clearly recognizable BS without any other external noises was used for the analysis.

Subjects lay at rest for 15 minutes in the position of 30° head up. In general, body position influences BS. Therefore, BS were measured 15 minutes after adopting the position of 30° head up. BS were measured for 5 minutes, since a 5-minute auscultation is usually required for the measurement of BS, and a 5-minute abdominal auscultation is also required for ileus diagnosis¹⁷. BS were measured again for 5 minutes after conducting PELT for 10 minutes. Heart rate (HR), systolic blood pressure (SBP), and respiratory rate (RR) were also measured before and after PELT, as well as the physical burden at the time of PELT. The discontinuance criteria for PELT were set in accordance with the criteria of discontinuation of early mobilization as proposed by Adler et al.⁹

Age, body mass index (BMI), invasiveness of surgery (operating time, arrest time, anesthesia time, bleeding), inflammation (C-reactive protein, white blood cell count), nutrition (total protein, albumin), renal function (estimated glomerular filtration rate, creatinine), use of analgesic drugs, and use of cardiotoxic drugs, were obtained from the medical records, and their relationships with bowel motility were investigated.

The paired t-test was used to compare BS, BSC, HR, SBP, and RR between before and after PELT. To clarify time-dependent change in BS after PELT, the change in BS between 1-minute before PELT and 1-minute after PELT was calculated using a multiple comparison test (Dunnett). In addition, the coefficient of correlation between individual parameters and the percent change in BS [(post BS – pre BS)/pre BS×100] was determined. Statistical analysis was performed using SPSS ver. 21.0 (IBM, Tokyo, Japan) and statistical significance was accepted for values of $p < 0.05$ in all tests.

We provided sufficient explanation about the study purpose and contents to all the study subjects (or their family) and obtained their consent. The study was approved by the ethical review committee of Hyogo College of Medicine Hospital (No.2228).

RESULTS

There were no significant differences in HR, SBP, and RR between before and after PELT, although each parameter showed a declining trend after PELT. In addition, there was no instance of PELT discontinuation during the study (Table 3).

Table 2. Patient characteristics

Age (years)	70.5 (62–79)
Gender (male/female)	4/6
Height (cm)	158.6 (150–169)
Weight (kg)	57.6 (50–70)
BMI (kg/m ²)	22.8 (20.1–26.7)
Cardiovascular surgery (n)	
AVR	4
AVR+TAR	2
TAR	1
MVR	1
CABG	1
MVR+TAR	1

Data are presented as medians (ranges)
 BMI: body mass index; AVR: aortic valve replacement;
 TAR: total arch replacement; MVR: mitral valve replacement; CABG: coronary artery bypass grafting

Table 3. HR, SBP and RR before and after PELT

	Pre PELT	Post PELT
HR (beats/min)	87.8 (76–101)	88.2 (78–101)
SBP (mmHg)	136.4 (101–158)	137.3 (102–158)
RR (breaths/min)	22.5 (17–26)	22.5 (18–28)

Data are presented as medians (ranges)
 PELT: passive exercise of the lower limbs and trunk; HR: heart rate; SBP: systolic blood pressure; RR: respiratory rate

Average BS after PELT was significantly increased compared with BS before PELT (before 63.1 ± 41.3 mVsec, after 115.0 ± 57.8 mVsec, $p < 0.01$). In addition, the number of BS increased significantly after PELT (before 14.0 ± 7.7 times, after 25.3 ± 13.5 times, $p < 0.01$). All cases, showed increased BS and BSC.

Regarding time-dependent changes, average BS at rest for 1 min was 1.3 ± 2.2 mVsec, and average BS after PELT at 1 minute intervals were: 4.6 ± 2.9 mVsec, 2.4 ± 3.5 , 2.6 ± 3.0 , 4.3 ± 4.7 , and 1.2 ± 2.4 mVsec. In particular, BS increased significantly 0–1 minute ($p < 0.01$), 1–2 minutes ($p < 0.05$), 2–3 minutes ($p < 0.05$), and 3–4 minutes ($p < 0.01$) after PELT in comparison to BS at rest.

The coefficient of correlation between individual parameters and the percent change in BS was determined, and those results are shown in Table 4. None of the parameters was significantly correlated with the percent change in BS (Table 4).

DISCUSSION

There was no adverse event during PELT and no significant changes were found in HR, SBP, or RR during PELT. PELT could be safely executed even for ICU patients.

Similar to previous studies of healthy subjects^{12, 13}, BS increased significantly as a result of PELT. The intestinal tract consists of smooth muscle and has a property of stretch-induced contraction, and eventually muscle contraction occurs when visceral smooth muscle is expanded¹⁸. It is considered that expansion of the intestinal tract, which facilitates bowel motility, is important¹⁸. Visceral smooth muscle in the abdominal cavity additionally receives an expansion stimulus through passive exercise of the lower limbs and trunk^{12, 13}. It was assumed that the bowel motility increased due to the additional expansion effect on the intestinal tract induced by PELT. Peak BS were measured 0–1 minute after PELT, and significant differences in BS before and 5 min after PELT were not noted. The temporal change in BS after PELT indicated approximately the same result as a previous study¹² in which the peak BS of healthy subjects was 0–1 minutes after PELT. A short-term effect of PELT was also seen in healthy subjects, but it might need periodic intervention in clinical practice because a long-term effect cannot be expected.

The relationship between the percent change in BS before and after PELT and individual parameters was examined, but no such relationship was noted for any of the parameters. It has been shown that bowel motility of ICU patients decreases with the use of narcotic drugs¹ and mechanical ventilation². Particularly, postoperative cardiovascular patients tend to have reduced intestinal motility due to various medical treatments such as sedative agents and catecholamine administration, mechanical ventilator, operative stress⁴. Furthermore, it was also reported in a recent randomized controlled trial that the use of sedative drugs could be deeply involved in postoperative ileus, and less narcotic use was associated with a shorter period of postoperative ileus¹. Patients in the current study were taken off of sedatives and they had been weaned from mechanical ventilation. To the extent possible, this study excluded medical factors affecting intestinal motility. This is presumably why there was no evidence of a relationship between intestinal motility and any of the parameters studied.

Table 4. Correlations between the percent changes in BS and parameters supposed to affect intestinal motility

	Medians (ranges)	Correlation Coefficient
Invasiveness of surgery		
Operation time (min)	311.2 (226–416)	–0.248
Arrest time (min)	108.5 (66–166)	–0.352
Anesthesia time (min)	425.8 (317–513)	–0.292
Bleeding (ml)	402.8 (130–890)	–0.273
Inflammation, Nutrition, Renal function [†]		
TP (g/dl)	5.8 (5.3–6.5)	–0.244
Alb (mg/dl)	3.7 (3.3–4.4)	–0.013
CRP (mg/dl)	5.1 (2.3–9.2)	0.185
WBC ($10^2/\mu\text{l}$)	86.1 (56.4–105.6)	–0.275
eGFR (ml/min/1.73m ²)	72.6 (52–121)	–0.133
Cre (mg/dl)	0.75 (0.4–1.1)	–0.249
Use of drugs [§]		
analgesic drugs [% (n)]	10 (1)	
cardiotonic drugs [% (n)]	90 (9)	

Data are presented as medians (ranges)

TP: total protein; Alb: albumin; CRP: C-reactive protein; WBC: white blood cell count; eGFR: estimated glomerular filtration rate; Cre: creatinine

[†]the postoperative most recent value [§]assay date of bowel sounds

A limitation of this study is that there was no clarification of the mechanism behind bowel sounds. In addition, it is still unknown how the increase in bowel sounds induced by PELT can be clinically interpreted. In future, it is our intention to examine how PELT influences the intestinal tract and the clinical meaning of the increase in bowel sounds induced by PELT.

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