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The factors determining early mobilization in elderly patients undergoing total knee replacement

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Abstract

Background Postoperative early mobilization after total knee replacement (TKR) is essential for preventing complications and offers numerous benefits. The purpose of this study was to evaluate the factors determining early mobilization (EM) after primary TKR and the effects on risk of falls and length of stay (LOS).

Methods This retrospective study recruited elder participants undergoing primary TKR. All patients were classified as EM(+), early mobilization (EM) within 24 h, or EM(-), delayed mobilization over 24 h. Demographic data, pain Visual Analog Scale (VAS), American Society of Anesthesiologists (ASA) score, perioperative blood pressure, postoperative pain control mode, medical catheters, dizziness or nausea/vomiting (PONV), falls during admission, and the LOS were collected.

Result A total of 1759 elder participants undergoing primary TKR were enrolled. Mean age was 73.00 ± 8.11 years. Among them, there were 1260 EM(-) and 499 EM(+) cases, with no significant differences in sex, BMI, PONV, postoperative Patient Controlled Analgesia (PCA) mode, or the use of medical catheters, but age, higher ASA score, VAS, muscle strength, postoperative nausea, and substantial changes of blood pressure were significantly different between the two groups. A greater reduction in systolic blood pressure, when compared to the preoperative baseline blood pressure, was found in EM(-) patients than EM(+) patients on the operative day (13 vs. 4 mmHg, $P < 0.001$) and first day post-TKR (20 vs. 17 mmHg, $P = 0.005$). LOS in EM(-) patients was significant longer than that in EM(+) patients, but risk of falls was not significantly different.

Conclusions Multiple factors influence patients' willingness to mobilize or ambulate earlier. However, more blood pressure reduction impeding early mobilization after TKR should be addressed. Maintaining post-TKR blood pressure without significant decreases is recommended for the successful mobilization after surgery. Early mobilization within 24 h after TKR may be beneficial in reducing the LOS and did not increase risk of falls.

Keywords Early mobilization, Fall, ERAS, Total knee replacement, Length of Stay

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Introduction

As populations age, osteoarthritis of the knee is becoming an increasingly common disease of the lower limbs in the elderly. Total knee replacement surgery (TKR) is highly effective in relieving pain, correcting deformities, restoring joint function, and enhancing overall quality of life for individuals with severe osteoarthritis of the knee [1]. The numbers of patients receiving TKR continue to grow, with primary TKA procedures estimated to increase by 85% to 1.26 million by 2030 in the USA [2]. Enhanced Recovery After Surgery (ERAS), is introduced to improve postoperative care, allowing early recovery [3]. Early mobilization (EM) is a key component of ERAS programs and strongly encouraged after total joint arthroplasty [4, 5].

Postoperative EM after TKR is crucial for recovery, as it helps prevent complications, such as lower limb thrombosis, pulmonary infections, and gastrointestinal problems [5, 6], and confers several benefits, e.g., reduced postoperative pain, improved recovery of surrounding tissues, promotion of joint mobility, and improved daily functional activities [7–9]. Studies have shown that postoperative EM within 24 h after TKR results in greater muscle strength gain, fewer complications, shorter length of hospital stays, and faster recovery of daily activities compared to patients who start mobilization 48 to 72 h after surgery [10–12]. After TKR, patients are instructed to initiate EM activities on the first day, ranging from simple bedside lower limb movements, further sitting, and standing, to walking with partial or full weight bearing [5, 13].

Various factors were reported to hinder TKR patients participating in early mobilization out of bed, including advanced age, body weight, American Society of Anesthesiologists (ASA) score, cognitive abilities, wound pain, swelling, postoperative nausea/vomiting (PONV), dizziness, low blood pressure, or postoperative acute delirium [14, 15]. Proper pain management strategies effectively alleviated postoperative pain along with PONV and encouraged patients to comply with immediate rehabilitation exercises after TKR [5, 16]. However, there are inconsistent findings in the literature on the leading factors and it has been suggested that sex, age, body mass index (BMI), and ASA score did not influence patients' early mobilization after surgery [17, 18, 19]. A consensus has not been reached regarding the determining factors of EM within 24 h and the results are still conflicting.

Excessive blood loss after TKR, typically ranging from 886 to 1,450 mL, is common and can lead to post-operative hypovolemia and hypotension, which should be managed using some postoperative protocols or medication [15, 20]. Significant changes in blood pressure, leading to postoperative hypotension, drowsiness, dizziness, nausea, syncope or orthostatic hypotension (OH), may hinder early mobilization following major orthopedic surgeries. [21, 22] However, the real hypotension was uncommon after TKR [15]. Furthermore, previous research has not elucidated whether blood pressure changes after TKR influence a patient's EM. Clarifying the relevant factors affecting post-TKR mobilization capacity is crucial to provide clinicians with information that may help address the changes in perioperative factors and to further adjust them, thereby enhancing the benefits of early mobilization after TKR.

This study aims to explore the determining factors affecting successful early mobilization after primary TKR and assess the relative outcomes associated with early mobilization, including the risk of falls and length of stay. We hypothesized that maintaining post-operative blood pressure without significant decreases of blood pressure is associated with successful mobilization within 24 h of surgery, and that early mobilization could reduce LOS without increasing fall risk after TKR surgery.

Methods

Study design and approved

This retrospective cohort study was approved and the informed consent has been waived due to the retrospective design of this current research by the Institutional Review Board (IRB) of a tertiary referral hospital (No. CE21301B). The study period ranged from January 1, 2018, to May 22, 2021. The study was carried out in compliance with the principles of the Declaration of Helsinki.

Enrollment of participants

Participants who underwent knee replacement were eligible for enrollment. The inclusion and exclusion criteria, demographic data, outcomes, and perioperative management were obtained from medical and nursing records. The inclusion criteria for TKR participants were: (1) age over 60 years, (2) no significant postoperative complications, (3) no severe cognitive impairment, and (4) well preoperative locomotion ability. A total of 1759 participants who underwent unilateral primary TKR were recruited after exclusion in this study and the data were used for further analysis. Exclusion criteria included (1) prior surgical site infection, (2) revision TKR, (3) simultaneous bilateral TKR, (4) unicompartmental knee arthroplasty, (5) major postoperative complications or Intensive Care Unit care.

Early mobilization and groups

All primary TKR patients received physical therapy at the bedside commencing on POD0 and subsequently continued once a day. All patients were requested and encouraged by physical therapist or registered nurse, according to their willingness (but not compelled), to leave their beds and mobilize as early as possible within 24 h after the end of TKR. The activities of early mobilization were defined as standing or walking at the patient's bedside with any partial or full weight-bearing activities (walking on the spot or a few steps and bed-to-chair) using a walker for assistance under the supervision of a physical therapist or registered nurse [4, 21].

Based on whether or not early mobilization beside the bed was successfully achieved, the participants were classified into two groups. The EM(-) (delayed mobilization) group consisted of patients who did not perform any out-of-bed activity within 24 h after surgery and only started routine bed-based bilateral lower limb exercises. The EM (+) (early mobilization) group comprised patients who performed out-of-bed activities within 24 h after surgery in addition to routine bed-based lower limb exercises.

Outcomes and evaluating parameters

The primary outcome of this study is to assess the change in perioperative blood pressure in relation to the success of early mobilization within the first 24 h after TKR. Secondary outcome parameters include age, gender, BMI, ASA score, muscle strength, postoperative VAS score, length of hospital stay (LOS), and fall risk in relation to EM after TKR. Data included patients' characteristics (age, sex, body mass index (BMI), and American Society of Anesthesiologists (ASA) physical status. Lower limb muscle strength was evaluated using manual muscle strength test on a 5-grade scale, with Grade 0 indicating no contraction and Grade 5 representing normal strength against full resistance. Grade 1 shows a slight contraction, Grade 2 indicates movement with gravity eliminated, and Grade 3 shows movement against gravity alone. Grade 4 reflects movement against moderate resistance. Visual Analogue Scale (VAS) pain score (scale 0–10), perioperative blood pressure (systolic blood pressure (SBP), diastolic blood pressure (DBP) and mean atrial pressure (MAP) calculated using the formula ($MAP = DBP + 1/3(SBP-DBP)$), postoperative medical catheters, including Intravenous (IV) line, central venous catheters (CVC), urinary catheter, surgical drains, IV or epidural mode Patient Controlled Analgesia (PCA-IV or PCA-epidural)), PONV, and outcomes (EM within 24 h after TKR, falls during hospitalization and LOS were collected from medical records. The data were collected at different time points, such as admission day (A day), operative day (POD0), the first day after POD0 (POD1) or discharge day (D day), respectively.

Statistical analysis

All variables were tested using the Kolmogorov–Smirnov test for data normality of distribution. Based on the data collected from medical records, continuous variables, such as age, BMI, American Society of Anesthesiologists (ASA) score, blood pressure, and LOS are presented as median (IQR), while categorical data, including gender, PONV, the use of medical catheters, PCA, and falls are presented as counts and percentages. Mann-Whitney U test was used to assess differences in characteristics between EM(+) and EM(-) groups for continuous variables, and Fisher's exact test and Chi-Square test were used to compare differences between the two groups for categorical data. Changes in VAS score, muscle strength and blood pressure including SBP, DBP and MAP at different time points, i.e. A day, POD0 and POD1, were analyzed using Generalized Estimating Equations. Simple and multiple logistic regression was employed to analyze the determining factors. Statistical analyses were performed using SPSS version 22.0 (IBM, New York, NY, USA), with a significance level set at $p < 0.05$.

Results

Demographics of all participants

In this study, a total of 1,759 primary TKR patients were included, among which 1,279 (72.71%) were females. The flowchart was demonstrated as Fig. 1. On the admission day, the systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP) were collected. 5 graded manual muscle strength was an average score of 4.44 ± 0.75 (Table 1).

Comparison of parameters between EM(-) and EM(+) groups

The comparisons of the demographic parameters between subgroups are shown in Table 1. In the EM(+) group, there were 499 individuals (28.37%). Among them, 361 individuals (72.34%) were females. The comparison between EM(-) and EM(+) groups revealed no significant differences in terms of sex, BMI, as well as pain control method and the presence of medical catheters. However, notable distinctions were observed in age, ASA score, five-grade muscle strength, and LOS between the subgroups. The age in the EM(-) group was 74 (69–79) years, while in the EM(+) group, it was 72 (68–78) years (Table 1). However, most PONV parameters have no significant differences except nausea on POD0 between EM(+) and EM(-) groups (Table 2). The VAS during A-day, POD0 and POD1 were significantly different between subgroups. Regarding the length of stay (LOS), the average was 6.39 ± 3.21 days for the entire cohort. LOS was significantly longer in the EM(-) group compared to the EM(+) group. Perioperative muscle strength and VAS scores showed statistically significant differences at the specific time points (Fig. 2).

The changes of perioperative blood pressure between subgroups

The baseline blood pressure, including SBP, DBP, and MAP, on the admission day were significantly higher in

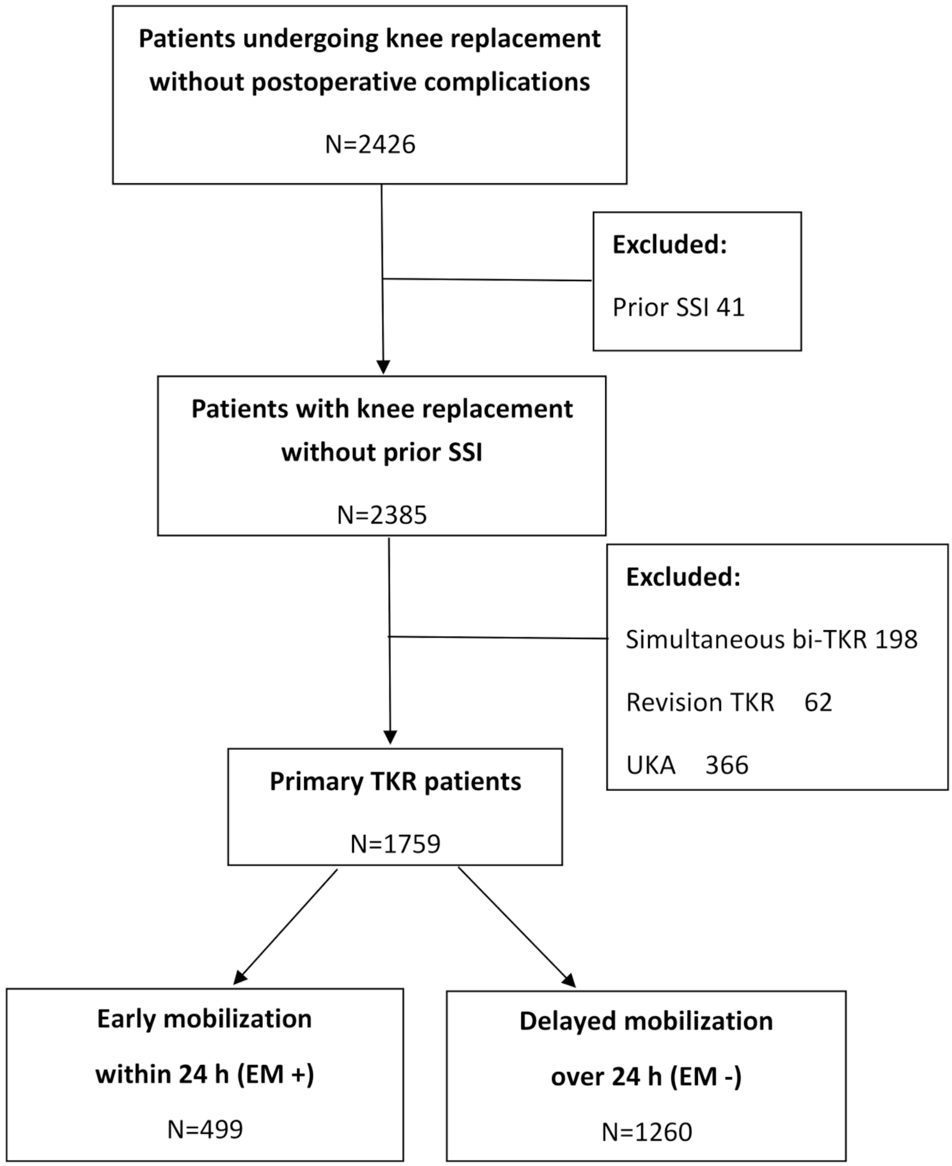

Fig. 1 Flowchart of patient enrollment. (SSI: Surgical site Infection; TKR: Total knee replacement; EM: Early mobilization)

the EM(-) group compared with the EM(+) group. The incidence of preoperative hypertension was significantly higher in the EM(-) group compared to the EM(+) group (64.68% vs. 56.11%, $P = 0.001$) (Table 1). Additionally, there were significant differences in average SBP on POD0 and DBP on POD1 between the two groups. There were no differences in DBP and MAP between groups were found on POD0 (Table 3; Fig. 3A). Concerning the disparity in blood pressure before and after surgery (ΔBlood pressure), there was a decrease in blood pressure compared to preoperative levels following TKR, and this decline trended similarly for both diastolic blood pressure (DBP) and mean arterial pressure (MAP) as observed for systolic blood pressure (SBP) (Fig. 3B). Moreover, a significant difference was noted in most parameters of ΔBlood pressure, encompassing SBP, DBP, and MAP, between the subgroups, as delineated in Table 3. In the present study, the drop in SBP in the EM(-) group was greater than the decrease of SBP in the EM(+) group on the operative day (13 vs. 4 mmHg, $P < 0.001$) and on the first day after TKR (20 vs. 17 mmHg, $P = 0.005$), when compared to the preoperative baseline blood pressure.

The factors associated with early mobilization

The simple logistic regression analysis revealed that older age and higher ASA score (ASA III-IV) were associated with a reduced likelihood of early mobilization in patients undergoing primary TKR. Regression analysis revealed that preoperative limb muscle strength and pain scores were associated with early mobilization after TKR.

Table 1 Demographic characteristics of all TKR participants

	Total (*n* = 1759)	EM		*p* value
		EM (-) (*n* = 1260)	EM (+) (*n* = 499)	
Age	73 (68–79)	74 (69–79)	72 (68–78)	0.001**
Sex				0.828
Female	1279 (72.71%)	918 (72.86%)	361 (72.34%)	
Male	480 (27.29%)	342 (27.14%)	138 (27.66%)	
BMI (kg/m^2)	27.43 (25.04–0.36)	27.38 (24.98–30.41)	27.51 (25.39–30.29)	0.519
ASA				0.046*
1–2	1312 (74.67%)	923 (73.37%)	389 (77.96%)	
3–4	445 (25.33%)	335 (26.63%)	110 (22.04%)	
Blood pressure (A Day)				
SBP	145 (131–158)	146 (132–160)	142 (130–153)	<0.001**
DBP	81 (72–90)	82 (74-91.75)	78 (70–85)	<0.001**
MAP	101.67 (93.67-111.33)	102.67 (94.67-112.67)	99.33 (92-106.33)	<0.001**
Hypertension incidence	1095 (62.25%)	815 (64.68%)	280 (56.11%)	0.001**
Muscle strength	5 (4–5)	5 (4–5)	5 (4–5)	<0.001**
Post-op. pain control				
PCA-IV	455 (25.87%)	335 (26.59%)	120 (24.05%)	0.273
PCA-epidural	1044 (59.35%)	753 (59.76%)	291 (58.32%)	0.578
Medical Catheters				
IV line	1754 (99.72%)	1255 (99.60%)	499 (100%)	0.330
Urinary catheter	1759 (100%)	1260 (100%)	499 (100%)	---
Surgical drains	1466 (83.34%)	1058 (83.97%)	408 (81.76%)	0.263
CVC	24 (1.36%)	20 (1.59%)	4 (0.80%)	0.200

Mann-Whitney U test. Chi-Square test for the comparisons between EM(-) and EM(+) groups. *$p < 0.05$, **$p < 0.01$. Continuous data were presented as median (IQR). Categorical data were presented as No.(percentage). EM: early mobilization; BMI: body mass index; SBP, Systolic blood pressure. DBP, Diastolic blood pressure. MAP, Mean arterial pressure; PCA: Patient Controlled Analgesia. A-day: Admission day; IV: intravenous; CVC: central venous catheters

Table 2 The comparison of outcomes between EM(-) and EM(+)

	EM (-) (*n* = 1260)	EM (+) (*n* = 499)	*p* value
Dizziness			
POD0	21 (1.67%)	12 (2.40%)	0.304
POD1	52 (4.13%)	20 (4.01%)	0.910
Nausea			
POD0	83 (6.59%)	48 (9.62%)	0.029*
POD1	93 (7.38%)	41 (8.22%)	0.552
Vomiting			
POD0	100 (7.94%)	41 (8.22%)	0.849
POD1	81 (6.43%)	34 (6.81%)	0.768

Mann-Whitney U test. Chi-Square test. *$p < 0.05$, **$p < 0.01$

Continuous data were presented as median (IQR). Categorical data were presented as No.(percentage). PONV: postoperative nausea and vomiting; VAS: Visual Analogue Scale; A-day: Admission day; POD0: operative day; POD 1: postoperative day 1

Furthermore, limb muscle strength on A day were also identified as factors impacting a patient's ability to initiate early mobilization out of bed (Table 4).

The perioperative blood pressure associated with early mobilization

According to the regression analysis, the preoperative blood pressure measurements, including SBP, DBP, and MAP on A day, as well as DBP and MAP on POD1, were found to influence early mobilization in patients undergoing primary TKR. Additionally, the differences between blood pressure measurements, such as ΔSBPA day-POD0, ΔSBPA day-POD1, ΔSBPPOD0-POD1, ΔDBPA day-POD0, ΔDBPA day-POD1, ΔMAPA day-POD0, and ΔMAPA day-POD1, were also found to impact early mobilization in TKR patients. However, the difference in DBP and MAP between POD0 and POD-1did not show any significant impact on early mobilization (Table 5).

Falls were not associated with early mobilization

There were no significant differences in the risk of falls between EM(-) and EM(+) groups using the Chi-Square test (Table 6).

Discussion

In this research, our findings indicate that the age of TKR patients, preoperative ASA score, pre- and post-TKR pain and muscle strength, nausea on the operative day, preoperative blood pressure levels, and post-TKR surgery drops in blood pressure were significantly different between EM(-) and EM(+) groups. Early mobilization (EM) following TKR might be associated with a reduction in the LOS without increase risk of falls.

The significant changes of blood pressure resulting in postoperative hypotension, orthostatic intolerance

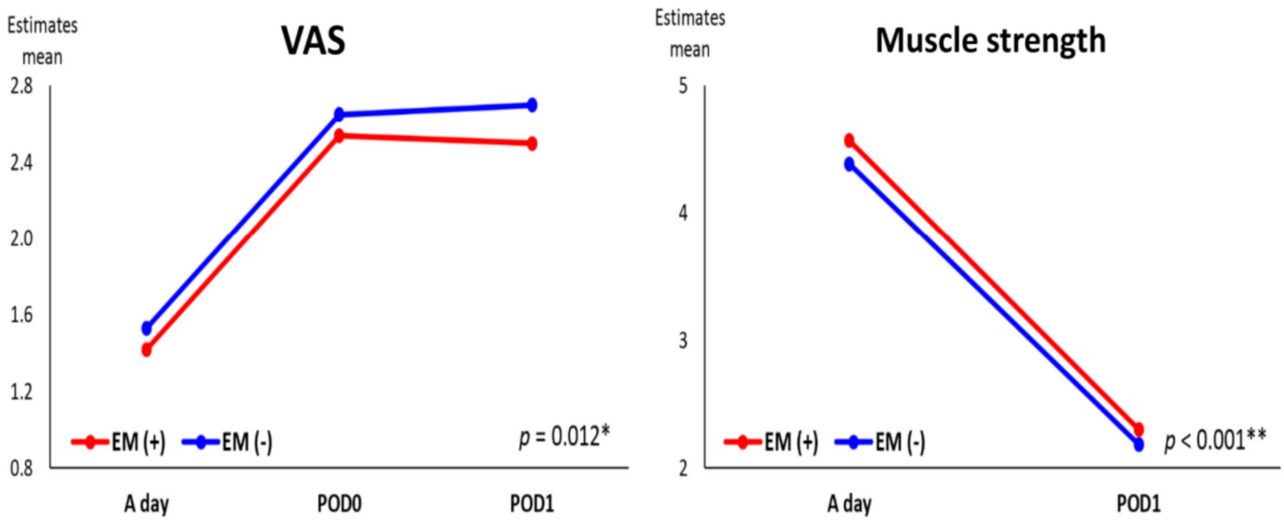

Fig. 2 The differences in VAS and muscle strength during perioperative course

Table 3 The differences in blood pressure between groups

	EM (-) ($n = 1260$)	EM (+) ($n = 499$)	p value
Blood pressure (mmHg)			
A day			
SBP	146 (132–160)	142 (130–153)	< 0.001**
DBP	82 (74-91.75)	78 (70–85)	< 0.001**
MAP	102.67 (94.67-112.67)	99.33 (92-106.33)	< 0.001**
POD0			
SBP	132 (119–147)	135 (124–148)	0.004**
DBP	73 (64–81)	72 (64–80)	0.056
MAP	93 (83.67-102.67)	93.33 (85-101.67)	0.787
POD1			
SBP	124 (109–140)	123 (111–138)	0.988
DBP	66 (58–74)	64 (57–72)	0.004**
MAP	85.33 (76.17–95.33)	84 (75.83-93)	0.08
ΔBlood pressure (mmHg)			
$\Delta SBP_{A\ day–POD0}$	13 (-4-29)	4 (-9-20)	< 0.001**
$\Delta DBP_{A\ day–POD0}$	10 (-1-20)	6 (-3-14)	< 0.001**
$\Delta MAP_{A\ day–POD0}$	10.67 (-1-22)	6 (-4-14.67)	< 0.001**
$\Delta SBP_{A\ day–POD1}$	20 (3–40)	17 (3–32)	0.005**
$\Delta DBP_{A\ day–POD1}$	16 (6–26)	13 (4–23)	0.001**
$\Delta MAP_{A\ day–POD1}$	17.33 (5.33-30)	15.33 (4.83-25)	0.001**
$\Delta SBP_{POD0–POD1}$	9 (-6-24)	12 (-2-26)	0.031*
$\Delta DBP_{POD0–POD1}$	7 (-2-15)	6 (-1-16)	0.601
$\Delta MAP_{POD0–POD1}$	8 (-3.33-18)	8 (-0.25-17)	0.263

Mann-Whitney U test. *$p < 0.05$, **$p < 0.01$. Continuous data were expressed median (IQR). EM: early mobilization; Δ: difference; A-Day: Admission day; POD0: operative day; POD 1, Postoperative day 1; SBP: systolic blood pressure; DBP: diastolic blood pressure; MAP: mean atrial pressure; ΔBlood pressure: the difference in blood pressure

(drowsiness, dizziness, blurred vision, nausea, or syncope) and orthostatic hypotension (OH) may impede early mobilization after major orthopedic surgeries [22, 23]. Orthostatic hypotension, i.e., postural hypotension after transitioning from supine posture to sitting/standing, is common in older patients [24], but is often overlooked and is not closely evaluated in regular clinical practices after TKR. In a control group of patients who received joint arthroplasty, 22.5-39.7% experienced orthostatic intolerance, adverse mobilization event, or OH [15, 25]. The postoperative blood pressure may be affected by pain, medications [26], hypovolemia caused by dehydration and blood loss [22], as well as postoperative systemic inflammatory response syndrome (SIRS)

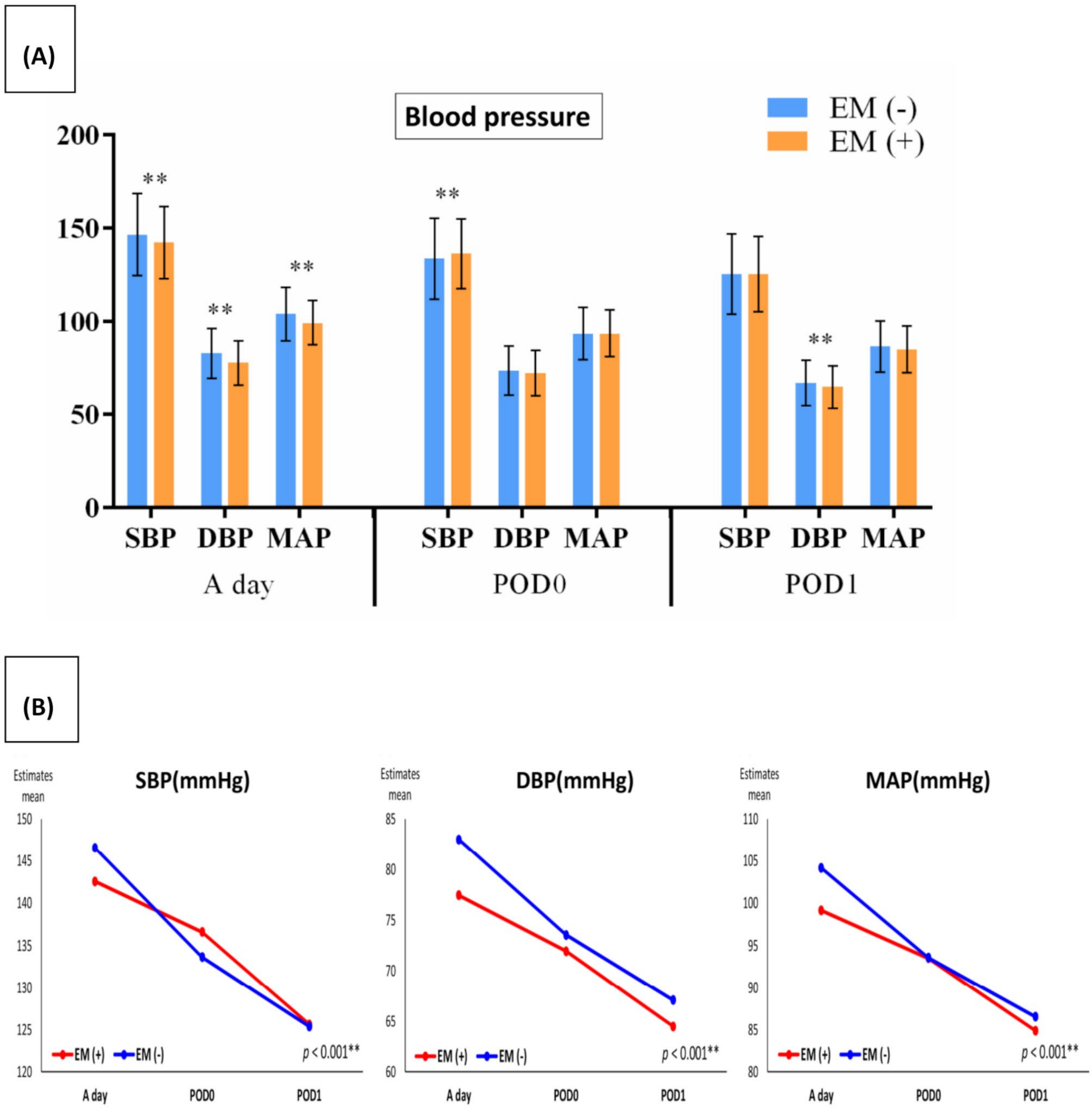

Fig. 3 The changes in blood pressure during perioperative periods. (**A**) The comparisons of blood pressure between EM(-) and EM(+) groups. (**B**) The changes in blood pressure, including SBP, DBP, and MAP before and after TKR

[27]. Although OH was not directly measured in this cohort, the blood pressure drop after TKR in both groups at POD0 and POD1 was assessed. A prior study reported a 16- to 20-mm Hg drop in postoperative SBP after THR, which was greater than that seen in our patients [25]. In the present study, the drop in SBP in the EM(-) group was greater than the decrease of SBP in the EM(+) group on POD0 and POD1 after TKR. Therefore, patients may decline early mobilization due to fear of falling, which may be caused by subclinical OH [28]. Ten milligrams oral alpha-adrenoceptor agonist, midodrine hydrochloride, would help patients undergoing total joint replacement to achieve a significant SBP elevation at 2 h after administration and decrease adverse mobilization events postoperatively [15]. We speculate that if the participants had achieved better control of blood pressure after TKR to avoid a significant drop in SBP while transitioning their position, the success rate of postoperative early mobilization would have been higher in this cohort. Based on the findings that the drop in SBP was greater

Table 4 The pre-operative factors of early mobilization in regression models

	Simple		Multiple	
	OR (95%CI)	***p* value**	**OR (95%CI)**	***p* value**
Age	0.98 (0.97–0.99)	0.002**	0.98 (0.97–0.99)	0.001**
Sex				
Female	1.00			
Male	1.03 (0.81–1.29)	0.828		
BMI (kg/m^2)	1.00 (0.98–1.03)	0.742		
ASA				
I-II	1.00			
III-IV	0.78 (0.61–0.996)	0.047*	0.83 (0.64–1.08)	0.163
MAP (A day)	0.97 (0.97–0.98)	<0.001**	0.97 (0.97–0.98)	<0.001**
VAS	0.87 (0.77–0.98)	0.022*	0.93 (0.82–1.06)	0.278
Muscle strength	1.44 (1.24–1.69)	<0.001**	1.37 (1.17–1.61)	<0.001**

Logistic regression. *$p < 0.05$, **$p < 0.01$

MAP: mean atrial pressure

Table 5 Regression analysis of blood pressure for early mobilization

	Simple		Adjusted for age and muscle strength (A day)	
	OR (95%CI)	***p* value**	**OR (95%CI)**	***p* value**
Blood pressure				
SBP				
A Day	0.99 (0.99–0.995)	<0.001**		
POD0	1.01 (1.001–1.01)	0.015*		
POD1	1.00 (1.00–1.00)	0.996		
DBP				
A Day	0.97 (0.96–0.98)	<0.001**		
POD0	0.99 (0.98-1.00)	0.068		
POD1	0.98 (0.98–0.99)	<0.001**		
MAP				
A Day	0.97 (0.97–0.98)	<0.001**	0.97 (0.96–0.98)	< 0.001**
POD0	1.00 (0.99–1.01)	0.916		
POD1	0.99 (0.98–0.999)	0.038*		
ΔBlood pressure				
$\Delta SBP_{A\ day-POD0}$	0.99 (0.98–0.99)	<0.001**	0.99 (0.98–0.99)	< 0.001**
$\Delta SBP_{A\ day-POD1}$	0.99 (0.99–0.998)	0.002**	0.99 (0.99–0.998)	0.004**
$\Delta SBP_{POD0-POD1}$	1.00 (1.00-1.01)	0.029*	1.01 (1.00-1.01)	0.024*
$\Delta DBP_{A\ day-POD0}$	0.98 (0.98–0.99)	<0.001**	0.98 (0.98–0.99)	< 0.001**
$\Delta DBP_{A\ day-POD1}$	0.99 (0.98–0.99)	<0.001**	0.99 (0.98–0.99)	< 0.001**
$\Delta DBP_{POD0-POD1}$	1.00 (1.00-1.01)	0.185		
$\Delta MAP_{A\ day-POD1}$	0.99 (0.98–0.99)	<0.001**	0.99 (0.98–0.99)	< 0.001**
$\Delta MAP_{A\ day-POD0}$	0.98 (0.98–0.99)	<0.001**	0.98 (0.98–0.99)	< 0.001**
$\Delta MAP_{POD0-POD1}$	1.01 (1.00-1.01)	0.058		

Logistic regression. *$p < 0.05$, **$p < 0.01$

Table 6 Fall associated with early mobilization

	Fall(+)	Fall(-)	*n*	*p* value
EM				0.705
EM (-)	4	1254	1260	
EM (+)	3	496	499	

Chi-Square test. *$p < 0.05$, **$p < 0.01$

in the EM(-) group compared to the EM(+) group on POD0 and POD1 after TKR, minimizing rapid drops in blood pressure might improve the success rate of early mobilization in post-TKR patients. Changes in blood pressure after TKR should be closely monitored, and antihypertensive medications ought to be used cautiously to prevent postoperative hypotension. However, further research is needed to explore this issue.

In this current study, we found gender was not an influencing factor for early mobilization, which is consistent with the results reported by Yakkanti et al. and Li et al. [19, 29] However, this finding contrasts with previous research that suggested sex and BMI were associated with early mobilization [30]. Moreover, higher ASA score (ASA III-IV) was also found to influence early mobilization in patients undergoing primary TKR, which is in line with the findings of our previous study [29], but contradicts the finding reported by Yakkanti et al. [19] Prior studies have suggested that pain affects early mobilization in TKR patients, which is consistent with the findings of this study [31]. Interestingly, we are the first to indicate no significant difference in the risk of falls during the perioperative period between early and delayed mobilization groups. The length of hospital stay in the EM(+) group was shorter than in the EM(-) group ($P < 0.001$).

Postoperative nausea and vomiting (PONV) and dizziness are common complications after TKR that may affect patient comfort and willingness to commence early mobilization. This study found a statistically significant difference between the presence of nausea on POD1 and early mobilization, which aligns with the findings of several studies [30]. However, this result is inconsistent with a study by Cheng et al. study, which suggested that PONV is not related to early mobilization after surgery [32]. It is essential to closely monitor the occurrence and severity of nausea and vomiting after TKR and take appropriate measures earlier to enhance patients' willingness to mobilize as early as possible.

The success rate of early mobilization (EM) in this study was only 28.3% (499 /1759). Compared to a report by Ripoll S-Melchor et al., where 2684 out of 3813 patients (70.3%) undergoing total knee arthroplasty (TKA) were mobile within the first 24 h after surgery in 131 Spanish hospitals, the success rate of EM in our study was relatively low [4]. This could be attributed to several factors: (1) Strict timing definition: EM was defined strictly as completion within 24 h after TKR in this current study, but their patients achieving mobilization after surgery was the median time of 24 h, which ranged from 16 to 30 h, and was therefore not strictly within 24 h. (2) Respecting patients' willingness: Physical therapists did not force patients to perform early mobilization within 24 h, respecting their willingness and readiness. Participants can decline this request if they have any concerns or discomfort. (3) Inconsistent definition of early mobilization activities: We requested that participants leave their beds and at least stand or take a few steps with the assistance of a walking aid or cane, and not just sit up in bed [7]. A multi-institutional study by Ripoll S-Melchor et al. claimed to follow the 16 components of ERAS recommended by EM Soffin and JT YaDeau in 2016, but they did not clearly define the activities performed for early mobilization [5].

Ripoll S-Melchor et al. further suggested that among TKR patients treated in ERAS centers with higher adherence to ERAS programs there was a significant association with shorter time to early mobilization before the first 24 h. Unfortunately, our institute was not yet an ERAS center during the study period, and we did not fully adhere to all perioperative components of ERAS after TKR [5, 33]. Similarly, their study included cases from 131 hospitals, some of which were also not ERAS centers, resulting in potential heterogeneity in their reported EM cases. In addition, there was a lack of clear and consistent definition of EM activities that widely ranged from first sitting on the bed to standing, walking, or even stepping out of bed in previous studies [3, 4, 7], which complicates meaningful comparisons among studies. Additionally, their study was a substudy of the POWER.2 study, a prior prospective cohort study [34], which was not specifically designed to determine factors of delayed mobilization. As a result, some crucial factors were not intensely explored, such as orthostatic hypotension, postoperative pain, or urinary retention [35]. In contrast, our study was conducted at a single institution, and all cases were recruited based on an identical EM definition, resulting in higher consistency. Moreover, we comprehensively investigated postoperative pain, changes in blood pressure, and many relevant factors affecting early mobilization in post-TKR patients.

The results of our study showed that early mobilization (EM) within 24 h after TKR was associated with a mean reduction in length of stay (LOS) by 0.57 days (6.56 ± 3.68 vs. 5.99 ± 1.41, $p < 0.001$). This finding is consistent with previous research that found EM reduced LOS by 0.36 to 2.0 days [7, 10, 19, 21, 36]. However, Ripoll S-Melchor J et al. did not find a significant reduction in LOS in patients with early mobilization. Early physical therapy can be safely initiated in the afternoon of the postoperative day after TKR [37, 38]. In our cohort, a total of 7 cases experienced falls during the perioperative period. After analyzing the data, we found that 4 out of 1260 cases (0.007%) in the EM(-) group and 3 out of 499 cases (0.06%) in the EM(+) group had falls. Although the incidence of falls appeared slightly higher in the EM(+) group, there was no statistically significant difference between the two groups, according to the Chi-Square test. Based on our findings, early mobilization under the proper guidance of healthcare providers does not pose an increased risk of falls for patients undergoing primary TKR and it can be performed safely.

This retrospective study has some limitations that should be considered. First, a retrospective design was employed, which is subject to potential biases and confounding factors. Potential factors influencing early mobilization, such as anemia, the use of blood transfusion, antihypertensive medications, pain management or anesthetic methods and the use of urinary catheters, did not collected and could not be controlled in this cohort. The second limitation is the relatively small sample size, which may limit the statistical power of the study. Another limitation is that our study focused only on TKR patients, which might restrict the applicability of the results to other joint replacement surgeries. Future research could consider including various types of joint arthroplasty to broaden the scope of inference and application. Additionally, the lack of long-term follow-up in this study meant that the prolonged benefits and risks of early mobilization after TKR could not be determined. Investigating the long-term outcomes and potential complications would provide a more comprehensive understanding of the impact of early mobilization on joint arthroplasty patients. Finally, this study was conducted using data from a single center, which may limit the generalizability of the findings.

Conclusion

Early mobilization is a cornerstone of ERAS after TKR to prevent morbidity and prolonged hospital stay. Multiple factors, including age, ASA, VAS, muscle strength, postoperative nausea, and significant decrease of blood pressure influenced post-TKR patients' willingness to mobilize earlier. The higher blood pressure before surgery and the greater systolic pressure drop after TKR may impede early mobilization in TKR patients. Based on the current evidence, early mobilization with transitioning from the bed within 24 h after TKR was safe without the higher risk of falls.

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Author contributions

All listed authors contributed substantially to thiswork. LH and SW for the study conception and design; LH, YC and YW for the data collection; YW, and LH for the data analysis; LH, YC and SW for the data interpretation; LH, YW and SW for the drafting of the manuscript, the figures, and the literature search.

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Data availability

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

Declarations

Ethics approval and consent to participate

The study was carried out in compliance with the principles of the Declaration of Helsinki. Ethical approval was obtained from Taichung Veterans General Hospital (reference number: CE21301B) and patient's consent was waived due to the retrospective design of this study. All methods and procedures used in this study adhered to the relevant guidelines.

Competing interests

The authors declare no competing interests.

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