Physical Activity in the Acute Hospital Following Elective Lower Limb Joint Arthroplasty

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ABSTRACT

The objective of this study was to quantify physical activity undertaken by patients in the acute setting following elective lower limb joint replacement and determine the relationship between physical activity and hospital outcomes (length of stay [LOS] and discharge destination). This prospective observational study included 74 adults with osteoarthritis who underwent lower limb arthroplasty (total hip replacement $n = 38$, total knee replacement $n = 36$). Participants were fitted with an accelerometer and inclinometer-based device (activPAL3™) post-operatively prior to first mobilisation for the duration of the acute hospital admission. Physical activity data collected were steps, sit-to-stand transitions and upright time (standing and stepping). The relationship between each physical activity variable and hospital outcomes was calculated using logistic regression (for discharge destination) and linear regression (for LOS). Potential confounding factors considered in multivariable models included age, sex, body mass index, Risk Assessment Prediction Tool, American Society of Anesthesiologists Score and surgical procedure. Analyses for the relationship with these outcomes used physical activity data from day two as these comprised the largest dataset for a single day. Participants' mean (SD) age was 67 (10) years and 53% were female. Participants performed a median (IQR) of 136 (50–294) steps, 17 (11–75) transitions and 52 (32–94) upright minutes per day. All physical activity variables were significantly negatively associated with LOS (steps $p = 0.016$, transition $p = 0.025$, upright time $p = 0.024$). There was a significant association between discharge to inpatient rehabilitation for steps ($p = 0.010$) and transitions ($p = 0.005$). Participants undergoing elective lower limb arthroplasty engaged in low levels of post-operative physical activity during hospitalisation. Lower levels of physical activity on post-operative day two were associated with discharge to inpatient rehabilitation and a longer total hospital LOS.

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INTRODUCTION

Osteoarthritis (OA) is the most common condition leading to total hip replacement (THR) and total knee replacement (TKR) in Australia and New Zealand (Australian Institute of Health and Welfare, 2020; Ministry of Health, 2019). Although these procedures are performed to restore joint function, relieve pain and improve quality of life, research has shown that patients undergoing elective lower limb arthroplasty do not meet recommended physical activity guidelines six months post-operatively (Harding et al., 2014). Previous research has also shown a reduction in total physical activity in the first few weeks following THR and TKR compared to pre-operative activity (Luna et al., 2019). Similarly, patients with higher variation in daily physical activity (i.e., peaks in highs and lows of daily activity patterns) in the acute setting have increased post-operative pain and longer acute hospital length of stay (LOS) following THR and TKR (Hayashi et al., 2018).

Studies using accelerometry have shown that patients hospitalised in acute medical or surgical wards are highly inactive (Baldwin et al., 2017). Low levels of physical activity during hospital admission have been associated with adverse outcomes including institutionalisation and death (Brown et al., 2004). Furthermore, in hospitalised older adults, increased walking in the acute hospital significantly reduced the risk of 30-day readmission (Fisher et al., 2016). Specifically, for each 100 step increase in daily step count, readmission rate was reduced by 10% (Fisher et al., 2016).

Historically, 'bed rest' was usual practice following orthopaedic surgery but recent evidence in people with hip fracture supports the need for early and frequent physical activity in the acute period to improve health outcomes and reduce hospital LOS (Kimmel et al., 2016). There is also growing evidence that fast-track THR and TKR pathways, including engagement in early mobilisation, can shorten LOS, reduce post-operative complications (e.g., venous thromboembolism [VTE]) and improve patient satisfaction (Glassou et al., 2014; Husted et al., 2010; Malviya et al., 2011; Martinez-Velilla et al., 2016; Schneider et al., 2009). Furthermore, previous research suggests patients with better pre-operative physical function may undertake higher levels of physical activity in the early post-operative setting and achieve higher physical function at six months following TKR (Takamura et al., 2021). However, there are no previous studies reviewing the association between physical activity levels in the acute setting and hospital outcomes following THR or TKR. This association is particularly important to investigate in people undergoing joint replacement, given the potential for extended hospital stays and costly rehabilitation admissions. Inpatient rehabilitation following TKR has significantly higher costs compared to community-based rehabilitation with no improvement in patient outcomes (Naylor et al., 2017), suggesting strategies to enable discharge home should be adopted. Therefore, the aims of this study were to:

1. Quantify physical activity undertaken by patients in the acute setting following elective lower limb joint replacement; and
2. Determine the relationship between physical activity and hospital outcomes (LOS and discharge destination).

METHODS

Participants and setting

This was a prospective observational study undertaken at the Alfred, a tertiary metropolitan hospital in Melbourne, Australia. All patients on the elective orthopaedic surgery list were screened for inclusion during two recruitment periods (April to August 2018, June to September 2019). A break in recruitment occurred due to investigator leave. Potential study participants were approached by one of the investigators pre-operatively on the day of surgery or day one post-operatively, prior to first mobilisation and provided with study information. All study participants provided written informed consent prior to participation.

Patients were eligible for inclusion if they had OA and were admitted for an elective primary THR or TKR. Patients were excluded from the study if they had rheumatoid arthritis or were admitted with a traumatic injury, were living in a nursing home, were allergic to adhesive tape, were unable to consent for themselves (e.g., dementia), were non-English speaking or had an intra-operative complication resulting in non-weight-bearing status. This study was approved by the Alfred Human Research Ethics Committee (registration approval number 76/18).

Procedures

All THRs were performed using a lateral or posterior approach. The most common prosthesis used for THR was the Exeter Hip System and for TKR was the Genesis II Total Knee System. Participants received post-operative care as per local clinical practice guidelines, which commenced day one post-operatively and aimed for early independence with transfers and mobility. Physiotherapy involved individualised lower limb exercises and gait retraining at least daily, seven days per week. For each physiotherapy visit, the treating clinician recorded details of the session including time of day, patient position (i.e., resting in bed or sitting in a chair), highest level of mobility (including level of assistance, gait aid and distance mobilised) and complications (e.g., cardiovascular instability, anaemia, patient fall).

Routinely-collected participant characteristics, extracted from the medical record included age, sex, body mass index (BMI) classification (normal 18.5 to 24.99 kg/m^2, overweight 25 to 29.99 kg/m^2, obese ≥ 30 kg/m^2) (World Health Organization, 2020) and American Society of Anesthesiologists (ASA) score, a five-category physical status classification system for overall pre-operative medical co-morbidities used to predict perioperative risks (Mayhew et al., 2019). Furthermore, operative details (including procedure, type of anaesthetic), use of femoral nerve block (in addition to anaesthetic type), post-operative complications (e.g., cardiovascular instability, intraoperative fracture and anaemia), total hospital LOS (including acute admission and inpatient rehabilitation) and discharge destination (home, inpatient rehabilitation) were recorded.

Physical activity measurement and processing

For the purpose of this study, the term 'physical activity' is used to describe total number of steps, sit-to-stand transitions and time upright (standing and stepping), measured using the activPAL3™, a triaxial accelerometer and inclinometer-based device (PAL Technologies Limited, Glasgow, UK). The activPAL3™ has been validated for collecting step counts across a wide range of walking speeds, including slow speeds and while using gait aids (Harrington et al., 2011; Ryan et al., 2006; Treacy et al., 2017). The activPAL3™ was applied once the patient reached the ward from theatre (day 0) and remained in place until the day of hospital discharge. The device was placed inside a disposable waterproof pocket and adhered to the non-operated thigh using the same tape used for the post-surgical wound dressing. This did not interfere with any daily activities or procedures, including showering or sleeping.

Activity data were downloaded using proprietary software (PAL Technologies software: research edition, version 7.2.38). For inclusion, participants needed to provide at least one full post-operative 'day' of data (24 hr period of data from 00:00 to 23:59). Physical activity occurring during the 'waking day' was reported. The 'waking day' was defined *a priori* as the 16 hr period from 06:00 to 22:00 to reflect the time period in which physical activity would usually be undertaken on an acute inpatient ward (Patterson et al., 2005). Physiotherapy intervention time was recorded to enable calculations of the proportion of physical activity undertaken during physiotherapy compared to physical activity undertaken at other times during the 'waking day'.

Data analyses

Data analyses were undertaken using commercial software (SPSS 26.0 software, SPSS Inc., Chicago, USA). Continuous participant and surgical characteristics were summarised using means and standard deviations (SD), or medians and interquartile ranges

(IQR), according to distribution. Categorical data were expressed as frequencies and percentages. Physical activity data for all participants were expressed as the median (IQR) according to post-operative day. The proportion of physical activity undertaken during physiotherapy sessions was expressed as a percentage of the total amount of physical activity undertaken during the waking day.

We investigated the association between physical activity variables (step count, transitions and upright time) and hospital outcomes (discharge destination and LOS) using logistic regression for discharge destination and linear regression for LOS. These analyses used the day two dataset as this comprised the largest dataset for all activity measures. Because LOS and day two physical activity data (steps, transitions and upright time) were skewed, these data were natural log-transformed prior to modelling. Potential confounding factors considered in multivariable models included age, sex, BMI, Risk Assessment Prediction Tool (RAPT), ASA and surgical procedure. Factors significantly associated with the physical activity variable and hospital outcome ($p < 0.2$), were included in multivariable models. While ASA score did not meet our criteria for inclusion in the multivariate models, previous research has shown ASA score to be a strong confounding factor to LOS and discharge destination (Kimmel et al., 2011); therefore, ASA score was included in the multivariate model. Adjusted log odds ratios and 95% confidence intervals (CI) were calculated for the relationship between log-transformed physical activity values and discharge destination. Given that the explanatory variables for the discharge destination models were log transformed, and both explanatory and outcome variables for LOS models were log transformed, outputs were back transformed into clinically relevant values using the methods outlined in Appendices A–C. In alignment with recommendations for sample size in relation to independent variables (IVs) in multiple regressions (20 + 5[IVs]) (Khamis & Kepler, 2010), our final sample exceeded the minimum number of respondents required in the model with the highest number of covariates (20 + (5 × 5) = 45).

RESULTS

Flow of participants through the study

A total of 80 patients were approached to participate in the study and only one patient declined. Therefore, 79 participants were included. Valid activPAL3™ data were available for 74 participants. Two participants removed the device prior to discharge from hospital and the device did not record data for a further three participants. No adverse events occurred.

Pre-operative and surgical characteristics of participants are presented in Table 1. The sample was balanced according to sex (females 53%, males 47%) and procedure (THR 51%, TKR 49%). The majority of participants were classified as obese (65%). Most participants were discharged home ($n = 52$, 70%) and their median (IQR) LOS was 5 (4–6) days, while the remaining 22 participants (30%) were transferred to inpatient rehabilitation with a total median (IQR) LOS (acute + inpatient rehabilitation) of 16 (13–22) days.

Table 1

Pre-operative and Surgical Characteristics of Participants

Characteristic	All participants		Discharge destination				Procedure			
			Home		Inpatient rehabilitation		THR		TKR	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
Age (years), mean (SD)	67 (10)		65 (9)		73 (10)		67 (11)		67 (10)	
Total	74		52	70	22	30	38	51	36	49
Female	39	53	26	50	13	59	16	42	23	64
Body mass index classification (kg/m²)										
Normal (18.5–24.9)	4	5	4	8	0	0	3	8	1	3
Overweight (25.0–29.9)	22	30	17	33	5	23	12	32	10	28
Obese (≥ 30.0)	48	65	31	60	17	77	23	60	25	69
Procedure										
THR	38	51	30	58	8	36				
TKR	36	49	22	42	14	64				
ASA score										
1 or 2	29	39	24	46	5	23	15	39	14	39
3 or 4	45	61	28	54	17	77	23	61	22	61
Type of anaesthesia										
General	43	58	31	60	12	55	23	61	20	56
Spinal	31	42	21	40	10	45	15	39	16	44
Femoral nerve block	6	8	4	8	2	9	1	3	5	14

Note. ASA = American Society of Anaesthesiologists; THR = total hip replacement; TKR = total knee replacement.

Post-operative physical activity

During the acute hospital admission, participants demonstrated a daily median (IQR) step count of 136 (50–294) steps, median (IQR) transitions of 17 (11–75) and 52 (32–94) upright minutes. Physical activity increased daily during the acute admission, with the most activity undertaken on day four with a median (IQR) of 251 (34–575) steps, 21 (13–33) transitions and 69 (31–119) minutes upright. Particularly on post-operative days one to three, a high proportion of physical activity occurred during physiotherapy (Table 2).

Unadjusted and adjusted relationships between physical activity variables hospital outcomes (discharge destination and LOS) can be found in Tables 3 (discharge destination) and 4 (LOS). There was a significant association between discharge destination and each of steps and transitions. For every 50% increase in either steps or transitions the probability of discharge to inpatient rehabilitation decreased by 5%. There was a significant association between all physical activity variables (steps, transitions and upright time) and LOS. For every 50% increase in steps, transitions and upright time, there was a decrease in LOS (days) by 4.56%, 7.79% and 6.66%, respectively.

Table 2

Physical Activity During the 'Waking' Day and Proportion Undertaken During Physiotherapy According to Post-operative Day

Post-operative day	Patients with complete 24hr data	Step count		Sit-to-stand transitions		Time upright (min)	
	n (%)	*Mdn* (IQR)	% during physiotherapy	*Mdn* (IQR)	% during physiotherapy	*Mdn* (IQR)	% during physiotherapy
Day 1	41 (55)	12 (4–63)	28	7 (3–11)	38	14 (5–45)	36
Day 2	73 (99)	80 (34–272)	22	16 (9–27)	21	46 (23–93)	25
Day 3	51 (69)	148 (48–318)	17	17 (9–27)	13	50 (26–92)	18
Day 4	32 (43)	251 (34–575)	20	21 (13–33)	17	69 (31–119)	18

Table 3

Association Between Physical Activity and Discharge to Inpatient Rehabilitation

Physical activity variable	Home discharge	IPR discharge	Unadjusted log *OR* (95% CI)	*p*	Adjusted log *OR* (95% CI)	*p*
	Mdn (IQR)					
Log steps	142 (37–379)	22 (3–109)	0.51 (0.32, 0.82)	0.006	0.46 (0.26, 0.83) [a]	0.010
Log transitions	19 (11–28)	11 (4–20)	0.50 (0.25, 1.01)	0.054	0.49 (0.30, 0.81) [b]	0.005
Log upright time (min)	59 (27–106)	39 (13–523)	0.59 (0.33, 1.06)	0.078	0.64 (0.34, 1.21) [c]	0.171

Note. IPR = inpatient rehabilitation.

[a] Adjusted for age, body mass index, American Society of Anesthesiologists score and procedure. [b] Adjusted for body mass index and American Society of Anesthesiologists. score. [c] Adjusted for body mass index and Risk Assessment Prediction Tool score.

Table 4

Association Between Physical Activity and Log Length of Stay (Days)

Physical activity variable	Unadjusted β (standard error)	*p*	Adjusted β (standard error)	*p*
Log steps	−0.17 (0.04)	< 0.001	−0.11 (0.04) [a]	0.016
Log transitions	−0.21 (0.09)	0.019	−0.20 (0.09) [b]	0.025
Log upright time (min)	−0.19 (0.07)	0.009	−0.17 (0.07) [c]	0.024

[a] Adjusted for age, body mass index and American Society of Anesthesiologists score. [b] Adjusted for body mass index and American Society of Anesthesiologists score. [c] Adjusted for body mass index and Risk Assessment Prediction Tool score

DISCUSSION

The aims of this study were to quantify physical activity undertaken in the acute setting following lower limb arthroplasty and determine the relationship between activity levels and hospital outcomes. The hospital outcomes (LOS and discharge destination) reported in this study were consistent with outcomes for usual care of THR and TKR patients across Australia and New Zealand hospitals (Hart et al., 2021). Within the acute hospital, participants engaged in low levels of physical activity following elective lower limb arthroplasty. Lower levels of physical activity on day two post-operatively were associated with discharge to inpatient rehabilitation and a longer total hospital LOS after accounting for potential confounders.

The median daily step count (136 steps) completed by our participants falls short of current recommended guidelines for older adults and special populations (i.e., those with chronic diseases), i.e., moderate intensity exercise to be undertaken three days per week during at least 10 min bouts (of 1000 steps each) to equate to 150 min per week, in addition to activities of daily living (Tudor-Locke et al., 2011). Similarly, the limited upright minutes achieved by our participants suggests a large amount of sedentary time in the acute post-operative period. The World Health Organization recommends that older adults should limit the time spent sedentary, replacing sedentary time with physical activity of any sort (Bull et al., 2020). The median step count was also considerably lower than other hospitalised post-surgical or acutely ill patients (Barkley et al., 2019; Bennett et al., 2016; Floegel et al., 2018; Kaplan et al., 2019; King et al., 2019; Rice et al., 2020; Tonosaki, 2012). Although a gradual increase in physical activity occurred during the acute stay, participants remained highly inactive on the day of discharge. For participants discharged home, the highest median number of steps per day was 281 (IQR 142–675). Considering 70% of participants in this study discharged directly home, this low level of activity may present a significant problem for managing activities of daily living in the community. Although services and support can be provided following discharge from acute care, the physical activity levels in our population were far inferior to recommended levels for older adults to safely access community sites such as banks, pharmacies and supermarkets (Salbach et al., 2014). In addition to encouraging more frequent engagement in physical activity throughout the course of the day, elective arthroplasty patients should be challenged to mobilise further in order to ensure safe community access on discharge, particularly those living alone. Research suggests even a few weeks of sedentary behaviour and physical inactivity in previously healthy adults can have an immediate impact on overall health (Convertino, 1997; Ferrando et al., 1996) and are linked to many chronic diseases (Bellettiere et al., 2017; Biswas et al., 2015; Woodcock et al., 2011). The lack of physical activity and abundance of sedentary time in our participants may increase the risk of future chronic health conditions if these behaviours become embedded. Previous research has demonstrated that, following elective lower limb arthroplasty, patients may remain inactive for up to six months (Harding et al., 2014). However, further research is required to determine if the observed lack of physical activity in the acute setting is linked to longer term outcomes.

The significant association between all physical activity variables and hospital LOS highlights the importance of assessing physical activity levels as part of routine inpatient care, as engagement in early and regular post-operative physical activity within hospital settings was associated with improved hospital-based outcomes. This is particularly important given longer hospital LOS has been associated with increased complication rates such as VTE, urinary retention and infection (Hauck & Zhao, 2011). Furthermore, each additional night in hospital increases the risk of adverse drug reactions and infection, as well as increasing healthcare costs (Hauck & Zhao, 2011). Our study has shown that LOS decreased by between 4.59% and 7.79% for every 50% increase in physical activity levels. Additionally, for every 50% increase in steps or transitions the probability of discharge to inpatient rehabilitation decreased by 5%. Patients who required an inpatient rehabilitation admission spent an average of 16 days in rehabilitation, which places a financial burden on the healthcare system and can expose patients to significant hospital-based harms. Whether increasing a patient's physical activity in hospital can reduce the risk of discharge to inpatient rehabilitation is unknown and further experimental research is needed. Earlier mobilisation (i.e., on the day of surgery) by a physiotherapist may be a potential option to increase physical activity and reduce rehabilitation admissions (Yakkanti et al., 2019). Our study also showed that up to 38% of total physical activity is undertaken during physiotherapy sessions. Encouraging physical activity outside physiotherapy sessions is also needed and may improve hospital outcomes, such as reducing both LOS and complications. Increasing patient physical activity within the acute setting could be achieved by enabling participation in unsupervised activity (e.g., bedside exercises) or encouraging patients to engage in meaningful goal-directed activities on the ward (e.g., walking to the bathroom or kitchen).

A strength of this study was that continuous objective physical activity data was collected throughout the acute inpatient admission. Furthermore, the age, sex, BMI and ASA score of the study cohort were comparable to national normative values for arthroplasty patients (Australian Orthopaedic Association National Joint Replacement Registry, 2019). Although two participants removed the activPAL3™ devices, no adverse events were observed. This study did not investigate the amount of physical activity undertaken following discharge from acute care and further research during this period would facilitate our understanding of the impact of acute and sub-acute physical activity on long-term outcomes. A limitation of this study is that it was undertaken in a large tertiary public hospital with strict post-operative protocols and priorities, which may differ in other institutions. Therefore, these results may not be generalisable to other settings. Further, as this study was observational, only association was shown and causality cannot be confirmed. In addition, while we adjusted for key confounding factors such as ASA score and the RAPT, we were unable to adjust for other potentially important confounding factors, such as frailty or psychosocial factors, which may have also affected the relationship between physical activity and outcome. Finally, we included procedure (THR or TKR) as a potential confounder in our multivariable models; however, we were underpowered to examine THR and TKR groups separately.

CONCLUSION

The results of this study highlight the importance of increasing physical activity in the acute setting following lower limb arthroplasty. Further strategies to enable early post-operative physical activity, including day-of-surgery mobilisation with a physiotherapist and encouraging patients to engage in goal-directed activities on the ward, may enable increased physical activity and thus may reduce hospital LOS and inpatient rehabilitation admissions.

KEY POINTS

1. This study demonstrates that participants undergoing elective lower limb arthroplasty engaged in low levels of post-operative physical activity during the acute setting.
2. The amount of physical activity undertaken was far less than other hospitalised patient groups and falls short of the recommended activity levels for older and special patient groups.
3. This study shows that lower levels of physical activity during the acute setting, particularly on day two post-operatively, were significantly associated with discharge to inpatient rehabilitation and a longer total hospital LOS.

DISCLOSURES

Asher Kirk was the recipient of the Alfred Health Physiotherapy Research Fellowship to enable preparation of the article. There are no conflicts of interest that may be perceived to interfere with or bias this study.

PERMISSIONS

Ethical approval for this study was granted from Alfred Human Research Ethics Committee (project number 76/18). All participants provided their written consent to participate in this research.

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Appendix A

METHODOLOGY FOR BACK-TRANSFORMATION OF LOG-TRANSFORMED VARIABLES

Discharge destination models

To interpret the log odds ratios for each of the physical activity variables, marginal effects were calculated, whereby for every 1% increase in the physical activity variable, the probability of discharge home was increased/decreased by x, whereby x is the 'margin' from the marginal effects model (Dimitriy, 2015).

Length of stay models

Adjusted coefficients and standard errors were calculated for the relationship between log-transformed physical activity values and log-transformed LOS. Given that both predictors and outcome were log transformed, and therefore proportional to one another, results were interpreted by considering a 50% increase in physical activity equivalent to an x% increase/decrease in LOS (days) where x = 1.50 to the power of the beta coefficient for the log physical activity variable (Ford, 2018).

Appendix B

FULL OUTPUT FOR MULTIVARIABLE MODEL OF THE ASSOCIATION BETWEEN PHYSICAL ACTIVITY AND DISCHARGE TO INPATIENT REHABILITATION

Covariate	Adjusted log *OR* (95% CI)	*p*
Log steps	0.46 (0.26, 0.83)	0.010
Age	0.94 (0.23, 3.92)	0.941
BMI	2.20 (0.49, 9.96)	0.305
ASA score		
1–2 (reference)	1	0.335
3–4	2.06 (0.47, 8.92)	
Procedure		
THR (reference)	1	0.026
TKR	5.76 (1.23, 26.80)	
Log transitions	0.49 (0.30, 0.81)	0.05
BMI	2.32 (0.56, 9.35)	0.237
ASA score		
1–2 (reference)	1	0.173
3–4	2.37 (0.68, 8.17)	
Log upright time (min)	0.64 (0.34, 1.21)	0.171
BMI	1.50 (0.52, 4.32)	0.448
RAPT	0.72 (0.56, 0.94)	0.014

Note. ASA = American Society of Anesthesiologists; BMI = body mass index; RAPT = Risk Assessment Prediction Tool; THR = total hip replacement; TKR = total knee replacement.

Appendix C

FULL OUTPUT FOR MULTIVARIABLE MODEL OF THE ASSOCIATION BETWEEN PHYSICAL ACTIVITY AND LOS

Covariate	Adjusted β (standard error)	*p*
Log steps	–0.11 (0.04)	0.016
Age	0.17 (0.13)	0.210
BMI	0.15 (0.11)	0.170
ASA score		
1–2 (reference)	1	0.407
3–4	0.11 (0.13)	
Log transitions	–0.20 (0.09)	0.025
BMI	0.11 (0.11)	0.345
ASA score		
1–2 (reference)	1	0.102
3–4	0.24 (0.14)	
Log upright time (min)	–0.17 (0.07)	0.024
BMI	0.10 (0.11)	0.358
RAPT	–0.07 (0.03)	0.020

Note. ASA = American Society of Anesthesiologists; BMI = body mass index; RAPT = Risk Assessment Prediction Tool score.