January 2013

Walk This Way: Predicting Postoperative And Discharge Outcomes Among Ambulatory Surgical Patients

Charles Odonkor

WALK THIS WAY: PREDICTING POSTOPERATIVE AND DISCHARGE OUTCOMES AMONG AMBULATORY SURGICAL PATIENTS

A Thesis Submitted to the Yale University School of Medicine

in Partial Fulfillment of the Requirements

for the Degree of Doctor of Medicine

By

Charles Amoatey Odonkor, MA

2012

WALK THIS WAY: PREDICTING POSTOPERATIVE AND DISCHARGE OUTCOMES AMONG AMBULATORY SURGICAL PATIENTS

Charles A. Odonkor, Robert B. Schonberger, Feng Dai, Kirk H. Shelley, David G. Silverman, and Paul G. Barash. Department of Anesthesiology, Yale University School of Medicine, New Haven, CT.

Within the ambulatory surgical setting, existing risk prediction models focus predominantly on postoperative factors of nausea, vomiting, and pain, but do not uniformly specify preoperative predictors of outcomes across multiple surgical specialties. Identification of preoperative markers, specifically those that are reversible, is key to improving risk stratification and designing patient-specific clinical interventions. Recent work shows that preoperative gait speed is a promising marker of postoperative morbidity and mortality within the inpatient surgical population. However, it remains to be explored whether gait speed is sensitive enough to delineate discharge and postoperative outcomes within the ambulatory surgical population.

We sought to determine which specific preoperative factors independently predict discharge readiness outcomes among ambulatory surgical patients. To address this aim and following Institutional Review Board (IRB) approval, we performed a cross-sectional analysis of data from a prospective observational study of 602 ambulatory surgical patients. The primary outcomes were: 1) Time to home discharge readiness from the ambulatory post-anesthesia care unit (PACU), and 2) 24-h postoperative occurrence of nausea, vomiting and bleeding. We evaluated the occurrence of unanticipated admissions from the ambulatory PACU to ancillary care units (inpatient wards and critical care) as a *post hoc* secondary outcome. Preoperative measures were gait speed (6.1 m divided by the average time to walk 6.10 meters), mean arterial pressure, heart rate, demographic factors and other clinical covariates. Statistical analysis was done with SAS, version 9.2® (Cary, NC), and $p<0.05$ was considered statistically significant.

Participants were 54.3% female, the mean gait speed was 0.90 ± 0.18 m/s, and the median home discharge readiness time was 89 minutes (interquartile range 61-126). Multivariable Cox regression analyses showed that gait speed (≥1 m/s vs. < 1 m/s) was an independent predictor of time to home discharge readiness after adjustment for covariates (adjusted hazard ratio = 1.25 (95% CI: 1.03-1.50), p = 0.02). For the primary outcomes, independent predictors of home discharge readiness ≤90 minutes were: preoperative heart rate, mean arterial pressure, and gait speed (adjusted odds ratio = 2.33 {95% CI: 1.52-3.54}, $p<0.0001$), when all other covariates are held constant. Monte-Carlo Cross validation (using $2x10^4$ iterations) showed the mean percentage of correctly classified predictions by our model was 65.6 (95% CI: 61.8-69.4). However, gait speed was not independently associated with 24-h postoperative complications, p=0.35. Predictors of unanticipated admissions included the history of cardiac surgery and prior hospitalizations, and gait speed (adjusted odds ratio = 0.54 {95% CI: 0.38-0.82}, p=0.003). We present the first cross-validated prediction model of outcomes in the ambulatory surgical setting and identify preoperative heart rate, mean arterial pressure and gait speed as three important modifiable factors, which independently associate with home discharge readiness time ≤90 minutes. Our findings underscore the importance of preoperative measures and elements of patients' history for potential risk stratification and resource allocation. We conclude that a focus on reversible clinical markers may help identify those patients at risk for delayed discharge in the ambulatory surgical setting.

Acknowledgements

My utmost gratitude goes to the Divine for grace and strength throughout the rigorous and blessed years of medical school and for the years of promise beyond. Equal gratitude goes to my loving parents, siblings and all my extended family for their devoted orisons and unending love. To all my coauthors, Dr. Robert Schonberger, Dr. Feng Dai, Dr. David Silverman, Dr. Kirk Shelley, and Dr. Paul Barash, for their invaluable input, discussions and suggestions at each phase of this work. Special recognition goes to Dr. Paul Barash for exemplar mentorship and guidance to find my own path, and for the freedom to explore. I would like to gratefully acknowledge the nursing and medical staff of the Yale New Haven Hospital Express Admission Surgery and Ambulatory Surgery Unit, without whose cooperation and kind assistance, this study would have been impossible. My eternal appreciation also goes to the staff of the Yale Office of Student Research for funding this work and for generous travel grants to present this work at two National Meetings (Oral presentation presented at: the National Meeting of the American Society of Anesthesiologist, Washington DC, October 10-12, 2013; and Oral presentation presented at: the Annual meeting of the Association of Academic Physiatrists; New Orleans, LA, March 6-10, 2013). I also thank the Yale School of Medicine Department of Anesthesiology, for providing a research home and supporting this thesis project.

Table of Contents

Introduction

Powerful prediction models are essential for accurate preoperative risk assessment and prognostication of surgical outcomes.(1-3) Traditionally, the American Society of Anesthesiologists' Physical Status (ASAPS) classification system has been used to sucessfully stratify patients' systemic illness and to classify patients with reference to surgical response and recovery. (4) While the ASAPS score may provide postoperative anticipatory guidance across a wide range of procedures, it does not provide specific targets that can be modified to improve surgical outcomes.(5) Presently, age remains among the strongest, but still crude, predictors of post-surgical outcome. (6-8) However, due to the heterogeneity and variance among patients of physiological and chronological age, measures of functional status may be superior to age as markers of intra- and postoperative risk. (9-11) The American College of Cardiology/American Heart Association (AHA) classification system is not ideal given its narrow focus on cardiovascular risks while neglecting other risks such as perioperative respiratory dysfunctions, for example chronic obstructive pulmonary disease. (12) Moreover, the complex algorithms of the AHA guidelines difficult to apply in the ambulatory population. (13) Other existing risk prediction models specify nausea, vomiting, and pain, but do not uniformly discuss perioperative predictors of outcomes across multiple surgical specialities. (3, 14-16) Prior studies indicate that factors such as age, the type of surgery, and some elements of a patient's medical history may predict perioperative complications.(8) However, abnormalities in routine preoperative laboratory tests failed to predict adverse peripoerative outcomes. (8)These findings suggest the need for new emphasis on demographic and medical characteristics of patients rather than on abnormal routine laboratory tests in preoperative assessments and in the design of prediction models. Importantly, there is the need to delineate which modifiable preoperative patient characteristics can be targeted clinically to optimize health status prior to surgery. Identification of targetable preoperative markers is key to improving risk stratification and designing patient-specific clinical interventions that could reduce postoperative morbidity and mortality.

In the ambulatory surgical setting, the utility of preoperative information in predicting adverse outcomes remains to be thoroughly explored.(17) It is thought preoperative measures such as heart rate variability have strong associations with long-term survival in the critical ill and the elderly. (18, 19) Hypertension and tachycardia have also been shown to directly influence non-cardiac surgical outcomes. (20) Recent work shows that gait speed, a measure of how fast patients can walk, is a promising preoperative marker that independently associates with long-term mortality in the elderly.(21) In particular, slow gait speed was shown to correlate with mortality from strokes and cardiovascular disease.(22) As a singular measure of frailty, gait speed also predicts hospitalizations, length of hospital stay and emergency department visits after major inpatient surgery. (23, 24) Thus, it has been suggested that gait speed may serve as a rapid, objective, inexpensive, and reproducible preoperative measure that will allow effective stratification of patients' functional status and has shown promise in several investigations. (25-27)

An important outcome in the context of ambulatory sugery is the time to home discharge readiness, a key component of overall hospital costs. (28, 29) Therefore, understanding how gait speed relates to recovery and discharge time in the ambulatory surgical population may provide an essential preoperative target for stratifying anticipated healthcare resources. Previous studies of gait speed have used retrospective data, and relatively small sample sizes in an *inpatient* setting, making it difficult to generalize results and implement findings within ambulatory surgical practice. (30-32) Thus, there is the need for larger prospective studies of gait speed within the ambulatory setting. We therefore sought to determine whether gait speed, as one of several preoperative markers, is predictive of discharge readiness in a prospective observational study of ambulatory surgical patients.

Predicting postoperative discharge status and outcomes requires well-fitted statiscal models that include preoperative, intraoperative and postoperative variables.(8) Traditionally, many risk prediction models focus primarily on nonreversible preoperative patient characteristics. (15) Moreover, few of these models have been cross-validated. (16, 23) As a measure of predictive performance of a statistical model, cross-validation tests enable evluation of model accuracy and allows predictions from the model to be applied to new data.(33, 34) Model validation provides care providers and physicians with better insight into the key variables that influence surgical outcomes and helps them to calibrate postoperative expectations and care management. (33) A validated prediction model also remains central to refocusing preoperative evaluations on key targets for better risk assessment in the ambulatory surgical population.

We therefore sought to design and internally cross-validate a prediction model that highlights gait speed and other simple reversible preoperative measures, which may help delineate between patients who will be discharged home versus those with unplanned admissions, in the ambulatory surgical setting. With the rise in demand for early discharge after ambulatory surgery and anesthesia, several criteria have been proposed to determine home readiness. (35-37) Yet, there are no standardized discharge readiness cut-off times to guide clinical decision-making. (38-40) Standard discharge criteria and discharge readiness times based on core data from each Ambulatory Center across the United States will allow for better comparative analysis of patient outcomes and to address patient needs in the ambulatory setting. Based on the standard Aldrete post-anesthesia discharge scoring system criteria, (41, 42) we internally cross-validated a prediction model with a predetermined home-readiness cut-off time of ≤ 90 minutes. We used the standardized anesthesia discharge scoring system criteria to allow cross-comparisons with other studies.

Statement of Purpose and Specific Aims

The overarching objective of this study was to identify those specific preoperative measures which are predictive of home discharge readiness and unplanned admissions after ambulatory surgery. We also sought to determine whether preoperative gait speed was associated with discharge and postoperative outcomes. Our ***hypothesis*** was that, reversible perioperative markers would be independently associated with time to home discharge readiness from the ambulatory post-anesthesia care unit. We anticipated that as a marker of functional status, faster gait speed will associate with shorter time to home discharge readiness, when all other variables were kept constant. We therefore performed a cross-sectional analysis of data from a prospective observational study of 602 ambulatory surgical patients to test the following specific aims:

Aim 1: To determine whether a fast walker would have a shorter time to home discharge readiness from the PACU than a slow walker, when all other chracteristics remained constant between them.

Aim 2: To determine whether preoperative gait speed was predictive of 24-hour postoperative complications of nausea, vomiting and bleeding

We also addressed the following *post hoc* specific aims:

Aim 3:To evaluate whether perioperative predictors are independently associated with home discharge readiness≤90 minutes.

Aim 4: To examine whether gait speed independently predicts unanticipated admissions after elective ambulatory surgery.

Methods

We conducted a prospective observational study of community-dwelling primary care patients undergoing elective ambulatory surgery at the Yale New Haven Hospital. With IRB approval, including a waiver of written informed consent, we obtained oral consent and evaluated patients prior to elective ambulatory surgery. Patients fulfilling the inclusion criteria were any adult patients undergoing elective ambulatory surgical procedures at Yale-New Haven Hospital. Patients demonstrating a history or with obvious findings of back pain, movement disorders, and the requirement of a walking aid or anticipated lower limb surgery were excluded. The primary outcomes were: 1) home discharge readiness time, treated as a continuous variable, and 2) the occurrence of 24-h postoperative complications of nausea, vomiting and bleeding. We also evaluated post hoc the outcomes of discharge readiness as a dichotomous variable ≤ 90 minutes (Yes vs. No), as well as unanticipated admissions from the ambulatory PACU to other units.

Aim 1: To determine whether a fast walker would have a shorter time to home discharge readiness from the PACU than a slow walker, when all other chracteristics remained constant between them.

To address this aim, consenting patients completed three consecutive 6.10 m (20-ft) walk tests on a level, non-carpeted floor in a well-lit area. Time to walk 6.10 m was defined as the time between the first footfall after the 0-mark and the first footfall after the 6.10 m mark. There was a 1-minute rest between each walk. Gait speed was computed by dividing 6.1m by the average time to walk the required 6.10 meters. Fast walkers were defined as patients with gait speed >1 m/s, while those with gait speed ≤ 1 m/s were considered slow walkers. Time to home discharge readiness was treated as a continuous variable and was defined as the time between patients arrival in the PACU and the time patients were noted to be ready to be discharged home, as determined by PACU nursing and medical staff using established Aldrete discharge criteria, supplementary Table 1. (43, 44) These personnel were blinded to results of the gait speed test.

Aim 2: To determine whether preoperative gait speed was predictive of 24-hour postoperative complications of nausea, vomiting and bleeding

To evaluate postoperative complications, all subjects were contacted 24-hours postoperatively by PACU nursing staff to ascertain the occurrence of nausea/vomiting, bleeding, post-operative pain and other self-reported complications. The relationship between gait speed and the 24-hour postoperative outcomes was analyzed by logistic regession analysis as described in the statistical analysis section.

Aim 3:To evaluate whether perioperative predictors are independently associated with home discharge readiness ≤ 90 minutes.

To address this aim, we collected and analyzed the following preoperative predictors: age, gender, gait speed, type of surgery and anesthesia technique (general aneshtesia [endotracheal tube, laryngeal mask airway], monitored anesthesia care, regional anesthesia), American Society of Anesthesiologist's Physical Status [ASAPS], Body Mass Index [BMI], preoperative blood pressure and respiratory rate, smoking and exercise history, self-reported health, prior surgery and hospitalizations, and major chronic health conditions, defined as a history of atrial fibrillation, hypercholesterolemia, stroke, heart disease, diabetes, hypertension, chronic obstructive pulmonary disease, asthma, and emphysema. Discharge time was based on a predetermined home-readiness cut-off time of ≤ 90 minutes (dichotomized as "Yes" if discharged in ≤ 90 minutes or "No" if discharged in longer than 90-minutes). Surgical category was dichotomized as major versus minor surgery.(8) Briefly, major surgery was defined as any of the following: duration of procedure ≥ 1h, expected blood loss ≥ 500 ml, opening of the visceral cavity, massive respiratory or hemodynamic effects due to surgery. Minor surgery was defined as all of the following: surgery duration <1h, expected blood loss <500 ml, and no opening of visceral cavity (except in case of diagnostic laparoscopic procedures).(8)

Aim 4: To examine whether gait speed independently predicts unanticipated admissions after elective ambulatory surgery.

To address this aim, gait speed was treated as a continuous variable and unanticipated admissions was defined as any admissions from the post-anesthesia care unit (PACU) to other ancillary care units (in-patient wards and critical care) rather than same-day home discharge after elective ambulatory surgery. Unanticipated admissions was dichotomized as "Yes" if admitted to wards and "No" if discharged home. The association between gait speed and home discharge readiness was analyzed by multivariable linear regression, while the relationship between gait speed and unanticipated admissions was analyzed by logistic regression. Other independent variables were preoperative mean arterial pressure and heart rate, the type of anesthesia technique (general anesthesia [endotracheal tube, laryngeal mask airway], monitored anesthesia care, regional anesthesia), total anesthesia time (defined as the time between the start of preoperative evaluation in the holding area to postoperative arrival time in the

PACU), total surgery time [time between surgical incision to placement of surgical dressing], total operating room time [time between arrival and departure from operating room], postoperative respiratory rate, oxygen saturation, and pain (via the visual-analog scale).

All preoperative data were recorded from patients' self-report, their anesthesia records and hospital charts.

Statistical Analysis

To determine the optimal number of patients required to observe gait differences of clinical significance in an ambulatory surgical setting, we performed *a priori* power analysis using the Power Analysis and Sample Size software (PASS, 2008,Kaysville, Utah). The analysis showed that assuming a 0.2 correlation between the predictor and outcome, a sample size of 600 allows for at least 80% power to reject the null hypothesis of zero correlation between gait speed and time to discharge readiness, using a two-sided hypothesis test with $p<0.05$ considered significant.

The Shapiro-Wilk test was used to test for normality of continuous outcomes. Descriptive statistics were calculated: continuous and normally distributed were presented as mean ± standard deviation (SD) and were compared with the Student t test; non-normally distributed data were presented as median (inter-quartile range) and were compared with the Wilcoxon-rank sum test for unpaired data.

The association between each variable and the time to home discharge readiness was quantified by Spearman rank correlation coefficient due to the non-normal distribution of discharge time. Variables with $p \leq 0.2$ in bivariate analysis were retained for entry in the multivariable analysis. In one model, time to home discharge readiness was treated as a time-to-event variable and we conducted Cox regression analysis to identify explanatory predictors that were independently associated with the outcome. In a separate multivariable linear regression model, time to home discharge readiness was treated as a continuous variable. Interaction effects were also considered in all analyses. A hazard ratio of greater than 1 (1 = no effect) for a variable indicates that it increases rate of patients being readily discharged, i.e., a shorter discharge-readiness time. Similarly, a hazard ratio of less than 1, indicates the variable has the opposite effect on discharge-readiness time.

For dichotomous outcomes, the relationship between each preoperative variable and the primary outcomes was determined in separate multivariable logistic regression models. A complementary-log log-function was used to analyze the outcome of unanticipated admissions due to the highly uneven distribution. The model predicting discharge readiness time ≤ 90 minutes was internally validated using Monte-Carlo Cross validation and bootstrapping methods. (45, 46). The model predicting unanticipated admissions could not be cross validated by the same methods due to the skewed distribution. The association of gait speed with secondary outcomes (nausea, vomiting, and bleeding) was determined by logistic regression analysis, with occurrence of one or more complications given a value of 1, and no complications, value of 0. All statistical analysis was done with SAS, version 9.2® (Cary, NC), and $p<0.05$ was considered statistically significant.

Results

Of 720 patients approached: 664 consented for the study, 44 declined participation and 12 did not meet inclusion criteria. Of those consented and completing the study: 46 patients were lost due to missing data, 1 patient died intra-operatively from vessel rupture and organ perforation, 8 were lost due to surgery cancellation. Seven outliers were removed from analysis based on clinical and statistical criteria. Thus, the data of 602 patients was used in the final statistical analysis. (Figure 1)

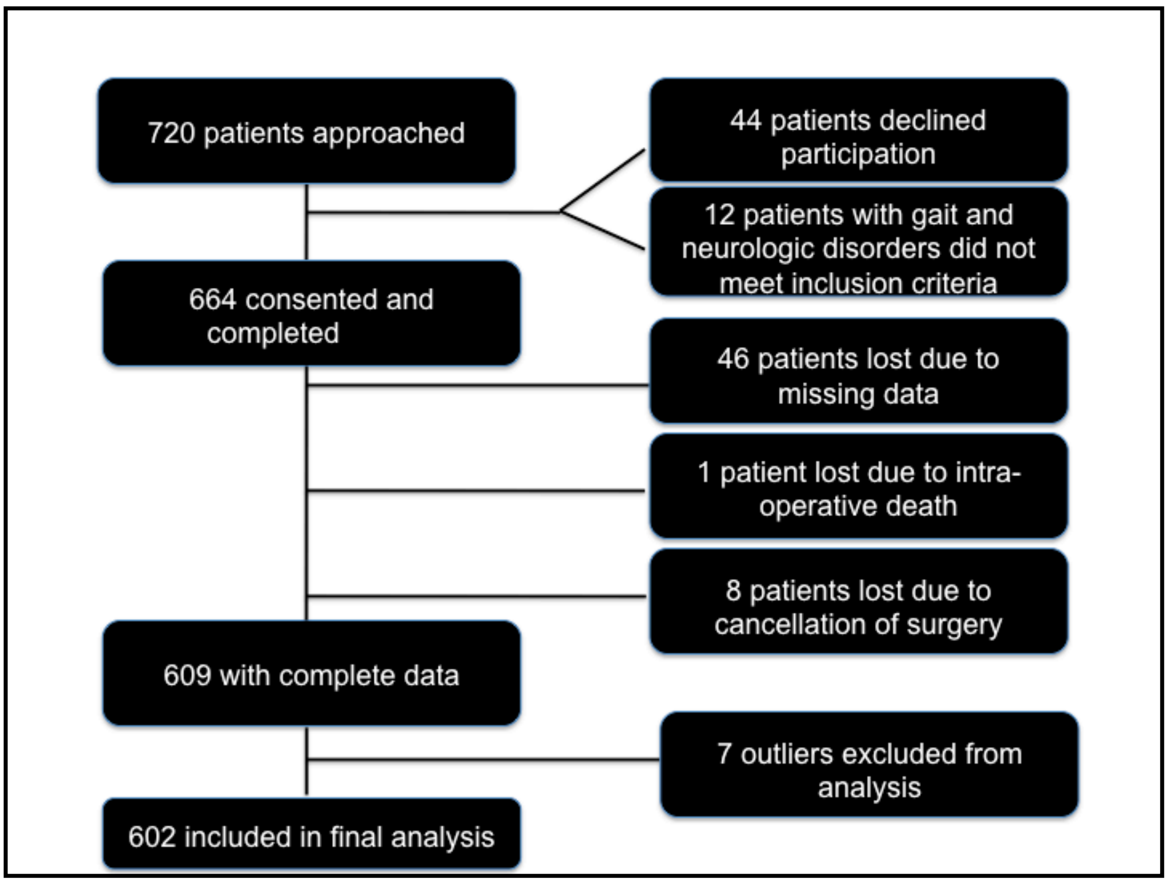

Figure 1: Flow diagram of patient enrollment.

Demographics and other clinical characteristics of study population are listed in Table 1 A. Overall, median time to walk 6.10 m was 6.7 seconds, with interquartile range 5.9-7.7 (Figure 2 A), and median gait speed was 0.91 (m/s) with an interquartile range of 0.80-1.03 m/s (Figure 2 B). Median home discharge-ready time was 89 minutes (interquartile range 61-126) (Figure 2 C). We assessed seven surgical specialties representing 140 of the most common ambulatory surgical procedures at the Yale New Haven Hospital.

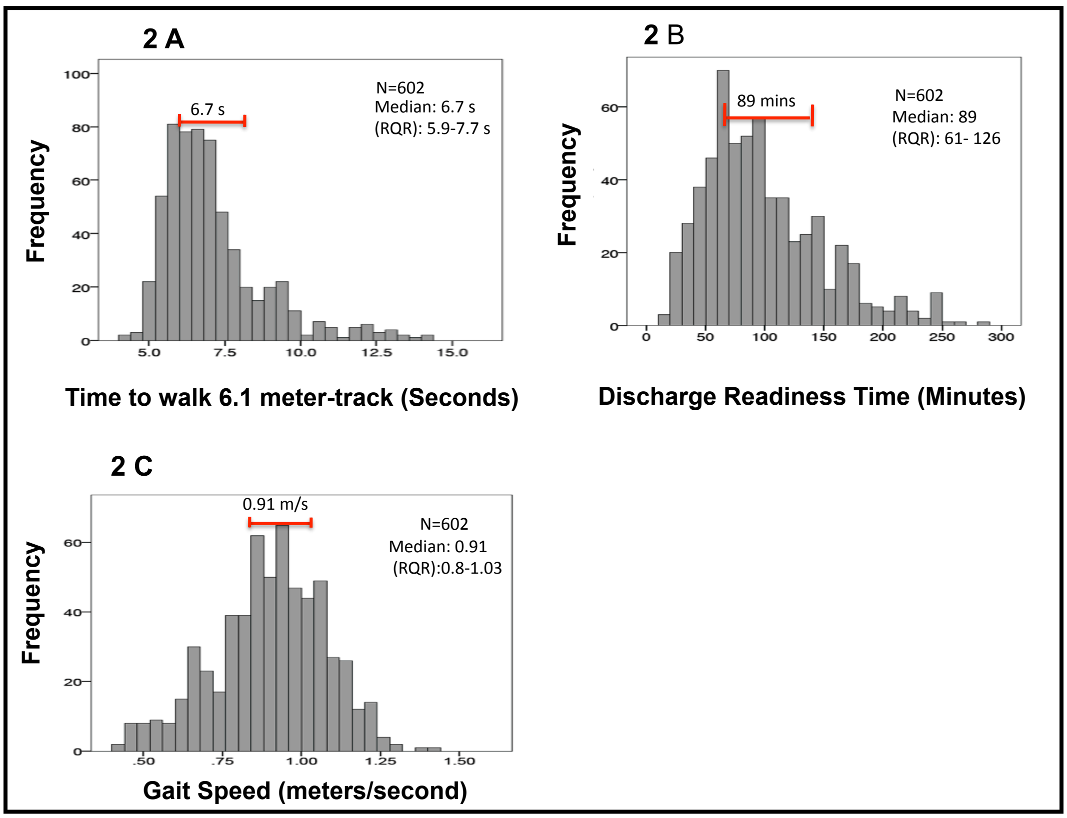

Figure 2.
A: Histogram distribution of average time to walk 6.1meters (in minutes).
B: Histogram distribution of gait speed (meters/sec = m/s).
C: Histogram distribution of Post-Anesthesia Care Unit Discharge-Readiness (minutes)

Table 1A. Demographic and clinical characteristics of 602 patients

Variable	Overall Cohort	Slow Walkers, N=422	Fast Walkers, N=180	p value*
Age mean ± SD , yrs	55.2 ± 14.7	57.4 ± 14.7	50.1 ± 13.3	<0.0001
Age <65yrs, n (%)	441(73.30)	282 (63.95)	159 (36.05)	<0.0001
Age>65yrs, n (%)	161(26.70)	140 (86.96)	21 (13.04)	<0.0001
Gender, n (%)				
Male	275 (45.70)	179 (42.42)	96 (53.33)	0.02
Female	327 (54.30)	243 (74.30)	84 (25.70)	0.02
Race, n (%)				
Caucasian/White	445 (73.90)	309 (69.44)	136 (30.56)	0.92
Black	75 (12.50)	53 (70.67)	22 (29.33)	0.92
Asian	14 (2.30)	10 (71.43)	4 (28.57)	0.93
Hispanic	68 (11.30)	50 (73.53)	18 (26.47)	0.93
BMI, median (IQR)	28.1 (24.3-32.4)	29.8 ± 7.3	28.3 ± 7.0	0.02
Overweight (24.9-29.5), n (%)	205 (34.05)	137 (66.80)	68 (33.20)	0.12
Obese (30-40), n (%)	223 (37.04)	168 (75.30)	55 (24.70)	0.03
Height (m) ± SD	1.69 ± 0.1	1.69 ± 0.1	1.70 ±0.1	0.09
ASAPS, n (%)				
1	45 (7.50)	31 (68.89)	14 (31.11)	0.25
2	324 (53.80)	218 (67.28)	206 (32.72)	0.35
3	219 (36.40)	162 (73.97)	57 (26.03)	0.45
4	14 (2.30)	11 (78.57)	3 (21.43)	0.36
<3	369 (61.30)	249 (67.50)	120 (32.50)	0.08
≥3	233 (38.70)	173 (74.30)	60 (25.70)	0.08
Number of Comorbid Conditions[a]	1 (0-3)	2 (1-3)	1 (0-2)	0.02
ANAESTHESIA TECHNIQUE, n (%)				
Endotracheal tube[b]	321 (53.3)	221 (68.85)	100 (31.15)	0.64
Laryngeal Mask Airway	98 (16.30)	68 (69.39)	30 (16.37)	0.62
Monitored Anaesthesia Care	173 (28.70)	127 (73.41)	46 (26.59)	0.65
Regional[c]	10 (1.70)	6 (60)	4 (40)	0.75
SURGICAL SPECIALTY, n (%)				
Ophthalmology	104 (17.30)	76 (73.08)	28 (26.92)	0.45
Obstetrics and Gynecology	64 (10.60)	41 (64.06)	23 (35.94)	0.90
General Surgery	189 (31.40)	131 (69.30)	58 (30.70)	0.92
Plastic Surgery	46 (7.60)	34 (73.91)	12 (26.09)	0.91
Orthopedics	104 (17.30)	73 (70.19)	31 (28.81)	0.90
Urology	51 (8.50)	37 (72.55)	14 (27.45)	0.91
Otolaryngology	44 (7.30)	30 (68.18)	14 (31.82)	0.91
Gait speed, m/s	0.91 (0.80-1.03)			
SURGICAL GROUP, n (%)				
Minimal intervention[d]	185 (30.70)	129 (69.70)	56 (30.30)	0.92
Major intervention[e]	417 (69.30)	293 (70.30)	124 (29.70)	0.89
Mean Arterial Pressure (mmHg)± SD	82.4 ± 28.3	83.4 ± 28.9	80.1 ± 26.8	0.20
Heart Rate, beats/min ± SD	74.3 ± 12.4	74.5 ± 12.6	73.8 ± 12.1	0.88
Total operating room time, mins	101 (65-153)	117.6 ± 69.7	113.7 ± 66.4	0.52
Total surgery time, mins	61.5 (33-105)	76.9 ± 58.4	76.1 ± 59.6	0.88
Total anaesthesia time, mins	112 (77-169	131.1 ± 71.2	128.2 ± 70.0	0.64

*: P value compares slow vs. fast walkers. Normal data, non-normal data, and categorical variables were summarized using mean (SD), median (interquartile range), and N (percentage), respectively.

ABBREVIATIONS

ASAPS - American Society of Anaesthesiologists' Physical Status (ASAPS),

BMI- Body Mass Index

IQR - Interquartile range

a - Cormobid conditions included: history of atrial fibrillation, hypercholesterolemia, stroke, heart disease, diabetes, hypertension, chronic obstructive pulmonary disease, asthma, and emphysema.

b - Endotracheal tube was coded when patient received general endotracheal anaesthetic with a narcotic technique, inhaled anaesthetic or with 'any other IV' drug.

c - Regional anaesthetic was coded when a spinal, epidural, or other regional block was performed.

d- Minimal intervention was defined as ophthalmologic procedures, gynecologic and any laparoscopic procedures.

e - Major intervention was defined as any procedures that were not ophthalmologic, gynecologic or laparoscopic.

Aim 1: To determine whether a fast walker would have a shorter time to home discharge readiness from the PACU than a slow walker, when all other chracteristics remained constant between them.

Of the 602 patients, 422 and 180 patients, were classified as slow walkers (gait speed ≤1 m/s) and fast walkers (>1 m/s), respectively. (Table 1 A) In comparison to fast walkers, slow walkers were on average 7-years older (p<0.0001), more likely to be female (57.6% vs. 42.4%, p=0.02), more likely to be obese (75.3% vs 24.7%, p=0.03), more likely to have a history of stroke (n=26 vs n=3, p=0.02) and hypercholesterolemia (n=170 vs. n=54, p=0.02) (Table 1 B), and more likely to have more chronic conditions, p=0.03. Among those < 65 years old, there were 282 slow walkers (63.95%) and 159 (36.05%) fast walkers. Among those > 65 years old, there were 140 slow walkers (86.96%) and 21 fast walkers (13.04%).

However, there was no statistically significant difference in anesthesia time, total surgery time or total operating room time between slow vs. fast walkers. On average, PACU-discharge readiness time was 10 minutes longer for slow walkers than for fast walkers, p = 0.04 (Table 1B). Bivariate analysis identified the following predictors (p ≤ 0.2), which were entered into the multivariable Cox regression model: age, female gender, BMI, gait speed, anesthesia technique, surgical risk, time in surgery room, preoperative mean arterial pressure and heart-rate, self-reported health, and number of chronic conditions (Table 2). After adjustment for these covariates, gait speed (slower walkers vs. fast walkers) was found to significantly associate with time to home (PACU) discharge readiness (adjusted hazard ratio (HR), 1.25, 95% CI: 1.03-1.50, p=0.02) (Model 1, Table 2). That is, when all other variables are held constant, patients who were fast walkers had a statistically significant shorter time to home discharge readiness than those who were slow walkers.

Table 1B. Comparing cormobidities and discharge readiness time of slow (N=422) vs. fast walkers (N=180)			
Comorbid Conditions	**Slow Walkers, N (%)**	**Fast Walkers, N (%)**	**p value**
Smoker	84 (68.85)	38 (31.15)	0.74
Atrial Fibrillation	24 (64.86)	13 (35.14)	0.47
Stroke	26 (89.66)	3 (10.34)	0.02
Hypertension	173 (71.19)	70 (28.81)	0.63
Hypercholesterolemia	170 (75.89)	54 (24.11)	0.02
Diabetes	84 (73.68)	30 (26.3)	0.35
Emphysema	21 (75.0)	7 (25.0)	0.43
Asthma	50 (74.63)	17 (25.37)	0.68
Arthritis	137 (73.66)	49 (26.34)	0.21
Self Reported Health			
Excellent	47 (66.2)	24 (33.8)	0.53
Very good	120 (68.97)	54 (31.03)	0.53
Good	178 (71.49)	71 (28.51)	0.53
Fair	67 (69.07)	30 (30.93)	0.53
Poor	10 (90.91)	1 (9.09)	0.55
Postoperative Discharge			
Discharge Readiness Time (mins)	100.7 ± 52.4	90.8 ± 44.3	0.04

A similar result was obtained when gait speed was treated as a continuous variable (m/s) in the regression analysis (adjusted HR = 1.72, 95% CI:1.07-2.77, p = 0.026; model 2, Table 2). Other independently associated predictors of time to home discharge readiness include age, female gender, mean arterial pressure, and monitored anesthesia-care, $p<0.05$ (Table 2). There were no significant interaction effects identified among the predictors. Of note, ASAPS score treated as either a categorical or dichotomous predictor, did not independently associate with PACU-discharge readiness.

Table 2	Cox regression results of independent predictors of PACU discharge time			
Model 1[β]	**Variable**	**Estimate (S.E)**	**Hazard Ratio (95% CI)**	**P-value**
	Demographic			
	Age[§]	-0.32 (0.21)	0.73 (0.60-0.88)	0.002
	Female gender	-0.32 (0.11)	0.73 (0.59-0.89)	0.002
	Overweight	-0.07 (0.13)	0.94 (0.73-1.20)	0.59
	Chronic conditions[ϕ]	0.09 (0.09)	1.10 (0.91-1.32)	0.32
	Pre-operative			
	Gait Speed[Ω]	0.22 (0.095)	1.25 (1.03-1.50)	0.02
	Mean Arterial Pressure	-0.03 (0.002)	0.971 (0.967-0.975)	<0.0001
	Heart Rate	0.007 (0.003)	1.007 (1.001-1.014)	0.01
	Peri-operative			
	Anesthesia Technique[Ψ]			
	Laryngeal Mask Airway	0.08 (0.13)	1.09 (0.85-1.39)	0.51
	Monitored Anesthesia Care	0.42 (0.11)	1.52 (1.22-1.89)	0.0002
	Regional	0.07 (0.33)	1.07 (0.56-2.04)	0.82
	Total Anesthesia Time	-0.0006 (0.0007)	1.00 (0.998-1.001)	0.35
Model 2[β]				
	Age[§]	-0.35 (0.10)	0.71 (0.58-0.87)	0.001
	Female gender	-032 (0.09)	0.73 (0.59-0.90)	0.003
	Overweight	-0.09 (0.13)	0.91 (0.71-1.17)	0.46
	Chronic conditions[ϕ]	0.10 (0.09)	1.10 (0.92-1.33)	0.29
	Pre-operative			
	Gait Speed	0.54 (0.24)	1.72 (1.07-2.77)	0.026
	Mean Arterial Pressure	-0.03 (0.002)	0.970 (0.960-0.975)	<0.0001
	Heart Rate	0.009 (0.003)	1.009 (1.002-1.016)	0.008
	Peri-operative			
	Anesthesia Technique[Ψ]			
	Laryngeal Mask Airway	0.12 (0.13)	1.13 (0.88-1.45)	0.34
	Monitored Anesthesia Care	0.42 (0.11)	1.52 (1.22-1.89)	<0.0002
	Regional	0.10 (0.33)	1.11 (0.58-2.10)	0.77
	Total Anesthesia Time	-0.0004 (0.0006)	0.999 (0.998-1.001)	0.56
Abrreviations: PACU-Post Anesthesia Care Unit, S.E- Standard Error				
§Patients who were >65 years old were used as a reference group for analysis				
ϕPatients with no chronic conditions were used as a reference group for analysis				
ΩSlow walkers (patients with gait Speed <1m/s) were used as a reference group for analysis				
ΨPatients receiving endotracheal tube were used as a reference group for analysis				
β: No significant interaction effects were identified among predictors. P>0.05				

Aim 2: To determine whether preoperative gait speed was predictive of 24-hour postoperative complications of nausea, vomiting and bleeding

To predict 24-hour postoperative complications, it was important to evaluate patients' preoperative health status and clinical characteristics. Pre- and postoperative characteristics of study population are listed in Table 3 A. Patients were overweight (32%) and obese (31%). The most common co-morbid conditions were hypertension (40.4%) and hypercholesterolemia (37.2 %). Majority of patients reported their health to be either very good (28.9%) or good (41.4%). Of the patients evaluated, one patient died perioperatively from major vessel rupture and organ perforation (0.17%), and 126 patients (20.9%) experienced post-operative pain as measured by the visual-analog scale score >5 in the PACU. At the twenty-four hour follow-up phone call fifty one percent of patients (306/602) responded. Of these, 27.7% (85/306 patients) reported nausea and vomiting, while 10.1% (31/306) reported bleeding. There was no statistically significant difference in the outcomes of nausea, vomiting, and bleeding, between slow vs. fast walkers (Table 3 B).

Table 3 A. Perioperative characteristics of study participants (N=602)	
Variable	**Summary**
Preoperative	
BMI Groups	
Underweight (<18.5), n, %	4 (0.7)
Normal weight (18.5-24.9), n, %	167(28)
Overweight (24.9-29.5), n, %	197 (32)
Obese (30-40), n, %	193 (31.3)
Morbid Obesity (>40), n, %	46 (8)
Comorbid Conditions	
Smoker, n, %	122 (20.3)
Atrial Fibrillation, n, %	37 (6.15)
Stroke, n, %	29 (4.8)
Hypertension, n, %	243 (40.4)
Hypercholesterolemia, n, %	224 (37.2)
Diabetes, n, %	114 (18.9)
Emphysema, n, %	28 (4.7)
Asthma, n, %	67 (11.1)
Arthritis, n, %	186 (30.9)
Average number of Comorbid Conditions (Range)	1 (0-3)
Self Reported Health	
Excellent, n, %	71 (11.8)
Very good, n, %	174 (28.9)
Good, n, %	249 (41.4)
Fair, n, %	97 (16.1)
Poor, n, %	11 (1.8)
Home Discharge Ready time ≤90 minutes	
Yes, n, %	307 (51)
No, n, %	295 (49)
24-h Postoperative Complications	
Nausea and Vomiting, n, %	85 (14.1)
Bleeding, n, %	31 (5.2)
Not Voiding, n, %	48 (8.0)
Poor ADL, n, %	9 (1.5)
Did not return to Normal Diet, n, %	80 (13.3)

Table 3 B. Comparing 24-h postoperative complications of slow (N=422) vs. fast walkers (N=180)			
Postoperative Complications	**Slow Walkers, N (%)**	**Fast Walkers, N (%)**	**p value**
Nausea and Vomiting	62 (72.94)	23 (27.06)	0.32
Bleeding	24 (77.42)	7 (22.58)	0.87
Not Voiding	39 (81.25)	9 (18.75)	0.97
Poor ADL	5 (55.6)	4 (44.4)	0.27
Did not return to Regular Diet	58 (72.5)	22 (27.5)	0.73
ABBREVIATIONS			
ADL: Activities of Daily Living			

Aim 3:To evaluate whether perioperative predictors are independently associated with home discharge readiness ≤ 90 minutes.

Patients were dichotomously classified as ready ('yes' or 'no') for home discharge at ≤90 minutes, since this discharge time is a clinically attainable target. At 90-minutes after surgery, 307 patients (51%), were ready for home discharge, while 295 patients (49%) were not ready for home discharge (Table 3 A). When all other covariates were held constant, logistic regression models identified the following preoperative measures as independent predictors of home discharge readiness ≤90 minutes: gait speed (<1ms vs. >1m/s) with adjusted odds ratio = 2.33 (95% CI: 1.52-3.54), p<0.0001; preoperative heart rate with adjusted odds ratio = 1.02 (95% CI: 1.007-1.04), p<0.004; and preoperative mean arterial pressure (MAP) with adjusted odds ratio = 0.97 (95% CI: 0.958-0.973), p<0.0001. The covariates of age, number of chronic conditions, and monitored anesthesia care were also found to be independently associated with home discharge readiness ≤90 minutes, p<0.05 (Table 4). Perioperative variables such as total anesthesia time, total surgery time, total operating room time, PACU pain levels (measured via visual analog scale), and PACU oxygen saturation levels did not independently associate with home discharge readiness time (data not shown). Monte-Carlo Cross validation (using $2x10^4$ iterations and $2x10^4$ estimable models) showed the mean percentage of correctly classified predictions by our model was 65.6 (95% CI: 61.8-69.4) (Table 4).

Table 4: Logistic Regression Model Predicting Home Discharge Readiness Time of T≤90mins		
Demographic	**OR Estimate (95% CI)**	P-value
Age§	2.14 (1.37-3.35)	0.01
Female gender	0.73 (0.45-1.08)	0.09
Overweight	0.85 (0.57-1.28)	0.44
Chronic conditions	1.78 (1.17-2.71)	0.01
Pre-operative		
Gait Speed$^{\Omega}$	2.33 (1.52-3.54)	<0.0001
Mean Arterial Pressure	0.97 (0.958-0.973)	<0.0001
Heart Rate	1.02 (1.007-1.04)	0.004
Peri-operative		
Monitored Anesthesia Care	3.44 (2.08-5.69)	0.049
Total Anesthesia Time	1.001 (0.998-1.004)	0.38
Model Performance		
Aikake Information Criterion (**AIC**)	692	
Bayesian Information Criterion (**BIC**)	750	
Area Under the Curve (**AUC**), 95% CI	0.78 (0.74-0.82)	
Monte Carlo Cross-Validation		
Total Cross Validation Iterations	20000	
Number of Estimable Models	20000	
Mean % Correctly Classified	65.60%	
Standard Error of % Correctly Classified	0.01%	
Abbreviations and Legend		
OR: Odds Ratio		
§Patients who were <65 years old were used as a reference group for analysis		
ΩSlow walkers (patients with gait Speed <1m/s) were used as a reference group for analysis		

Area under the curve for this model was 0.78 (95% CI: 0.74-0.82) (Figure 3). Stratified by gait speed (<1ms vs. >1m/s), the probability of early discharge ≤90 minutes was 70% (based on adjusted odds ratio 2.33 i.e. [2.33]/[1+2.33] x 100) (Figure 4 A). The probability of early discharge ≤90 minutes based on patient's preoperative heart rate (odds ratio of 1.02) was 50.5% (i.e. [1.02]/[1+1.02] x 100) (figure 4 B). Patients with preoperative mean arterial pressure (MAP) <75 mmHg had a 62.5% probability of discharge ≤90 minutes (Figure 4 C).

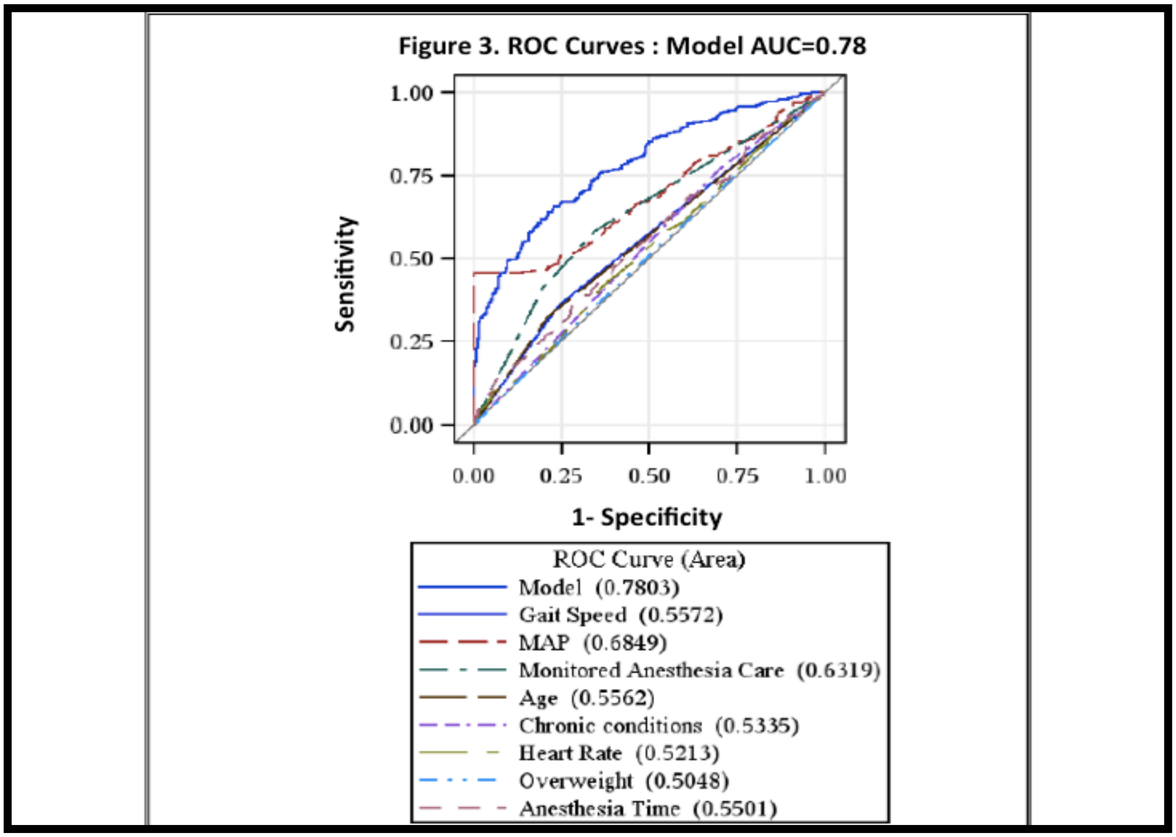

Figure 3: Area under the curve for predicting home discharge readiness ≤90 minutes among ambulatory surgical patients

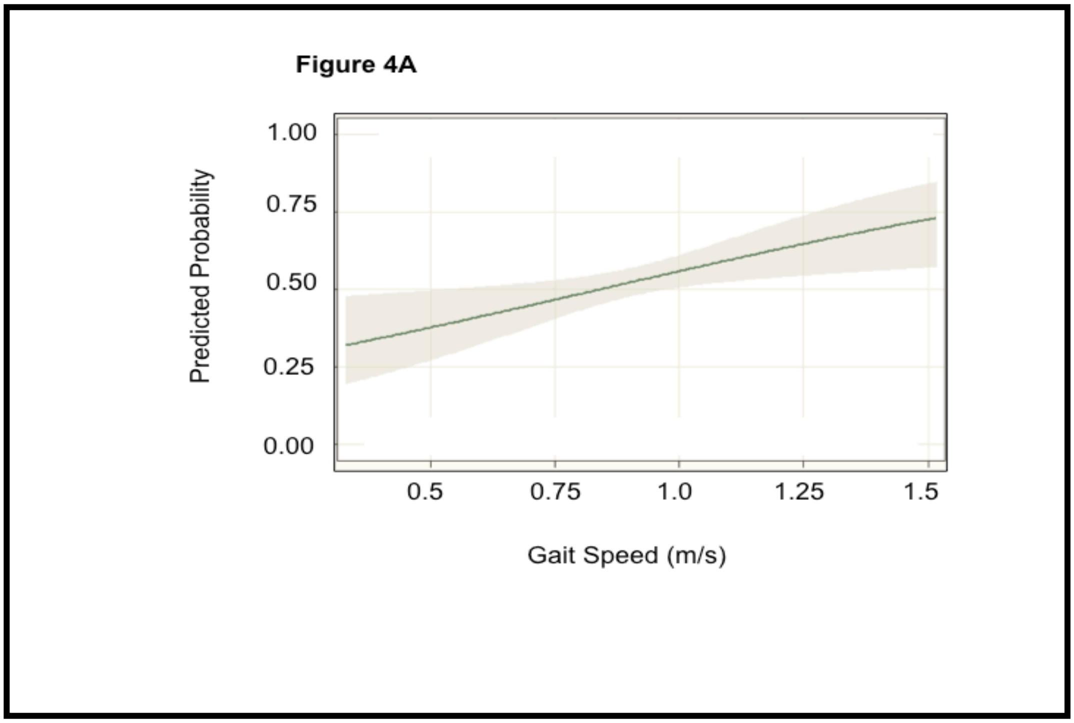

Figure 4 A. Predicting the probability of home discharge readiness ≤90 minutes among ambulatory surgical patients based on their preoperative gait-speed.

Figure 4C

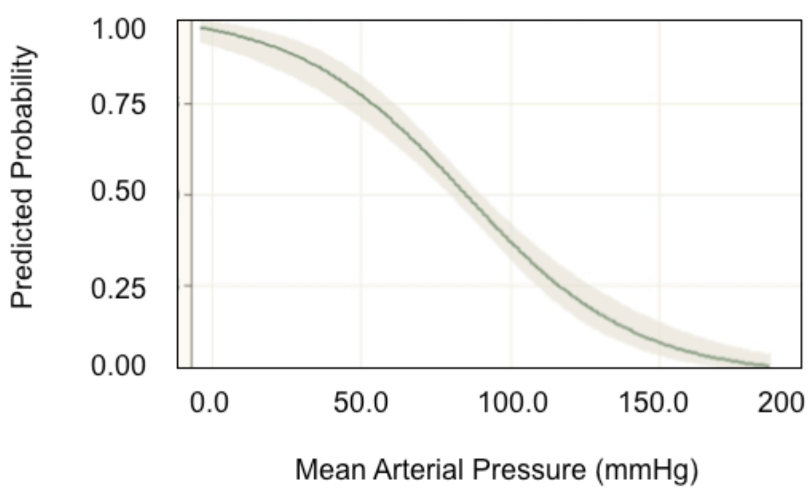

Figure 4B

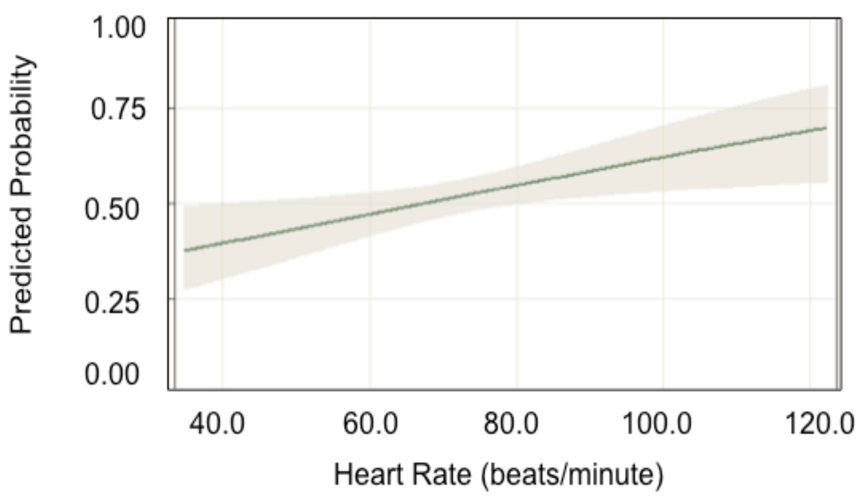

Figure 4 B and C. Predicting the probability of home discharge readiness ≤90 minutes among ambulatory surgical patients based on their: B) Preoperative Mean Arterial Pressure, and C) Preoperative heart rate.

***Aim 4: To examine whether gait speed independently predicts unanticipated admissions after elective ambulatory surgery*.**

In order to identify those patients with prolonged PACU stay (greater than 3 hours by the Yale New Haven Hospital PACU nursing requirements), we conducted a *post hoc* analysis to determine whether preoperative gait speed was correlated with prolonged stay and subsequent admission to ancillary units. For those who were discharged home, the association of gait speed with home discharge readiness was evaluated by multivariable linear regression as previously described in the text. Gait speed independently predicted home discharge readiness time, with a 1 m/s change in gait speed resulting in a 0.5 h change in home discharge readiness (Table 5). Other independent predictors of home-discharge readiness time included age ($p = 0.008$), female gender ($p= 0.02$), preoperative mean arterial pressure ($p< 0.001$), and surgical category (major vs. minor surgery), $p = 0.01$ (Table 5). There were no significant interaction effects identified among the predictors. For those patients who were admitted from the ambulatory PACU to other ancillary units rather being discharge home the same day after elective ambulatory surgery, preoperative gait speed appeared to be predictive of this disposition.

The association of preoperative gait speed with unanticipated admissions was evaluated by logistic regression. The following preoperative characteristics were found to be independently associated with unanticipated admissions when other covariates wee held constant: female gender ($p=0.024$), history of cardiac surgery ($p=0.001$), history of prior hospitalizations ($p<0.0004$), and gait speed with adjusted odds ratio = 0.54 (95% CI: 0.38-0.82), $p=0.003$ (Table 6). The area under the curve for this model was 0.73 (95% CI: 0.67-0.79) (Table 6). The model predicting unanticipated admissions could not be internally cross validated by the same methods due to the skewed distribution of the outcome.

Table 5. Multivariable linear regression model of predictors of time to discharge readiness

Model	Variable	Estimate (S.E)[x]	P-value	95% CI
p<0.0001	**Demographic**			
Adjusted R^2	Age[a]	-0.5 (0.1)	<0.0001	-0.8 to -0.3
0.28	Female gender	-9.0 (3.6)	0.01	-16.1 to -1.8
	BMI (Overweight)	6.8 (3.8)	0.07	-0.6 to 14.2
	Cormorbid conditions[ϕ]	2.9 (3.6)	0.41	-4.1 to 10.0
	Pre-operative			
	Gait Speed[b]	-30.9 (10.3)	0.003	-51.2 to -10.7
	Mean Arterial Pressure	0.9 (0.1)	<0.0001	0.7 to 1.0
	Heart Rate	-0.4 (0.1)	0.02	-0.6 to -0.07
	Surgical Risk*	11.0 (4.3)	0.01	2.6 to 19.4
	Peri-operative			
	Anesthesia technique	-3.4 (2.4)	0.15	-8.1 to 1.3
	Total Anesthesia Time	0.04 (0.03)	0.17	-0.02 to 0.09

X- Estimates represent unstandardized coefficients. S. E represents the standard error.
ϕPatients with no cormobid conditions were used as a reference group for analysis.
Cormobid conditions included: history of atrial fibrillation, hypercholesterolemia, stroke, heart disease, diabetes, hypertension, chronic obstructive pulmonary disease, asthma, and emphysema.
a- Age was used as a continuous variable in the analysis.
b- Gait speed was used as a continuous variable in the analysis.
*Surgical Risk was categorized as major vs. minor. The latter was used as a reference group for analysis.
Minor surgery was defined as all of the following: surgery duration <1h, expected blood loss <500 ml, and no opening of visceral cavity (except in case of diagnostic laparoscopic procedures).
Major surgery was defined as any of the following: duration of procedure ≥1h, expected blood loss≥ 500 ml, opening of visceral cavity, potential massive respiratory or hemodynamic effects due to surgery.

*Reference:Fritsch G, Flamm M, Hepner DL, Panisch S, Seer J, Soennichsen A. Abnormal pre-operative tests, pathologic findings of medical history, and their predictive value for perioperative complications. Acta anaesthesiologica Scandinavica. 2012;56:339-350.

Table 6: Logistic Regression Model Predicting Unanticipated Admission from PACU*			
Covariate	Estimate (S.E)	95% CI	P-Value
Age[§]	-0.31 (0.30)	-0.92-0.31	0.33
Female gender	-0.31 (0.14)	-(0.58-0.04)	0.024
Cardiac Surgery History	1.77 (0.52)	0.76-2.78	0.001
Prior Hospitalizations	-1.07 (0.30)	-(1.67-0.48)	0.0004
Pre-operative			
Gait Speed[Ω]	-0.60 (0.20)	-(0.96-0.20)	0.003
Mean Arterial Pressure	0.002 (0.002)	-0.009-0.01	0.97
Heart Rate	-0.01 (0.01)	-0.001-0.01	0.49
Peri-operative			
Total Anesthesia Time	0.003 (0.002)	-0.0001-0.007	0.09
Model Performance			
Aikake Information Criterion (**AIC**)	362		
Bayesian Information Criterion (**BIC**)	340		
Area Under the Curve (**AUC**), 95% CI	0.73 (0.67-0.79)		
Abbreviations and Legend			
OR: Odds Ratio			
SE: Standard Error			
PACU: Post-Anesthesia Care Unit			
§Patients who were <65 years old were used as a reference group for analysis			
ΩSlow walkers (patients with gait Speed <1m/s) were used as a reference group for analysis			
*Model was developed using complementary-log log-function due to highly skewed binary outcome.odds ratio of gait speed=e(-0.6*1)=0.54 CI:0.38-0.82			

Discussion

In contrast to most studies with small data sets (N<150 subjects) and which are retrospective,(47, 48) this study presents the first prospective observational cohort study of the important preoperative clinical factors that independently associate with home discharge readiness among a large sample population (N=602) of ambulatory surgical patients. In agreement with our hypothesis and specific aims, the study results show that gait speed was independently associated with time to home discharge readiness from the PACU. A fast walker relative to a slow walker had a statistically significant 10 minutes shorter PACU discharge time, when all other characteristics remained constant between them.

These findings corroborate results of other studies which demonstrate that gait speed predicts length of hospital stay in older surgical and stroke patients.(49-51) Previous reports have focused on single surgical specialties; (52, 53) however, we present the first prospective report covering multiple surgical specialties. We identify several important independent predictors of discharge time, notably: age, female gender, history of stroke and hypercholesterolemia, preoperative mean arterial pressure and heart rate. Our finding of the association of female gender with discharge readiness is consistent with other reports which show that the duration of recovery room stay was longer in women. (54) It has been postulated that this association may be related to higher pain scores, the need for treatment for nausea and vomiting, and the negative effect of progesterone on overall recovery among women. (54)

To the best of our knowledge, we delineate for the first time an internally cross-validated model depicting the independent association of preoperative measures and home discharge readiness after ambulatory surgery. While most reports discuss age, gender, and anesthesia technique as key determinants of prolonged post-operative stay, (35, 55) there remains a need to identify simple, clinically targetable perioperative factors that would facilitate optimum outcome measures. Presently, preoperative heart rate and blood pressure are routinely measured as part of patients' vital signs before surgery and hospitalization. Others, however, have suggested the inclusion of gait speed as part of patients' preoperative screening assessment. (31, 56) But until now, it was unclear if there was a predictive association of these measures with discharge outcomes. Using a cross-validated model, we show the utility and feasibility of including gait speed as an important preoperative marker given its predictive association with discharge readiness. (44)

Within the *inpatient* surgical population, heart rate and heart-rate variability, as well as the medical history of co-morbid conditions, have been used in the diagnostic evaluation and prediction of patient outcomes. (18, 57-59) Among similar inpatient cohorts, *intraoperativ*e mean arterial pressure has been shown to predict postoperative morbidity and mortality. (60-62) Likewise, baseline gait speed was predictive of length of hospitalization and overall survival. (63-66) Our work corroborates the results of these reports, but also underscores a risk management role for these *preoperative* measures among the ambulatory surgical population.

We show that a patient's history of cardiac surgeries and prior hospitalizations is independently associated with unanticipated admissions in the ambulatory surgical setting. Since *preoperative* information, such as medical history, appear to be better predictors of *perioperative* complications and adverse outcomes, than are routine assessments of laboratory tests, for example electrocardiograms, and chest X-rays, (8) our findings call for renewed emphasis on good clinical history in preoperative assessments. We also identify a potential role for *preoperative* measurements such as gait speed in prediction modeling in the ambulatory surgical setting. In the current climate of increasing health care costs, it may be more expedient to shift focus to less expensive and validated measures that potentially allow for better risk modeling and prognostication of outcomes.

By identifying key preoperative factors that influence discharge outcomes, this study sets the stage for subsequent investigations to probe whether long-term modifications of some of these preoperative targets such as gait speed, heart rate and blood pressure in the clinical setting would improve overall patients' functional health status and ambulatory surgical outcomes. Additionally, this study calls for a more nuanced understanding of the utility of gait speed in the perioperative setting. Based on our analyses, it appears that faster pre-operative gait speed results in a shorter time to home-discharge readiness from the PACU. Robust check of our Cox regression model (using gait cut-offs of 0.6m/s, 0.6-1m/s and >1m/s) shows that gait speed remains independently associated with PACU-time, although >1m/s appears to yield the highest rate increase in time to discharge readiness. A separate multivariable linear regression of PACU-readiness time also produced similar results (Table 5).

Of note, the odds ratio of early discharge (≤90 minutes) was 2-fold greater in patients with preoperative gait speed >1 m/s versus those with gait speed <1 m/s (Table 4). This corresponded to a 65% probability of early home discharge (Figure 4 A). Traditionally, gait speed has been used as a performance-based test of functional capacity in patients with chronic respiratory disease and heart failure. (67, 68) In these pulmonary and cardiovascular conditions, gait speed may reflect exercise tolerance as slower gait speeds associates with lower functional and aerobic capacity. Although gait speed may have a predictive role in patients with pulmonary and cardiovascular conditions, it appears that its prognostic value, is at best, limited in other contexts. (69, 70) Among older adults with mobility deficits, it has been shown that small clinically meaningful change in gait speed is 0.05 m/s. (71, 72), which are equivalent to 2.7% (exp [0.05*0.54]-1) increase in rate of discharge readiness based on our Cox regression model.

However, an estimate of clinically meaningful change must take into account whether the magnitude of improvement can be realistically achieved.(72) In some studies of home exercise, gait and strength training, there was a reported increase of 0.06 m/s in gait speed.(73) In a 1-year follow-up of older patients with disabilities, substantial clinically meaningful change in gait speed was reported to be 0.1 m/s.(72) Our multivariable linear regression model shows that a change of 1/ms is required to correspond with a 30-min decrement in discharge readiness time (Table 5). Although our study excluded patients with mobility limitations, our model underscores a limited clinical utility to preoperative gait speed testing alone among ambulatory surgical patients. To obtain a clinically useful 30 minute decrement in time to discharge readiness, would require a magnitude of improvement in gait speed that may not be realistically attainable. Although gait speed performs better than other predictors (when used as a continuous variable; Table 5), a more promising approach for future research may be to consider how functional measures such as gait speed could be incorporated into a composite preoperative prediction score that takes into account other factors such as age, gender, surgical risk, preoperative heart rate and mean arterial. This score may provide a more clinically relevant prediction of extended PACU stay and offer a rapid reliable way to risk stratify ambulatory surgical patients.

Working with patients to improve functional markers such as gait speed prior to surgery, may translate into better discharge and surgical outcomes. However, our study results indicate that targeting gait speed alone may not be sufficient for improving outcomes. Nonetheless, gait speed provides a viable option for targeting reversible preoperative functional measures. Combined with a patient's history and other clinical indicators, these preoperative measures may also provide anticipatory guidance for postoperative planning.

The strength of the present study lies in the fact that our protocol prospectively tested and evaluated *readiness* to discharge rather *actual* discharge time from the PACU. Thus, we bypassed some of the logistical issues of lack of escorts as well as other systemic delays unrelated to discharge readiness, which could have biased our findings and prolonged time to PACU discharge disproportionately. Secondly, in contrast to previous gait studies that used retrospective data,(24) this study is the first prospective observational study of gait speed among a large cohort of patients in an ambulatory surgical setting. This report is also unique in its coverage of 7-surgical specialties representing 140 of the most common ambulatory surgical procedures at the Yale New Haven Hospital. Importantly, we demonstrate the feasibility of preoperatively evaluating gait-speed within the busy environment of the ambulatory surgical suite.

In contrast to expensive laboratory tests which poorly predict discharge outcomes, (8, 52) preoperative measures like gait speed, mean arterial pressure and heart rate, have the added advantage of being simple, inexpensive, and easy-to-perform, as demonstrated by this study. Additionally, nursing and medical staffs, who were blinded to all subjects' co-morbidity status, or anesthetic management, performed the determination of home-discharge readiness, hence limiting the potential for observer bias. Lastly, by identifying the history of cardiac surgery and of prior hospitalizations as factors that are significantly associated with unanticipated admissions, our results further underscore the importance of elements of patients' history to surgical care.

Study Limitations

First, this study was performed at a single academic medical center. In the absence of standardized home discharge readiness times, (35, 43) we chose the arbitrary cut-point of 90-minutes. While our protocol follows those of others, (74) the wide range of variability in home discharge readiness times at different institutions and medical centers, makes cross-comparisons difficult. (39, 44, 75) Thus our internally validated prediction model may need to be externally validated at other medical centers and ambulatory surgical settings.

Second, in contrast to studies of gait speed within the in-patient surgical population, failure to find a predictive association between gait speed and secondary outcomes of complications of nausea/vomiting, and bleeding at 24-hr postoperative surgery in our study, could be due to the fact that the 24-hr window may have been too narrow to observe any significant complications. This could have inflated the counts of patients considered to have no postoperative complications. The fact that only fifty one percent of patients (306/602) responded to the 24-h follow-up phone call from the PACU nurses, could have also affected the estimation of the true relationship of gait speed with the outcomes of nausea/vomiting, and bleeding. A longer-term follow-up (1-week) in the future may allow more accurate assessments of any possibly delayed complications. However, the twenty-four follow-up for complications is the standard of practice. (76, 77)

Third, in contrast to previous reports with older cohorts (mean age 70 – 80 years),(24, 78) this study has a relatively young population (mean age 55.2 years). That we did not find a clinically substantial association between gait speed and discharge readiness in this young cohort may suggest that gait speed may have better clinical utility in an older cohort. The exclusion of patients with movement disorders and mobility limitations from this study may make it difficult to extend our study results to this subgroup with movement disabilities. However, work by others showing that gait and handgrip strength are independently associated with morbidity among mobility-limited adults with dementia,(79-82) lends support to our findings. One may surmise that patients with movement disorders and mobility limitations may have slower gait speeds, thus would have more prolonged home-discharge readiness times. However, the spread of gait-variability among different older adult populations makes establishing a standard cut-off a daunting task. (83, 84) It is plausible that the 1m/s cut-off used in this study may be too high of a threshold for this subgroup of patients. (31, 85) Thus, one may have to recalibrate a different gait-speed cut-off when performing gait testing among a cohort of patients who are mobility-limited.

A way forward may be population-specific determinations that account for mobility-related disorders that potentially influence performance on gait testing. Future work may consider the use of validated wearable and detachable mobile accelerometers for automated recording of different gait vectors and parameters, allowing for richer and more nuanced data interpretation. (86, 87). Home discharge readiness is the beginning of an extensive postoperative recovery process, which continues long after patients are discharged home. Although our work shows that preoperative measures of gait speed, heart rate and mean arterial pressure are associated with discharge readiness, it would be instructive to determine their relationship to other phases of patient recovery. Nonetheless, the prediction models used in this study add to our understanding of the association between preoperative vital signs and discharge readiness outcomes in the ambulatory surgical population.

Summary

In this prospective observational study, we evaluated the role of preoperative gait speed and other measures in predicting discharge readiness outcomes in the ambulatory surgical setting. Specifically we tested and found evidence in support of our specific aims, and have determined that :

Aim 1: A fast walker spent an average of 10-minutes shorter time to home discharge readiness from the PACU than did a slow walker, when all other chracteristics remained constant between them.

Aim 2: Preoperative gait speed was not predictive of 24-hour postoperative complications of nausea, vomiting and bleeding, holding all other variables constant.

Aim 3: Perioperative predictors such as age, gender, preoperative gait speed, heart rate and mean arterial pressure, history of stroke and hypercholesterolemia, were independently associated with home discharge readiness ≤ 90 minutes, holding all other variables constant.

Aim 4: Preoperative gait speed, among other predictors such as prior hospitalizations and the history of cardiac surgery, were independently associated with unanticipated admissions after elective ambulatory surgery.

By providing evidence in support of these specific aims, this study adds to the growing body of literature, which suggests that gait speed is predictive of clinical outcomes in selected populations.(24, 88) In contrast to studies of general and cardiac surgical in-patients, where gait speed predicted morbidity and mortality,(78) we demonstrate a clinically modest association of preoperative gait speed with time to discharge readiness in a heterogeneous population of ambulatory surgical patients. While using gait speed by itself may have limited clincal utility in this setting, our study underscores the importance of a good history and functional measures in the preoperative assessment of ambulatory surgical patients. Our findings lay the groundwork for subsequent studies focused on the design of a risk score based on the predictive associations of preoperative gait speed with other risk classification measures, which may help identify patients at risk for delayed discharge readiness.

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Supplementary Data

Supplementary Table 1. Modified Aldrete Scoring System[ref] for determining readiness for home discharge*

Consciousness	
Not reactive or responsive	0
Arousable on calling	1
Fully Awake	2
Oxygenation	
Oxygen saturation < 90% even with oxygen supplementation	0
Needs oxygen inhalation to maintain oxygen saturation > 90%	1
Able to maintain oxygen saturation > 90% on room air	2
Respiration	
Apneic and ventilated	0
Supported airway or dyspneic	1
Spontaneous ventilation	2
Activity: able to move voluntarily or on command	
Moves no extremities	0
Moves two extremities	1
Moves four extremities	2

* A score of ≥ 8 was required for discharge. In addition blood pressure was required to be at or close to pre-anesthetic levels (± 20 mm Hg), or with minimal or no pain ,and minimal or no nausea/vomiting or responsive to treatment, and no bleeding.
Examinations for discharge criteria were done at 15-minute intervals by anesthesia care team who were blinded to the results of gait study.

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