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REPORTS OF ORIGINAL INVESTIGATIONS

Unplanned hospital admission after ambulatory surgery: a retrospective, single cohort study

Admission non planifiée à l'hôpital après une chirurgie ambulatoire : une étude rétrospective de cohorte unique

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Abstract

Purpose *We estimated the rate of unplanned hospital and intensive care unit (ICU) admissions following ambulatory surgery centre (ASC) procedures, and identified factors associated with their occurrence.*

Methods *This retrospective cohort included adult patients who underwent ASC procedures within a large community practice from January 2010 to December 2014. Patients were categorized into two groups: unplanned postoperative hospital/ICU admission within 24 hr of procedure or uneventful discharge. Demographics, comorbidities, anesthesia type, procedure type, procedure group, and ASC facility were assessed.*

Results *Of the 211,389 patients included, there were 211,147 uneventful discharges (99.89%) and 242 unplanned hospital admissions (0.11%), of which 75 were ICU admissions (0.04%). The multivariable logistic regression model for hospital admission showed an increased risk associated with age > 50 yr (odds ratio [OR], 1.53); American Society of Anesthesiologists (ASA) physical status (III vs II: OR, 1.45; IV vs II: OR, 1.88), comorbidity (chronic obstructive pulmonary disease: OR, 2.63; diabetes mellitus: OR, 1.62; transient ischemic attack: OR, 2.48) procedure (respiratory: OR, 2.92; digestive: OR, 2.66; musculoskeletal system: OR, 2.53), anesthetic management (general anesthesia [GA] and peripheral nerve block vs GA: OR, 1.79), and ASC facility (189BB: OR, 2.29; 30E9A: OR, 7.41; and BD21F: OR, 1.69). The multivariable logistic regression model for ICU admission showed increased risk of unplanned ICU admission associated with ASA physical status (ASA III vs II: OR, 3.0; ASA IV vs II: OR, 8.52), procedure (musculoskeletal system: OR, 2.45), and ASC facility (00E6C: OR, 3.14; 189BB: OR, 2.77; 30E9A: OR, 2.59; and BD21F: OR, 3.71).*

Conclusion *While a small percentage of adult patients who underwent ASC procedures required unplanned hospital admission (0.07%), approximately one-third of these admissions were to the ICU (0.04%). Facility was at least as strong a predictor of hospital admission as the patient- and/or procedure-specific variables.*

Résumé

Objectif *Nous avons estimé le taux d'admissions non planifiées à l'hôpital et à l'unité de soins intensifs (USI)*

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après des interventions dans des centres de chirurgie ambulatoire (CCA), et identifié les facteurs associés à leur survenue.

Méthode *Cette étude de cohorte rétrospective a porté sur des patients adultes ayant subi une intervention dans un CCA appartenant à une grande pratique communautaire entre janvier 2010 et décembre 2014. Les patients ont été catégorisés en deux groupes : admission postopératoire non planifiée à l'hôpital/USI dans les 24 h suivant l'intervention ou congé sans incident. Les données démographiques, les comorbidités, le type d'anesthésie, le type d'intervention, le groupe d'intervention et l'établissement de CCA ont été évalués.*

Résultats *Parmi les 211 389 patients inclus, il y a eu 211 147 congés sans incident (99,89 %) et 242 admissions non planifiées à l'hôpital (0,11 %), 75 desquelles étaient des admissions à l'USI (0,04 %). Le modèle de régression logistique multivariée des admissions hospitalières a montré un risque accru associé à un âge > 50 ans (rapport de cotes [RC], 1,53); au statut physique ASA (American Society of Anesthesiologists) (III vs II : RC, 1,45; IV vs II : RC, 1,88), aux comorbidités (maladie pulmonaire obstructive chronique : RC, 2,63; diabète: RC, 1,62; accident ischémique transitoire : RC, 2,48); à l'intervention (respiratoire : RC, 2,92; digestive : RC, 2,66; appareil locomoteur : RC, 2,53); à la prise en charge anesthésique (anesthésie générale [AG] et bloc nerveux périphérique vs AG : RC, 1,79) et établissement de CCA (189BB : RC, 2,29; 30E9A : RC, 7,41; et BD21F : RC, 1,69). Le modèle de régression logistique multivariée des admissions à l'USI a montré un risque accru d'admission non planifiée à l'USI associé au statut physique ASA (ASA III vs II: RC, 3,0; ASA IV vs II: RC, 8,52), à l'intervention (appareil locomoteur : RC, 2,45), et à l'établissement de CCA (00E6C: RC, 3,14; 189BB: RC, 2,77; 30E9A: RC, 2,59; et BD21F: RC, 3,71).*

Conclusion *Alors qu'un faible pourcentage de patients adultes ayant subi des interventions en CCA ont nécessité une admission non planifiée à l'hôpital (0,11 %), environ un tiers de ces admissions étaient à l'USI (0,04 %). L'établissement était un prédicteur au moins aussi puissant d'admission à l'hôpital que les variables spécifiques au patient et/ou à l'intervention.*

Keywords ambulatory surgery · unplanned hospital admissions · outpatient · ICU

Introduction

Improvements in surgical and anesthetic practice permit procedures to be performed on an outpatient basis that previously required inpatient admission.[1] There are strong organizational and economic pressures supporting this transition[1] and it is imperative to continually assess outcomes associated with this evolving medical practice.

Standards of quality in anesthesia care are based on measured outcomes and outcome indicators,[2] and the incidence of unplanned hospital admissions/readmissions is one such measure.[3,4] Unplanned admissions include patients unexpectedly admitted directly to the hospital from the outpatient surgical facility, and unplanned readmissions constitute patients discharged from the outpatient surgical facility and subsequent readmission.[5] Unplanned admissions/readmissions result from unanticipated perioperative events. The rate for unplanned hospital admissions following outpatient surgery is 0.3–9.5%[6–17] and the rate of unplanned hospital readmissions is 1.1–3%.[1,18,19] Variability in these rates reflects, in part, different definitions of admission/readmission and different mechanisms for capturing these events.

Many of the studies investigating unplanned admissions/readmissions following *outpatient surgery* are dated, confined to hospital-based facilities, and limited in sample size. Moreover, there are no studies that detail the incidence and risk factors for unplanned intensive care unit (ICU) admissions.[20–22] Unplanned ICU admissions is a validated measure of patient safety in surgical patients,[20]

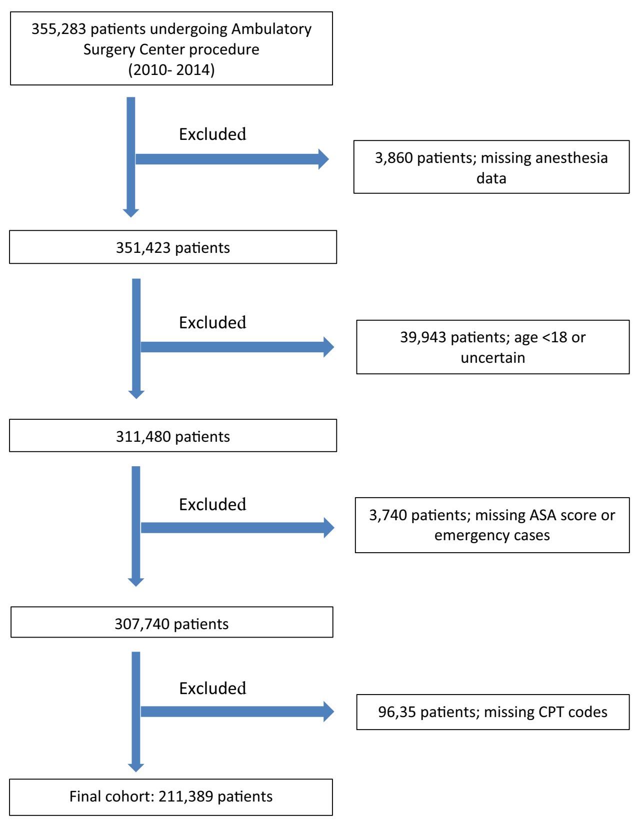

Fig. 1 Consort diagram summarizing inclusion and exclusion criteria for developing the data set.

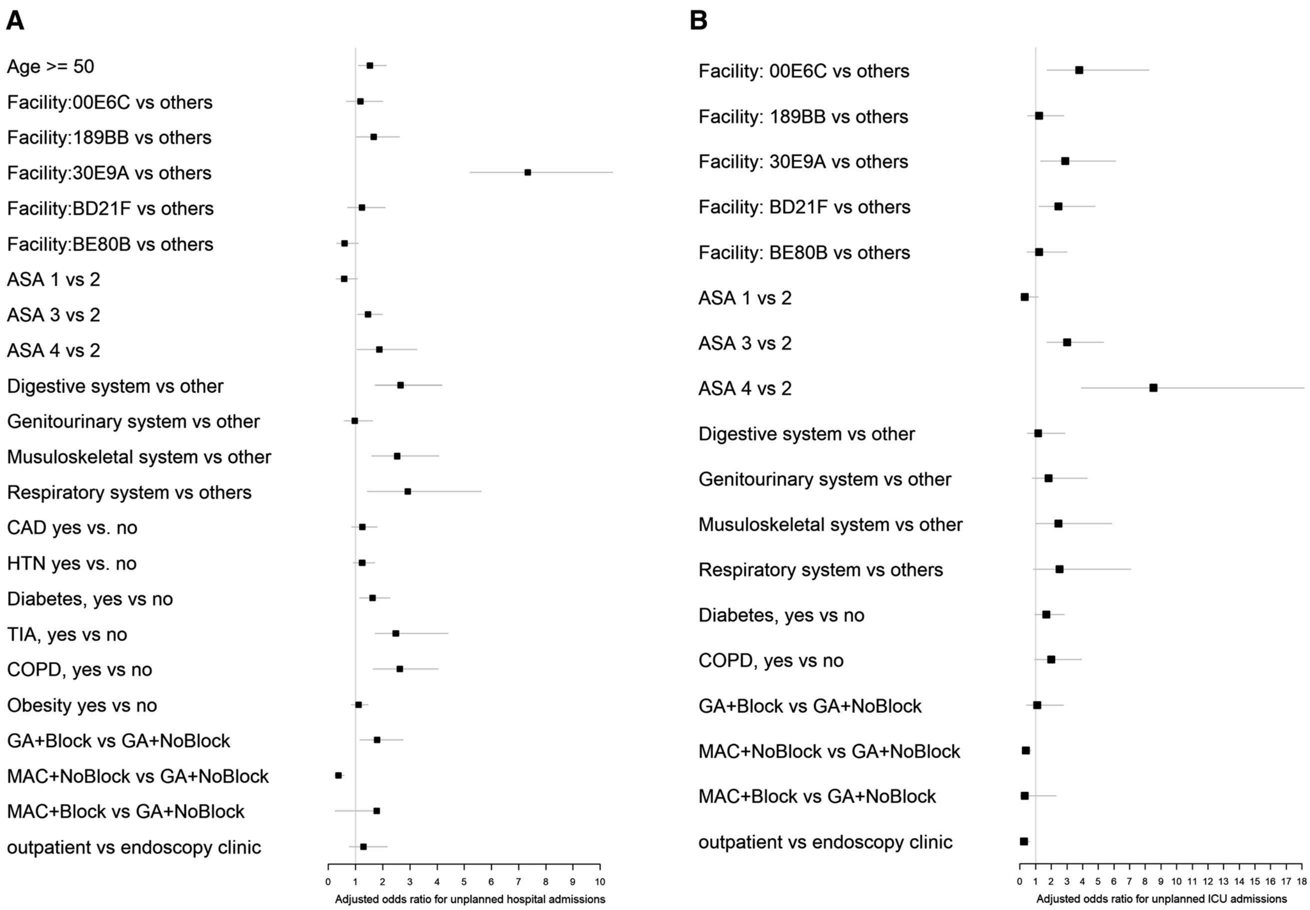

Fig. 2 Forest plots indicating effect size in the final multivariable logistic regression model for unplanned hospital (Fig. 2A) and ICU admission (Fig. 2B). Data plotted as adjusted odds ratio (squares) with 95% CI's indicated by horizontal lines. CI = confidence interval; ICU = intensive care unit.

and may help identify at-risk outpatient surgery groups, procedures, and practices.[21–23]

The objective of this study was to assess the incidence of unplanned hospital and ICU admissions/readmissions following ambulatory surgery centre (ASC) procedures in a large, regional community-based anesthesia practice and to identify factors associated with increased risk of their occurrence.

Methods

This study met Duke University Health System Institutional Review Board exemption and the requirement for written informed consent from patients was waived (DUHS IRB #Pro00065103). The results of our cohort study are reported according to the Strobe criteria. This cohort consisted of de-identified data obtained from the quality assurance database of a large regional, community-based anesthesiology group practice (MEDNAX, Inc.), located in the Mid-Atlantic region of the United States.[24,25] No anesthesiology trainees were present at any site, and more than 98% of care was delivered via anesthesiologists supervising certified registered nurse anesthetists, with the balance receiving care by physicians practicing alone.

The anesthesia group utilizes an internally designed quality improvement program, the Quantum™ Clinical Navigation System (Q-CNS).[24,25] The Q-CNS system collects comorbidities, anesthetic data, procedural information, and outcomes using a standardized quality assurance (QA) sheet across its entire system for every anesthetic delivered.[25] Care team members (anesthesiologists, certified registered nurse anesthetists, and post-anesthesia care unit registered nurses) enter data into the QA sheet by shading boxes on a restricted report form (i.e., limited options with no free text), separate from the clinical anesthesia record.[25] Data from the entered QA reports are subsequently validated within 48 hr by a trained QA nurse. Any missing fields are completed using both the

Table 1 Patient characteristics of unplanned hospital and ICU admissions

Characteristic	Descriptive statistics			Group comparison			
	No hospital and no ICU admissions (A) (*n*=211,147)	Hospital admissions (B) (*n*=242)	ICU admissions (C) (*n*=75)	*P* value (B *vs* A)	SMD (B *vs* A)	*P* value (C *vs* A)	SMD (C *vs* A)
Age (numeric)	53[41,65]	60[50,70]	61[50,70]	< 0.001^	0.40	< 0.001^	0.46
Age (categorical)				< 0.001*	0.43	0.003*	0.53
< 21	4,267 (2.0%)	0 (0.0%)	0 (0.0%)				
21–30	17,140 (8.1%)	12 (5.0%)	4 (5.3%)				
31–40	30,351 (14.4%)	19 (7.9%)	3 (4.0%)				
41–50	41,729 (19.8%)	35 (14.5%)	12 (16.0%)				
51–60	44,844 (21.2%)	58 (24.0%)	17 (22.7%)				
61–70	41,685 (19.7%)	63 (26.0%)	20 (26.7%)				
71–80	23,680 (11.2%)	35 (14.5%)	11 (14.7%)				
> 81	7,451 (3.5%)	20 (8.3%)	8 (10.7%)				
Age >50	117,660(55.7%)	176(72.7%)	56(74.7%)	< 0.001*	0.36	0.001*	0.41
Facility 00E6C	28,008(13.3%)	18(7.4%)	13(17.3%)	< 0.001*	0.86	0.075*	0.34
189BB	26,105(12.4%)	28(11.6%)	7(9.3%)				
30E9A	24,306(11.5%)	113(46.7%)	12(16.0%)				
BD21F	24,802(11.7%)	17(7.0%)	15(20.0%)				
BE80B	26,129(12.4%)	11(4.5%)	6(8.0%)				
Other	81,797(38.7%)	55(22.7%)	22(29.3%)				
ASA physical status				< 0.001*	0.47	< 0.001*	0.91
I	24,911 (11.8%)	10 (4.1%)	1 (1.3%)				
II	113,484 (53.7%)	101 (41.7%)	21 (28.0%)				
III	63,782 (30.2%)	110 (45.5%)	37 (49.3%)				
IV	8,970 (4.2%)	21 (8.7%)	16 (21.3%)				
Sex (male)	84,392 (40.0%)	91 (37.6%)	35 (46.7%)	0.45*	− 0.29	0.24*	− 0.43
Procedure type (CPT code)				< 0.001*	0.46	< 0.001*	0.43
Digestive system	65,978 (31.2%)	83 (34.3%)	27 (36.0%)				
Genitourinary system	33,239 (15.7%)	28 (11.6%)	12 (16.0%)				
Musculoskeletal system	45,050 (21.3%)	85 (35.1%)	17 (22.7%)				
Respiratory system	5,622 (2.7%)	12 (5.0%)	8 (10.7%)				
Others	61,258 (29.0%)	34 (14.0%)	11 (14.7%)				
Smoking	35,099 (16.6%)	47 (19.4%)	16 (21.3%)	0.24*	0.073	0.27*	0.12
CAD	18,261 (8.6%)	44 (18.2%)	18 (24.0%)	< 0.001*	0.28	< 0.001*	0.42
HTN	93,854 (44.4%)	152 (62.8%)	50 (66.7%)	< 0.001*	0.37	< 0.001*	0.46
History of stroke	3,750 (1.8%)	4 (1.7%)	3 (4.0%)	>1.0†	− 0.001	0.15†	0.13
History of OSA	21,160 (10.0%)	30 (12.4%)	8 (10.7%)	0.24†	0.075	0.85†	0.021
Renal insufficiency	6,997 (3.3%)	7 (2.9%)	4 (5.3%)	0.86†	− 0.024	0.32†	0.1
Obesity	65,364 (31.0%)	96 (39.7%)	24 (32.0%)	0.003*	0.18	0.85*	0.022
DM	20,645 (9.8%)	52 (21.5%)	20 (26.7%)	< 0.001*	0.33	< 0.001*	0.45
TIA	2,215 (1.0%)	11 (4.5%)	4 (5.3%)	< 0.001†	0.21	0.008†	0.25
COPD	5,656 (2.7%)	26 (10.7%)	10 (13.3%)	< 0.001*	0.33	< 0.001 *	0.40
Primary anesthesia Type				< 0.001*	0.56	0.13*	0.33
GA+ No PNB	118,600 (56.2%)	164 (66.5%)	50 (66.7%)				

Table 1 continued

Characteristic	Descriptive statistics			Group comparison			
	No hospital and no ICU admissions (A) (*n*=211,147)	Hospital admissions (B) (*n*=242)	ICU admissions (C) (*n*=75)	*P* value (B *vs* A)	SMD (B *vs* A)	*P* value (C *vs* A)	SMD (C *vs* A)
GA+ PNB	18,943 (9.0%)	46 (19.0%)	8 (10.7%)				
RA (MAC+ PNB)	4,866 (2.3%)	4 (1.7%)	0 (0.0%)				
MAC (No PNB)	68,738 (32.6%)	31 (12.8%)	17 (22.7%)				
Procedure group				0.005*	– 0.19	0.001†	0.37
Endoscopy	44,229 (20.9%)	33 (13.6%)	28 (37.3%)				
Outpatient	166,918 (79.1%)	209 (86.4%)	47 (62.7%)				

^Wilcoxon * Chi square † Fisher exact

ASA = American Society of Anesthesiologists; CAD = coronary artery disease; COPD = chronic obstructive pulmonary disease; CPT code = current procedural terminology code; DM = diabetes mellitus; GA = general anesthesia; HTN = hypertension; ICU = intensive care unit; MAC = monitored anesthesia care; PNB = peripheral nerve block; RA = regional anesthesia; TIA = transient ischemic attack.

Standardized mean differences (SMD) computed using Cohen's D to represent the effect size of each variable between cases and controls (unplanned hospital admission *vs* uneventful discharge; unplanned ICU admission *vs* uneventful discharge

anesthetic and electronic medical record, and maintained in a central database.[24] Data quality validation processes have shown a mean (standard deviation [SD]) accuracy of this database of 99.6 (0.11) %. A review of audit activity showed that only 2% of cases required more than two corrections.[24]

The definition of ASC in this manuscript reflects current Medicare terminology. Ambulatory surgery centres are defined as facilities independent from hospitals (once referred to as freestanding ASCs), as opposed to hospital outpatient department surgery (once referred to as hospital-based ASCs).[1,26] Medicare changed this terminology to reflect reimbursement categories for these services, and other insurers followed Medicare's lead.[1,26] There were five primary ASC sites (facility code [N = number of patients]: 00E6C [n = 28,026], 189BB [n = 26,133], 30E9A [n = 24,419], BD21F [n = 24,819], BE80B [n = 26,140]), with the others sites grouped together (other [n = 81,852]), for total of n = 211,389 patients.

Eligible patients for this study included adult patients ($\geq$ 18 yr) undergoing procedures at ASCs within the MEDNAX system (see eAppendix in the Electronic Supplementary Material for ASC patient selection criteria) from January 2010 to December 2014, with an identifiable current procedural terminology (CPT) code that was categorized as digestive, genitourinary, musculoskeletal, respiratory, or other. From this group, admission status (admitted to hospitals or ICUs within 24 hr of receiving an anesthetic) was recorded. Unplanned admission (directly from the ASC) and readmission (unplanned admission after ASC discharge) were not differentiated in this study. Thus, unplanned admissions as defined in this study refer to unplanned admissions or readmissions within a 24-hr time period of receiving an anesthetic.

The primary outcome (QA nurse validated) of this study was unplanned hospital admission, a binary outcome that refers to patients who were admitted/readmitted to the hospital (cases admitted: unplanned hospital admission group) or not (non-hospital-admitted: uneventful discharge group) within a 24-hr time period after receiving an anesthetic. There were no planned hospital admissions. The secondary QA nurse validated outcome was unplanned ICU admission, which refers to patients who were admitted to the ICU after hospital admission/readmission (cases: unplanned ICU admission) or not (non-ICU-admitted: uneventful discharge group). By definition, unplanned ICU admission is a subset of unplanned hospital admission. Additional exploratory QA nurse validated outcomes of interest included performance of cardiopulmonary resuscitation (CPR) and death within 24 hr of receiving an anesthetic.

Other QA nurse validated variables were categorized as follows: 1) demographics: age, sex, and ASC facility; 2) comorbidities and lifestyle: American Society of Anesthesiologists (ASA) physical status, smoking status, coronary artery disease (CAD), hypertension (HTN), diabetes mellitus (DM), renal insufficiency with creatinine > 2.0, body mass index (BMI) > 30.0 kg·m^{-2}, transient ischemic attack (TIA), cerebrovascular accident, and obstructive sleep apnea (OSA); and 3) procedural variables: anesthetic type (general anesthesia [GA], GA + peripheral nerve block, regional anesthesia, monitored anesthesia care [MAC]), procedure type (organized by the

Table 2 Final multivariable logistic regression model for unplanned hospital and unplanned ICU admissions

Risk factors	For hospital admissions (*n*=242)		For ICU admissions (*n*=75)	
	Odds ratio (95% CI)	*P* value	Odds ratio (95% CI)	*P* value
Age (>50)	1.53 (1.11, 2.13)	0.0082		
Facility				
Other	Reference		Reference	
00E6C	1.17 (0.66 to 2.05)	0.55	3.79 (1.72 to 8.24)	< 0.001
189BB	1.66 (1.03 to 2.61)	0.03	1.23 (0.49 to 2.80)	0.63
30E9A	7.33 (5.21 to 10.45)	< 0.001	2.89 (1.32 to 6.10)	0.004
BD21F	1.23 (0.70 to 2.08)	0.44	2.46 (1.23 to 4.81)	0.007
BE80B	0.59 (0.30 to 1.10)	0.11	1.24 (0.45 to 3.01)	0.64
ASA physical status				
I	0.58 (0.28 to 1.06)	0.09	0.29 (0.03 to 1.14)	0.13
II	Reference	–	Reference	–
III	1.45 (1.06 to 1.99)	0.02	3.0 (1.72 to 5.32)	< 0.001
IV	1.88 (1.05 to 3.25)	0.03	8.52 (3.93 to 18.13)	< 0.001
Procedure type (CPT code)				
Others	Reference		Reference	–
Digestive system	2.66 (1.72 to 4.18)	< 0.001	1.16 (0.47 to 2.86)	0.73
Genitourinary system	0.97 (0.58 to 1.63)	0.91	1.83 (0.79 to 4.28)	0.14
Musculoskeletal system	2.53 (1.59 to 4.06)	< 0.001	2.45 (1.02 to 5.85)	0.03
Respiratory system	2.92 (1.43 to 5.62)	0.002	2.53 (0.85 to 7.08)	0.07
CAD	1.25 (0.85 to 1.79)	0.23		
HTN	1.24 (0.91 to 1.70)	0.17		
Diabetes	1.62 (1.15 to 2.27)	0.004	1.68 (0.95 to 2.85)	0.05
TIA	2.48 (1.27 to 4.39)	0.003		
COPD	2.63 (1.65 to 4.03)	< 0.001	1.99 (0.92 to 3.93)	0.05
Obesity	1.11(0.84 to 1.45)	0.45		
Anesthesia type				
GA + No PNB	Reference		Reference	
GA+ PNB	1.79 (1.16 to 2.75)	0.007	1.11 (0.43 to 2.77)	0.82
MAC (No PNB)	0.37 (0.23 to 0.58)	< 0.001	0.37 (0.19 to 0.70)	0.002
RA (MAC+ PNB)	0.78 (0.25 to 1.85)	0.61	0.30 (0.002 to 2.30)	0.39
Procedure group				
Endoscopy	Reference		Reference	
Outpatient	1.29 (0.78 to 2.17)	0.31	0.26 (0.11 to 0.61)	0.001

ASA = American Society of Anesthesiologists; CAD = coronary artery disease; CI = confidence interval; COPD = chronic obstructive pulmonary disease; CPT code = current procedural terminology code; DM = diabetes mellitus; GA = general anesthesia; HTN = hypertension; MAC = monitored anesthesia care; PNB = peripheral nerve block; RA = regional anesthesia; TIA = transient ischemic attack

CPT codes digestive system, genitourinary system, musculoskeletal system, respiratory system, and other), and procedure group (surgical procedures *vs* endoscopic procedures). Surgical events and hospital/ICU admitting diagnoses were not captured in the data repository.

Descriptive statistics for patient demographics and baseline characteristics were computed for unplanned hospital admission and unplanned ICU admission and for uneventful discharge groups, respectively, and presented as mean (standard deviation [SD]) for continuous variables and frequency (percentage) for categorical variables. As well as considering age as a continuous variable, we also examined its distribution by decades and by a dichotomized variable defined as age $\leq$ 50 *vs* > 50 yr. We defined obesity variable based on BMI $\leq$ 30 *vs* > 30 $kg{\cdot}m^{-2}$. For comparing the characteristic difference between two groups, Wilcoxon rank-sum test was applied for continuous variables, and Chi square or Fisher's exact

Table 3 Comparisons of patient characteristics and outcomes (unplanned admissions) in patients with missing *vs* non-missing CPT codes

	Total (*n*=307,740)	Missing CPT code (*n*=96,351)	Available CPT code (*n*=211,389)	SMD
Unplanned hospital admission	271 (0.1%)	29 (0.03%)	242 (0.1%)	0.03
ICU admission	86 (0.03%)	11 (0.01%)	75 (0.04%)	0.02
Age (numeric)	54.0 (42.0,65.0)	55.0 (46.0,66.0)	53.0(41.0,65.0)	− 0.13
Age > 50 years	179,487 (58.3%)	61,651 (64.0%)	117,836 (55.7%)	− 0.17
ASA physical status				0.13
I	37,626 (12.2%)	12,705 (13.2%)	24,921 (11.8%)	
II	170,964 (55.5%)	57,109 (59.3%)	113,585 (53.7%)	
III	88,067 (28.6%)	24,175 (25.1%)	63,892 (30.2%)	
IV	11,353 (3.7%)	2,362 (2.5%)	8,991 (4.3%)	
Sex (female)	182,616 (59.5%)	55,723 (58.4%)	126,893 (60.0%)	− 0.04
Facility				
00E6C	31,586 (10.3%)	3,560 (3.7%)	28,026 (13.3%)	0.35
189BB	29,384 (9.5%)	3,251 (3.4%)	26,133 (12.3%)	0.34
30E9A	27,419 (8.9%)	3,000 (3.1%)	24,419 (11.6%)	0.33
BD21F	26,581 (8.6%)	1,762 (1.8%)	24,819 (11.7%)	0.40
BE80B	29,487 (9.6%)	3,347 (3.5%)	26,140 (12.4%)	0.33
Other	163,283 (53.1%)	81,431 (84.5%)	81,852 (38.7%)	− 1.1
Smoker	48,467 (15.7%)	13,321 (13.8%)	35,146 (16.6%)	0.08
Coronary artery disease	24,399 (7.9%)	6,094 (6.3%)	18,305 (8.7%)	0.09
Hypertension	134,333 (43.7%)	40,327 (41.9%)	94,006 (44.5%)	0.05
Renal insufficiency	8,232 (2.7%)	1,228 (1.3%)	7,004 (3.3%)	0.14
Obese (BMI > 30 $kg{\cdot}m^{-2}$)	91,472 (29.7%)	26,012 (27.0%)	65,460 (31.0%)	0.09
Diabetes	31,935 (16.1%)	11,299 (14.0%)	20,636 (17.6%)	0.1
History TIA	3,233 (1.6%)	1,017 (1.3%)	2,216 (1.9%)	0.05
COPD	8,522 (5.4%)	2,874 (4.1%)	5,648 (6.3%)	0.1
History stroke	5,349 (1.7%)	1,595 (1.7%)	3,754 (1.8%)	0.01
History OSA	29,920 (9.7%)	8,730 (9.1%)	21,190 (10.0%)	0.03
Anesthesia type				
GA+PNB	22,621 (7.4%)	3,632 (3.8%)	18,989 (9.0%)	0.21
GA+No PNB	145,836 (47.4%)	27,075 (28.1%)	118,761 (56.2%)	0.59
RA	6,748 (2.2%)	1,878 (1.9%)	4,870 (2.3%)	0.03
MAC	132,535 (43.1%)	63,766 (66.2%)	68,769 (32.5%)	− 0.71
Procedure group				− 0.71
Endoscopy	104,376 (33.9%)	60,114 (62.4%)	44,262 (20.9%)	
Outpatient	203,364 (66.1%)	36,237 (37.6%)	167,127 (79.1%)	

ASA = American Society of Anesthesiologists; CAD = coronary artery disease; COPD = chronic obstructive pulmonary disease; CPT code = current procedural terminology code; DM = diabetes mellitus; GA = general anesthesia; HTN = hypertension; MAC = monitored anesthesia care; PNB = peripheral nerve block; RA = regional anesthesia; TIA = transient ischemic attack.

tests were applied for categorical variables as appropriate. Because of the large unbalanced sample sizes, we also computed standardized mean differences (SMD) using Cohen's D to represent the effect size of each variable between cases and controls (unplanned hospital admission *vs* uneventful discharge; unplanned ICU admission *vs* uneventful discharge). Considering the low number of cases in each outcome, logistic regression with Firth's correction for rare events was used as the primary regression model. Univariate logistic regression was performed first to test one predictor at a time for each outcome. To build the multivariable regression model, we included variables that met $P < 0.2$ from the univariate analysis or were of *a-priori* interest in the initial model to perform backward selection, where the least significant variable was removed in each iteration and Akaike information criterion (AIC) was monitored. The final model was based on the one with minimum AIC. To check if collinearity existed among all covariates in the model, because of the nature of binary outcomes and categorical predictors, we computed the estimated correlation matrix of parameter estimates from logistic regression and checked if any pairs of variables had higher than 80% correlation to consider for collinearity. To depict the effect size of each predictor in the final multivariable logistic regression model, forest plots were generated for each outcome. Statistical significance was determined based on $P < 0.05$. As we excluded 27% of patients from the initial cohort (Fig. 1) because of missing CPT codes, we evaluated if missing CPT codes impacted the outcome and covariate variables used in the final model. The distributions of each variable (unplanned hospital admission, unplanned ICU admission, and covariates) were compared between groups with and without CPT codes using SMD. We considered SMD $\leq$ 0.2 as a minimal effect, 0.2–0.5 a moderate effect, 0.5–0.8 a moderately large effect, and > 0.8 a large effect. All analyses were performed using SAS 9.4 (SAS Inc. Cary, NC, USA), and R 3.4.0 (https://www.r-project.org/).

Results

The initial cohort consisted of 355,283 patients who underwent ASC procedures under anesthesia care. Patients were excluded for the following reasons: missing anesthesia record, age < 18 yr or missing, ASA physical status > IV or missing, procedure classified as emergency, and missing or unidentified CPT codes (Fig. 1). Of these exclusion criteria, we excluded 11% of patients because of unqualified age, 1% because of unqualified ASA physical status, and 27% because of missing CPT codes. The final analysis data set consisted of 211,389 adult patients (60% of initial cohort) who had identified CPT codes and outcome measures. Among them, there were 211,147 uneventful discharges (99.89%) and 242 (0.11%) with unplanned hospital admissions (primary outcome) within 24 hr of receiving an anesthetic, of which 75 (0.04%) were ICU admissions (secondary outcome) (Fig. 1).

While the median [interquartile range] age in the entire cohort was 53 [41–65] yr, the unplanned hospital admission group was older, 60 [50–70] yr, with 73% > 50 yr. Female sex comprised 60% (126,893 patients) of the entire cohort, and there was no difference in sex between the groups. A majority of patients had an ASA physical status of II or III (84% [177,266 patients]) in the uneventful discharge group, 87% (211 patients) in the unplanned hospital admission group, and 77% (58 patients) in the unplanned ICU admission group. Unplanned hospital admissions and ICU admissions each showed higher rates of CAD, HTN, DM, TIA, and chronic obstructive pulmonary disease (COPD). Fifty-six percent (118,761 patients) of the entire cohort underwent GA alone, and 31% (66,061 patients) had procedures related to the digestive system. Significant differences in obesity were present between those uneventfully discharged and unplanned hospital admissions (31% [65,364 patients] *vs* 40% [96 patients], $P = 0.003$), but not for ICU admissions (31% [65,364 patients] *vs* 32% (24 patients), $P = 0.85$ (Table 1).

The final multivariable logistic regression model for unplanned admission consisted of age > 50 yr, ASA physical status, ASC facility, DM, COPD, TIA, anesthesia type, procedure type, and procedure group (Table 2). This model showed an increased risk of unplanned hospital admission associated with age > 50 yr old (odds ratio [OR], 1.53; 95% confidence interval [CI], 1.11 to 2.13), higher level of ASA physical status (III *vs* II: OR, 1.45; 95% CI, 1.06 to 1.99; IV *vs* II: OR, 1.88; 95% CI, 1.05 to 3.25), COPD (OR, 2.63; 95% CI, 1.65 to 4.03), DM (OR, 1.62; 95% CI, 1.15 to 2.27), TIA (OR, 2.48; 95% CI, 1.27 to 4.39), respiratory system CPT code *vs* other (OR, 2.92; 95% CI, 1.43 to 5.62), digestive system CPT code vs other (OR, 2.66; 95% CI, 1.72 to 4.18), musculoskeletal system CPT code *vs* other (OR, 2.53; 95% CI, 1.59 to 4.06), GA + peripheral nerve block *vs* GA alone (OR, 1.79; 95% CI, 1.16 to 2.75), and ASC facility (189BB: OR, 2.29; 95% CI, 1.50 to 3.46; 30E9A: OR, 7.41; 95% CI, 5.33 to 10.45; and BD21F: OR, 1.69; 95% CI, 1.04 to 2.68). The model showed reduced risk of unplanned hospital admission associated with MAC compared with GA alone (OR, 0.37; 95% CI, 0.23 to 0.58) (Table 2).

For unplanned ICU admission, because there were only 75 cases in the data set, we chose to include variables with $P < 0.05$ in the initial model, which included age > 50 yr, ASA physical status, ASC facility, CAD, HTN, DM, TIA, COPD, procedure type, and procedure group as variables. The final multivariable model for unplanned ICU admissions was reduced to seven covariates including ASC facility, ASA physical status, DM, COPD, anesthesia type, procedure type, and procedure group (Table 2). This model showed increased risk of unplanned ICU admission associated with higher levels of ASA physical status (III *vs* II: OR, 3.0; 95% CI, 1.72 to 5.32; = IV *vs* II: OR, 8.52; 95% CI, 3.93 to 18.13), musculoskeletal system CPT code *vs* other (OR, 2.45; 95% CI, 1.02 to 5.85), and ASC facility (00E6C: OR, 3.14; 95% CI, 1.55 to 6.08; 189BB: OR, 2.77; 95% CI, 1.45 to 5.23; 30E9A: OR, 2.59; 95% CI, 1.28 to 5.09; and BD21F: OR, 3.71; 95% CI, 2.08 to 6.55). The model showed reduced risk of unplanned ICU admission associated with MAC *vs* GA (OR, 0.37; 95% CI, 0.19 to 0.70), and by procedure group (outpatient vs endoscopy: OR, 0.26; 95% CI, 0.11 to 0.61) (Table 2**).** The effect sizes of all predictors in the final model for each outcome are depicted in Figs 2A and 2B.

Of the 211,389 patients in our cohort, there were 14 deaths (0.0066%) and 28 cardiac arrests (0.013%). Breaking down these figures, of the 211,147 patients that were not admitted to the hospital, there were 13 deaths (0.0062%) and 15 cardiac arrests (0.0071%) within 24 hr of the procedure. Of the 242 unplanned hospital admissions, there was one death (0.41%) and 13 cardiac arrests (5.37%), which included 75 ICU admissions with one death (1.33%) and ten cardiac arrests (13.33%).

Finally, for comparisons of patient characteristics and outcomes (unplanned admissions) in patients with missing *vs* non-missing CPT codes, unplanned hospital admission, ICU admission, and most of the study variables had a small SMD < 0.2, (i.e., minimal effect). Only ASC facility and anesthesia type showed larger differences; the "other" category of facility, GA with no nerve block, and MAC showed a moderate to large effect with SMD > 0.5 (Table 3).

Discussion

In this cohort of adult patients who underwent ASC procedures at a community-based facility, the number of unplanned hospital admissions was low (0.07%). Nevertheless, when unplanned admissions occurred in this setting, approximately one-third of these admissions were to the ICU. Patient-, procedure-, and anesthesia-related factors, and ASC facility were associated with an increased risk of unplanned hospital and ICU admissions. The incidence of death and cardiac arrest was substantially higher in patients with unplanned hospital and ICU admissions.

The incidence of unplanned hospital admissions we observed is lower than that reported in previous (albeit smaller) studies (0.3–9.5%) following surgery in hospital outpatient surgery departments.[6–17] In the 2010 National Hospital Ambulatory Medical Care Survey, which included 28.6 million ambulatory surgery visits to hospital outpatient surgery departments and ASCs, 2% of those with a discharge status were admitted to the hospital as an inpatient.[1] The present study consisted of procedures performed at freestanding outpatient surgery centres (ASCs) as distinguished from hospital-based centres (hospital outpatient surgery departments). Lower unanticipated hospital admissions associated with ASCs is likely secondary to patient selection bias—healthier patients with decreased comorbidity burden, as well as appropriate procedures specifically tailored to the surgical venue.[17]

While there were no intraoperative deaths in our cohort, unplanned hospital admission was associated with markedly increased rates of cardiac arrest and death. A majority of deaths (13/14), however, occurred in patients without unplanned hospital/ICU admissions. Given that there were no palliative surgeries, 13 of 14 deaths were presumably sudden arrests with death before the patient could reach the hospital. Our observation of 6.6 deaths / 100,000 cases (entire cohort) is about three-fold higher than the rate of two deaths/100,000 cases reported in other studies concerned with patients undergoing outpatient surgery in ASCs[27] and hospital outpatient surgery departments.[17,27] The diversity of surgical procedures and small number of deaths in these cohorts makes comparing mortality data and defining predictors of mortality difficult.[17]

In our cohort, approximately one-third of unplanned hospital admissions were admitted to the ICU, indicating the escalation of care that can be required when perioperative events occur. Perioperative emergencies extending beyond the resources available at the ASC must be identified immediately. Emergency care and transfer protocols must be in place and activated without hesitation. The evolving utilization of point-of-care-ultrasound may prove beneficial in these situations, providing early diagnosis and management while awaiting ICU transfer.[28–31] In our study, we did not anticipate that ASC surgical procedure *vs* endoscopy would be associated with a decreased incidence of ICU admission. The current investigation did not include subgroup analysis of the endoscopic procedures and specific risk factors therein.

In this study, facility appears to be at least as strong a predictor of admission as investigated patient- and/or procedure-specific variables are. Of the five predominant facilities evaluated in this study, two facilities showed approximately one- to ten-fold increased odds of hospital admission, and three showed approximately one- to eight-fold odds of ICU admission. Expanded analysis that accounted for the different patient- and procedure-specific variables, by facility, was beyond the scope of this study. Such a detailed analysis may help identify facility-specific modifiable risk factors associated with unplanned hospital admissions.

Our observation that age > 50 yr was associated with an increased risk of unplanned hospital admission should be considered in light of previous work showing an incremental increase in total, planned, and unplanned admission within 30 days after ambulatory surgery for each ten-year epoch in age beginning at age 50 yr.[17,32] Those data were collected from hospital outpatient surgery departments and ASCs, but facility was not considered. It is not surprising that advanced age increases hospital admission risk due to associated increases in disease burden. Nevertheless, age appears to be independently associated with an increased risk of unanticipated hospital admission after ambulatory surgery.[32] Elderly patients may be challenged by the fast paced nature of the outpatient setting, with brief healthcare provider encounters, rapid dissemination of postoperative care instructions, and potentially unrealistic expectations to engage in self-care.[32] In 2010, approximately one-third of ambulatory surgeries in the United States were performed in patients $\geq$ 65 yr,[1] and as this age group is projected to double in size by 2050, this proportion is likely to increase accordingly.[33]

Studies of surgical outcomes that stratify patients based on age may fail to address the association of impaired physiologic reserve with postoperative complications impacting quality of life.[34] Assessing frailty may offer a valuable tool to inform ambulatory surgery patient selection criteria and perioperative decision-making.[33,35] Frailty is a measure of decreased physiologic reserve, resulting from multiple organ system impairment that is distinguishable from the aging process and comorbidity.[34] Frailty has been associated with increased perioperative morbidity in common, low-risk ambulatory procedures—independent of age, type of anesthesia, and other comorbidities.[33] Importantly, frailty appears to be an important risk factor for unplanned readmission after hospital-based outpatient surgery.[35]

Similar to a previous report in adult patients,[36] OSA was not associated with an increased risk of unplanned hospital admission. This may reflect heightened screening processes, patient selection and/or perioperative initiatives in caring for OSA patients.[37] In the current study, patients prescribed continuous positive airway pressure (CPAP) devices were not differentiated from those not using such therapy. Obstructive sleep apnea patients require specific perioperative strategies to reduce the risk of postoperative respiratory compromise. There are evolving selection criteria and management strategies for OSA patients in the ambulatory setting, including having patients bring their CPAP machines on the day of surgery and using them postoperatively.[36,38–43]

Anesthesia type was associated with risk of unplanned hospital and ICU admissions. For example, MAC *vs* GA showed a decreased association with both hospital and ICU admission, while GA in combination with peripheral nerve block (PNB) was associated with an increased risk of unplanned hospitalization. With the former observation, this may reflect the minimal surgical trespass and risk associated with procedures typically performed under MAC. With the latter observation, this may be related to more invasive procedures, surgery extending beyond regional anesthetic coverage, or failed PNBs that required GA. In a study that involved outpatient surgery departments and ASCs, acute postoperative pain was one of the most common CPT and ICD-9 codes associated with unplanned ICU admissions.[23] In another study involving patients undergoing outpatient arthroscopic shoulder surgery, regional anesthesia compared with GA was shown to be associated with a decreased rate of hospital admission or emergency department visits.[44] Nevertheless, in our study, regional anesthesia was not associated with decreased or increased risk of unplanned hospitalization.

The following study limitations are acknowledged. The most important limitation is the inability of our data set to capture the reason for the unplanned hospital admission. Unplanned hospital admissions may be associated with medical (patient, anesthesia, surgery) and social factors.[22] Another limitation is that we could not account for unplanned admission to hospitals outside of the MEDNAX system. Finally, CPT codes had the highest rate of missing data (27%) among variables with missing data. Considering the large number of CPT codes in the cohort, imputation would not be reliable. Of note, we showed that the majority of variables are SMD < 0.2, which suggests that the impact of missing CPT codes on the results is likely to be small.

To conclude, in this retrospective cohort study of adult patients who underwent ASC procedures, a small percentage required unplanned hospital admission (0.07%) and approximately one-third of these admissions were to the ICU (0.04%). Patient-, procedure- and anesthesia-related factors, and ASC facility were associated with an increased risk of unplanned hospital and ICU admission. Facility was at least as strong a predictor of admission as the patient- and/or procedure-specific variables.

Author contributions *Y-JL* and *KR* contributed to all aspects of this manuscript, including study conception and design; acquisition, analysis, and interpretation of data; and drafting the article. *MSM* contributed to the analysis and interpretation of data and drafting the article. *RP*, *TH*, *WB*, *BT*, *SA*, and *MS-S*contributed to the conception and design of the study and to the acquisition of data. *Zhengxi Chen* and John Hunting contributed to the interpretation and analysis of data.

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