
Reports of Investigation

Adverse events in ambulatory surgery. A comparison between elderly and younger patients

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Purpose: An increasing number of elderly patients are undergoing ambulatory surgery. We examined whether ambulatory surgery carries a higher risk for the elderly than for younger patients.

Methods: A total of 17,638 consecutive ambulatory surgical patients were enrolled in a prospective cohort study during a three-year period. Preoperative, intraoperative, and postoperative information was collected. Twenty-seven percent of the enrolled patients were 65 yr or older. Incidence rates of intraoperative and postoperative adverse events among the elderly were compared with those among younger patients; we controlled for sex, ASA physical status, body mass index, type of surgery, and duration of procedure, using multiple logistic regression models.

Results: Elderly patients had a higher incidence of any intraoperative event (adjusted odds ratio, 1.4; 99.7% confidence interval [CI], 1.0-2.0) and of intraoperative cardiovascular events (adjusted odds ratio, 2.0; 99.7% CI, 1.3-3.0). They also had a lower incidence of any postoperative event (adjusted odds ratio, 0.4; 99.7% CI, 0.3-0.6) and of postoperative pain (adjusted odds ratio, 0.2; 99.7% CI, 0.1-0.4), nausea and vomiting (adjusted odds ratio, 0.3; 99.7% CI, 0.1-0.6), and dizziness (adjusted odds ratio, 0.4; 99.7% CI, 0.2-1.0).

Conclusion: The risks reported do not constitute a contraindication for elderly patients to undergo ambulatory surgery but this population may require more careful intraoperative cardiovascular management.

Objectif : Un nombre croissant de patients âgés se retrouvent en chirurgie ambulatoire. Nous avons cherché à savoir si la chirurgie ambulatoire comporte un plus grand risque pour les gens âgés comparés aux jeunes patients.

Méthode : Ce sont 17 638 patients qui se sont présentés successivement en chirurgie ambulatoire qui ont été recrutés pour une étude comparative des cohortes qui a duré trois ans. On a recueilli les renseignements préopératoires, peropératoires et postopératoires nécessaires. Parmi les patients choisis, 27 % avaient 65 ans ou plus. On a comparé l'incidence des effets secondaires peropératoires et postopératoires entre les patients âgés et les jeunes patients selon le sexe, l'état physique ASA, l'indice de masse corporelle, le type de chirurgie et la durée de l'opération, en utilisant des modèles de régression logistique multiple.

Résultats : Les patients âgés présentaient une plus forte incidence de tout événement peropératoire (coefficient de risque ajusté, 1,4 ; intervalle de confiance de 99,7 % [IC], 1,0 - 2,0) et d'incidents cardiovasculaires peropératoires (CR ajusté, 2,0 ; IC de 99,7 % , 1,3 - 3,0). Ils présentaient, par ailleurs, une plus faible incidence de tout événement postopératoire (CR ajusté, 0,4 ; IC de 99,7 % , 0,3 - 0,6) et de douleur (CR ajusté, 0,2 ; IC de 99,7 % , 0,1 - 0,4), de nausées et de vomissements (CR ajusté, 0,3 ; IC de 99,7 % , 0,1 - 0,6), et d'étourdissement postopératoires (CR ajusté, 0,4 ; IC de 99,7 % , 0,2 - 1,0).

Conclusion : Les risques rapportés ne constituent pas une contre-indication à la chirurgie ambulatoire pour les gens âgés, mais cette population demande qu'on soit plus attentif aux risques cardiovasculaires peropératoires.

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IN the last decade, there has been a considerable increase in the proportion of surgical procedures performed in ambulatory settings.^{1,2} The growing popularity of ambulatory surgery is primarily explained by its substantial cost saving. However, its safety, convenience, and wide acceptance by both patients and health care providers are also important factors.³ Owing to the aging of society, and the development of safer surgical and anesthetic techniques, older and more debilitated patients are now undergoing ambulatory surgery.^{4,5} Despite this continuing trend, there is a scarcity of literature on ambulatory surgery in the elderly.^{6,7}

Traditionally, the incidence rates of mortality, major morbidity, delayed discharge, and unanticipated admission are considered the measures of quality of care in ambulatory anesthesia.⁸⁻¹⁴ Recently, less serious, non-life-threatening adverse events, such as postoperative pain, nausea and vomiting, drowsiness, and dizziness, have been shown to be predictors for unanticipated hospital admissions, patient satisfaction, and level of postoperative functioning.^{12,14,15} However, few studies have dealt with the incidence of adverse intraoperative and postoperative symptoms among elderly ambulatory surgical patients.¹⁶

We conducted a concurrent cohort study over a three-year period. The goals were, first, to characterize the population undergoing ambulatory surgery and anesthesia in a major Canadian tertiary care facility and to ascertain the incidence of unanticipated intraoperative and postoperative adverse events, and, second, to determine whether old age (≥ 65 yr) was a risk factor for experiencing adverse events during or immediately after ambulatory surgery.

Methods

Patient population

With the approval of our institutional ethics committee, a prospective, observational study was conducted over a three-year period. Data were collected on 17,877 consecutive ambulatory surgical patients in the Ambulatory Surgery Unit of the Toronto Western Hospital. Since this was an observational study with no deviation from standard care, the ethics committee did not require written consent from patients before data collection. Two hundred and thirty-nine patients were eventually excluded because of canceled surgery or missing data.

Data collection

The attending anesthesiologists completed specifically designed anesthesia records for each patient. These records included information on patient characteris-

tics, such as age, sex, weight, height, American Society of Anesthesiology (ASA) status, preexisting medical conditions, type of surgical procedure, duration and type of anesthesia, physiological variables, and drugs given. The clinical management of the patients was left to the discretion of the anesthesiologist.

Intraoperative adverse events, i.e., those occurring in the operating room (OR), were also documented by the anesthesiologists on a standardized event sheet. The event sheet contained a list of adverse events accompanied by their concise definitions (Appendix I).

Postoperative adverse outcomes occurring during the patients' stay in the Postanesthesia Care Unit (PACU) and in the Ambulatory Surgical Unit (ASU) were documented by trained nursing staff on standardized event sheets. The PACU and ASU event sheets contained a list of adverse events accompanied by their concise definitions (Appendices II, III).

Length of stay and the type and amount of medication given in the PACU and the ASU were also documented. Patients were discharged when they achieved a score of 9 or 10 in the Postanesthetic Discharge Scoring System.^{18,19} Patient records and event sheets were systematically reviewed and checked for completeness and consistency on the next day by a research assistant and an experienced anesthesiologist. The data were coded and entered into the database by using a customized data entry program. Before analysis, the database was randomly screened for data entry errors. Range checks, time checks, and logic checks were incorporated in the program to ensure accurate data entry.

Statistical Analysis

Descriptive statistics of the baseline characteristics (age, sex, body mass index, ASA status, type of surgery, type and duration of anesthesia, length of stay in PACU and ASU) were calculated and compared between the elderly (≥ 65 yr) and younger (< 65 yr) patients. Student's *t* test was used for continuous variables and the Chi-square test for categorical variables.

Incidence rates of the intraoperative and postoperative adverse events (number of events per 100 operations) among the elderly and among the younger patients were computed after the events were grouped as cardiovascular, respiratory or intubation related, technical, and other events in the OR; excessive pain, nausea and vomiting, central nervous system (CNS) related, cardiovascular, respiratory, and other events in the PACU; and nausea and vomiting, pain and aches, dizziness, drowsiness, cardiovascular, and other events in the ASU.

To determine whether the elderly population differed from patients < 65 yr in the risk of experiencing

the various intraoperative and postoperative adverse events, we first plotted the crude frequencies of OR, PACU, and ASU events in the two age groups, categorized by surgical subspecialty. To adjust for the effect of confounding variables, we then calculated odds ratios by multiple logistic regression models to compare the odds of the various outcomes occurring among the elderly and among patients < 65 yr.

The following 18 groups of adverse events were selected as dependent variables: the occurrence of any adverse event in the OR and of cardiovascular events, respiratory events, and intubation-related events in the OR; the occurrence of any adverse event in the PACU and of cardiovascular events, respiratory events, pain, nausea and vomiting, drowsiness, excessive agitation, and shivering or hypothermia in the PACU; and the occurrence of any adverse event in the ASU and of cardiovascular events, pain or aches, nausea and vomiting, drowsiness, and dizziness in the ASU.

TABLE I Characteristics of Patients and Procedures

	<i>Patients < 65 yr (n=12,852)</i>	<i>Patients ≥ 65 yr (n=4,786)</i>	<i>Total (n=17,638)</i>
Age, yr *	36 ± 13	76 ± 7	47 ± 21
Body mass index, kg·m ⁻²	25 ± 5	26 ± 5	25 ± 5
Sex, % *			
Female	69.3	61.0	67.0
Male	30.7	39.0	33.0
ASA status, % *			
I	68.1	9.3	52.1
II	29.7	72.9	41.4
III	2.3	17.7	6.5
Surgery duration, min *	49 ± 49	61 ± 26	52 ± 44
PACU duration, min *	51 ± 25	47 ± 28	51 ± 26
ASU duration, min *	101 ± 60	91 ± 43	98 ± 56
Type of anesthesia, % *			
General	75.5	8.5	57.3
Monitored anesthesia care	16.9	86.4	35.7
Local	3.6	2.6	3.3
Regional	3.0	2.0	2.7
Chronic pain block	1.0	0.5	0.9
Type of surgery, % *			
Ophthalmic	17.8	85.4	36.2
Gynecological	46.0	0.9	33.8
Orthopedic	22.6	5.7	18.0
Plastic	4.0	2.4	3.6
Neurosurgery	3.0	2.1	2.7
General	2.8	0.9	2.3
ENT/dental	1.6	0.5	1.3
Urological	1.2	1.7	1.3
Chronic pain block	1.0	0.5	0.9

Values are expressed as mean ± SD where appropriate.

* *P* < 0.001 when comparing patients < 65 vs patients ≥ 65.

For each of these 18 outcomes, a logistic regression model was fitted (i.e., we had 18 different regression models), with age (≥ 65 yr vs < 65 yr) as the primary independent variable. To control for possible bias, we included potential confounding variables (sex, ASA status, body mass index, and duration and type of surgery) in the models. Body mass index and duration of surgery were entered in the model as continuous variables and sex as a dichotomous variable. ASA status was represented with two dummy variables, referencing to ASA class I (there were only class I, II, and III patients in our study), and type of surgery, grouped into nine distinct categories, was represented with eight dummy variables. Type of anesthesia was not controlled for in the analysis, since the chosen anesthetic technique was completely dependent on the type of surgery. Indeed, after repeating the analysis and including variables representing the type of anesthesia instead of the type of surgery in the above models, the results obtained were similar to those reported here. The odds ratios, 99.7% confidence intervals, and corresponding *P* values are presented. Since there were 18 different models, only *P* values ≤ 0.003 were considered significant.

To underline the importance of the intraoperative and postoperative adverse events, we also calculated two major outcome indices of ambulatory surgery, i.e., length of postoperative stay and frequency of unanticipated hospital admission, for groups of patients with different adverse events. All analyses were carried out using SAS (version 6.12) software.

Results

Characteristics of the patients and the procedures

Of the 17,877 subjects originally enrolled in the study, 153 were excluded because of missing data and 86 were excluded because their scheduled surgery was canceled. Thirty-three of the cancellations were due to medical reasons, 20 to surgical reasons, and 33 to other reasons. Characteristics of the remaining 17,638 patients and the procedures undergone are listed in Table I.

Patients < 65 yr were generally healthier. They were more likely to be ASA status I (68%), whereas most of the older patients were ASA status II (73%). There were also major differences in the frequency of the types of surgery and anesthesia undertaken by the two age groups. Among the younger patients, gynecological (46%), orthopedic (23%), and ophthalmic (18%) procedures dominated, whereas 85% of the elderly patients underwent ophthalmic procedures. Correspondingly, general anesthesia was the most common anesthetic technique (76%) in the younger

TABLE II Incidence of Adverse Events in the OR

Type of Adverse Event	No. of Events	Rate per 100 Operations	No. of Events	Rate per 100 Operations	No. of Events	Rate per 100 Operations
	Patients < 65 yr (n=12,852)		Patients ≥ 65 yr (n=4,786)		Total (n=17,638)	
<i>Cardiovascular</i>	173	1.35	335	6.99	508	2.88
Hypertension	50	0.39	236	4.93	286	1.62
Hypotension	46	0.36	23	0.48	69	0.39
Bradycardia	58	0.45	19	0.40	77	0.44
Dysrhythmia	10	0.08	50	1.04	60	0.34
Tachycardia	8	0.06	7	0.15	15	0.09
Hypovolemia	1	0.01	0	0.00	1	0.006
<i>Respiratory</i>	79	0.61	7	0.15	86	0.49
Laryngospasm/stridor	27	0.21	1	0.02	28	0.16
Desaturation	22	0.17	3	0.06	25	0.14
Bronchospasm	23	0.18	0	0.00	23	0.13
Apnea	2	0.02	3	0.06	5	0.03
Aspiration	3	0.02	0	0.00	3	0.02
High airway pressure	1	0.01	0	0.00	1	0.006
Pneumothorax	1	0.01	0	0.00	1	0.006
<i>Intubation related</i>	36	0.28	8	0.17	44	0.25
Difficult intubation	26	0.20	6	0.13	32	0.18
Unplanned intubation	7	0.05	1	0.02	8	0.05
Esophageal intubation	1	0.01	1	0.02	2	0.01
Unintentional extubation	1	0.01	0	0.00	1	0.006
Dental damage	1	0.01	0	0.00	1	0.006
<i>Technical problems</i>	25	0.19	8	0.17	33	0.19
Nerve block failed	12	0.09	4	0.08	16	0.09
Difficult vein access	8	0.06	1	0.02	9	0.05
Epidural abandoned	3	0.02	0	0.00	3	0.02
Automatic blood pressure problems*	0	0.00	2	0.04	2	0.01
Nerve block abandoned	1	0.01	0	0.00	1	0.006
Intravenous block abandoned	0	0.00	1	0.02	1	0.006
Oximeter not working†	1	0.01	0	0.00	1	0.006
<i>Nausea, vomiting</i>	7	0.05	0	0.00	7	0.04
<i>Other†</i>	16	0.12	3	0.06	19	0.11
Total	336	2.61	361	7.54	697	3.95

* Equipment problems, patients were not affected.

† Other events: allergic skin symptoms (4 cases), cough (4), awareness/restlessness (3), excessive bleeding (2), muscle rigidity (1), anaphylaxis (1), excessive preoperative sedation (1), excessive preoperative agitation (1), excessive pain in patient with monitored anesthesia care (1), dysphoria (1).

patient group, and monitored anesthesia care (86%) among the elderly patients.

On average, the elderly patients spent a longer time undergoing surgery (61 vs 49 min, $P < 0.001$) and a shorter time in the PACU (47 vs 51 min, $P < 0.001$) and in the ASU (91 vs 101 min, $P < 0.001$) than did younger patients. The elderly patients had a somewhat higher mean body mass index, and there were fewer female patients in the older group.

Incidence of intraoperative and postoperative events

In the OR, 599 patients (3.4%) experienced 697 intraoperative events, or 4.0 events per 100 operations. Cardiovascular events were the most frequent, accounting for 73% of all OR events, followed by respiratory events (12%), intubation-related events (6.3%), and technical problems (4.7%) (Table II). Overall, the crude rate of intraoperative events was about three times higher among the elderly than

TABLE III Incidence of Adverse Events in the PACU

Type of Adverse Event	No. of Events	Rate per 100 Operations	No. of Events	Rate per 100 Operations	No. of Events	Rate per 100 Operations
	Patients < 65 yr (n=12,852)		Patients ≥ 65 yr (n=4,786)		Total (n=17,638)	
<i>Excessive pain</i>	807	6.27	29	0.61	836	4.73
<i>Nausea, vomiting</i>	352	2.73	33	0.69	385	2.18
Requiring antiemetics	312	2.42	30	0.63	342	1.94
Requiring no treatment	40	0.31	3	0.06	43	0.24
<i>CNS problems</i>	276	2.15	16	0.33	292	1.65
Shivering/hypothermia	145	1.13	7	0.15	152	0.86
Drowsiness/sleepiness	72	0.56	6	0.13	78	0.44
Excessive agitation	51	0.40	2	0.04	53	0.30
Other*	8	0.06	1	0.02	9	0.05
<i>Cardiovascular</i>	53	0.41	51	1.06	104	0.59
Hypertension	6	0.05	28	0.58	34	0.19
Hypotension	13	0.10	3	0.06	16	0.09
Bradycardia	18	0.14	8	0.17	26	0.15
Dysrhythmia	9	0.07	4	0.08	13	0.07
Tachycardia	4	0.03	1	0.02	5	0.03
Ischemia	2	0.02	6	0.13	8	0.05
Myocardial infarction	0	0.00	1	0.02	1	0.006
Hypovolemia	1	0.01	0	0.00	1	0.006
<i>Respiratory</i>	49	0.38	16	0.33	65	0.37
Desaturation	28	0.22	9	0.19	37	0.21
Bronchospasm	10	0.08	3	0.06	13	0.07
Upper airway problem	7	0.05	0	0.00	7	0.04
Pneumothorax	0	0.00	1	0.02	1	0.006
Hypoventilation	1	0.01	0	0.00	1	0.006
Pulmonary edema	0	0.00	2	0.04	2	0.01
Relaxant problem	3	0.02	1	0.02	4	0.02
<i>Excessive bleeding</i>	8	0.06	2	0.04	10	0.06
<i>Other†</i>	7	0.05	2	0.04	9	0.05
Total	1,552	12.07	149	3.11	1,701	9.64

* Other CNS problems: sensory deficit (4 cases), seizure (3), confusion (2).

† Other events: hyperglycaemia (3 cases), intravenous interstitial (2), hematuria (1), anaphylaxis (1), epistaxis (1), skin injury (1).

among the younger patients. This was mainly due to an occurrence of cardiovascular events, which were five times more frequent among older patients. Respiratory and intubation-related events were more frequent among younger patients.

In the PACU, 1,531 patients (8.7%) experienced 1,701 events, or 9.6 events per 100 operations. Excessive pain was the most frequent event (49%), followed by nausea and vomiting (23%) and CNS-related events (17%) (Table III). Cardiovascular and respiratory events were less common in the PACU than in the OR. In the PACU, younger patients experienced a four-fold increase in adverse events compared to elderly patients; they had about a 10-fold higher rate of excessive pain, shivering, and excessive agitation. The frequency of nausea and vomiting and

drowsiness was also about four-fold higher among younger patients. The crude rate of cardiovascular events, however, was more than two-fold higher among the elderly.

In the ASU, 1,051 patients (6.0%) experienced 1,386 events, or 7.9 events per 100 operations. Nausea and vomiting dominated, accounting for 49% of all ASU events, followed by pain and aches (24%), dizziness (17%), drowsiness (3.5%), and cardiovascular events (1.8%) (Table IV). In the ASU, younger patients had a two- to four-fold increase in the occurrence of all types of adverse events, except cardiovascular events, which occurred about three times more frequently among the elderly.

Two hundred and eighteen patients (1.2%) were admitted to hospital.¹² During the study period, no

TABLE IV Incidence of Adverse Events in the ASU

Type of Adverse Event	No. of Events	Rate per 100 Operations	No. of Events	Rate per 100 Operations	No. of Events	Rate per 100 Operations
	Patients < 65 yr (n=12,852)		Patients ≥ 65 yr (n=4,786)		Total (n=17,638)	
<i>Nausea, vomiting</i>	622	4.83	63	1.31	685	3.88
Requiring treatment	342	2.66	37	0.77	379	2.15
Requiring admission	42	0.33	6	0.13	48	0.27
Requiring no treatment	238	1.85	20	0.42	258	1.46
<i>Pain, aches</i>	285	2.21	50	1.04	35	1.90
Requiring treatment	159	1.24	23	0.48	182	1.03
Requiring admission	33	0.26	1	0.02	34	0.19
Headache	71	0.55	24	0.50	95	0.54
Sore throat	14	0.11	1	0.02	15	0.09
Muscle ache	8	0.06	1	0.02	9	0.05
<i>Dizziness</i>	214	1.66	18	0.38	232	1.31
Requiring treatment	16	0.12	0	0.00	16	0.09
Requiring admission	6	0.05	1	0.02	7	0.04
Requiring bed rest	33	0.26	4	0.08	37	0.21
Requiring no treatment	159	1.24	13	0.27	172	0.97
<i>Drowsiness</i>	47	0.37	2	0.04	49	0.28
Requiring admission	2	0.02	1	0.02	3	0.02
Requiring no treatment	45	0.35	1	0.02	46	0.26
<i>Cardiovascular</i>	12	0.09	13	0.27	25	0.14
Hypertension	1	0.01	11	0.23	12	0.07
Hypotension	11	0.09	1	0.02	12	0.07
Dysrhythmia	0	0.00	1	0.02	1	0.006
<i>Excessive bleeding</i>	12	0.09	4	0.08	16	0.09
<i>Other*</i>	32	0.25	12	0.25	44	0.25
Total	1,224	9.52	162	3.38	1,386	7.85

* Other events: chills/fever (15 cases), inability to void (9), excessive agitation (8), hyperglycemia (3), allergic skin symptoms (3), cough (1), diarrhea (1), hematuria (1), hematoma at iv site (1), seizure (1), pneumothorax (1).

deaths, cardiac arrest or stroke occurred among the patients. In one case, myocardial infarction was diagnosed postoperatively, and one patient was admitted to the Intensive Care Unit for treatment of lidocaine toxicity and hand ischemia, which developed after a failed tourniquet block.

When we examined the frequency of any OR, PACU, or ASU event by age group, a clear pattern was identified (Figure 1). Except in the oldest age group, the frequency of OR events monotonically increased with increasing age, from 1.4% among patients younger than 21 yr to 9.6% among patients 81-90 yr of age. In contrast, the frequency of postoperative events, although increasing minimally with age among the younger patients, decreased linearly with age after age 40 in both the PACU and the ASU.

The frequency of cardiovascular events showed a similar monotonic increase with age in the OR, PACU, and ASU (Figure 2). The only difference was

in the magnitude of frequency, which was highest in the OR and lowest in the ASU. The frequency of respiratory events did not show a clear pattern, either in the OR or in the PACU. Postoperative pain and nausea and vomiting were more frequent among younger patients, showing a decreased frequency in the older age groups in both the PACU and the ASU.

The incidence of any intraoperative adverse event was uniformly higher among the elderly patients in all types of surgery, except general surgery. In contrast, the incidence of any postoperative event in both the PACU and the ASU was consistently lower among the elderly patients, except for those receiving chronic pain block (Figure 3).

We adjusted for the effects of various confounding variables by using multiple logistic regression. After controlling for the effects of sex, ASA status, body mass index, type of surgery, and duration of procedure, the elderly were overall more likely to develop

TABLE V Adjusted Odds Ratios of Different Types of Adverse Events Comparing Elderly Patients to Patients Younger Than 65 Years of Age*

Type of Adverse Event	Odds Ratio	99.7% CI	P value
<i>OR</i>			
Any event	1.42	1.00 - 2.00	0.003
Cardiovascular event	1.96	1.29 - 2.97	0.0001
Respiratory event	0.25	0.01 - 7.83	0.004
Intubation related event	0.86	0.19 - 3.95	0.776
<i>PACU</i>			
Any event	0.43	0.30 - 0.60	0.0001
Cardiovascular event	1.75	0.73 - 4.20	0.060
Respiratory event	0.61	0.18 - 2.10	0.239
Pain	0.23	0.13 - 0.44	0.0001
Nausea and vomiting	0.28	0.14 - 0.56	0.0001
Drowsiness	0.37	0.07 - 1.98	0.077
Excessive agitation	0.22	0.02 - 2.50	0.063
Shivering, hypothermia	0.55	0.15 - 2.06	0.182
<i>ASU</i>			
Any event	0.36	0.25 - 0.51	0.0001
Cardiovascular event	2.34	0.41 - 13.5	0.149
Pain	0.39	0.21 - 0.70	0.0001
Nausea and vomiting	0.23	0.13 - 0.40	0.0001
Drowsiness	0.17	0.02 - 1.90	0.030
Dizziness	0.38	0.15 - 0.95	0.002
Any event in OR, PACU, or ASU	0.61	0.50 - 0.76	0.0001

* Adjusted for sex, ASA status, body mass index, type of surgery, and duration of procedure.

an event in the OR (adjusted odds ratio, 1.4) (Table V). The risk of experiencing an intraoperative cardiovascular event was about twice as high among the elderly as in the younger age group (adjusted odds ratio, 2.0). In contrast, the elderly were less likely to suffer from adverse events related to the respiratory system, although the difference was not significant. There was no association observed between old age and intubation-related events.

In the PACU, the elderly were less likely to develop any adverse event (adjusted odds ratio, 0.43). Compared with younger patients, they were much less likely to suffer from pain (adjusted odds ratio, 0.23) and nausea and vomiting (adjusted odds ratio, 0.28). Although the estimated adjusted odds ratio for cardiovascular events in the PACU showed a higher risk among the elderly, it did not reach significance. The odds for all other adverse events in the PACU were lower among the elderly, although none was significant.

In the ASU, the elderly were less likely to develop any adverse event (adjusted odds ratio, 0.36). Nausea and vomiting, dizziness, and pain were less frequent in the ASU among the elderly (adjusted odds ratios, 0.23, 0.38, and 0.39, respectively). The estimated adjusted odds ratio for experiencing a cardiovascular event in the ASU showed a higher risk among the elderly but it was not significant.

Considering the occurrence of any intraoperative and postoperative events together, 17% of the younger patients experienced at least one intraoperative or postoperative adverse event (2,205 from 12,852), while only 10% of the elderly population suffered from at least one intraoperative or postoperative adverse event (486 from 4,786). The result of the multiple logistic model showed, that, overall, the elderly were about 40% less likely to develop any intraoperative or postoperative event related to ambulatory surgery (adjusted odds ratio 0.6).

Patients who experienced any of the intraoperative or postoperative adverse events stayed 13 to 108 min longer in the hospital, on average, than did patients without those events (Table VI). Similarly, patients experiencing adverse events had a 2- to 60-fold increased risk of being admitted to the hospital after surgery. The postoperative duration of stay was longest among patients who suffered from drowsiness, nausea and vomiting, or dizziness in the ASU and among patients who experienced excessive postoperative bleeding. The rate of unanticipated admission was highest among patients with excessive bleeding, followed by patients suffering from intraoperative or postoperative respiratory events, postoperative cardiovascular events (both PACU and ASU), or excessive pain or drowsiness in the ASU.

TABLE VI Duration of Postoperative Stay and Frequency of Admission among Patients with Different Intraoperative and Postoperative Adverse Events

Type of Adverse Event	Duration of Stay (min)*		P value	Frequency of Hospital Admission (%)		P value
	With Event	Without Event		With Event	Without Event	
OR						
Any event	154 ± 80	133 ± 68	0.0001	5.7	1.1	0.0001
Cardiovascular event	147 ± 80	134 ± 68	0.0006	4.6	1.2	0.0001
Respiratory event	180 ± 84	134 ± 69	0.0001	13.5	1.2	0.0001
Intubation-related event	191 ± 77	134 ± 69	0.0001	7.1	1.2	0.015
PACU						
Any event	202 ± 78	128 ± 64	0.0001	6.7	0.7	0.0001
Cardiovascular event	193 ± 80	134 ± 69	0.0001	15.6	1.2	0.0001
Respiratory event	224 ± 99	134 ± 68	0.0001	16.4	1.2	0.0001
Excessive pain	208 ± 73	130 ± 66	0.0001	6.0	1.0	0.0001
Nausea and vomiting	212 ± 91	132 ± 67	0.0001	6.1	1.1	0.0001
Drowsiness	184 ± 91	134 ± 68	0.0001	2.6	1.2	0.25
Excessive agitation	177 ± 62	134 ± 69	0.0001	3.8	1.2	0.14
Shivering	192 ± 73	133 ± 68	0.0001	8.6	1.2	0.0001
ASU						
Any event	220 ± 92	128 ± 63	0.0001	9.1	0.7	0.0001
Cardiovascular event	215 ± 104	134 ± 69	0.0007	12.0	1.2	0.0035
Excessive pain	209 ± 99	133 ± 67	0.0001	11.3	1.1	0.0001
Nausea and vomiting	239 ± 89	131 ± 65	0.0001	8.3	1.0	0.0001
Drowsiness	238 ± 98	134 ± 68	0.0001	14.6	1.2	0.0001
Dizziness	227 ± 90	133 ± 68	0.0001	7.4	1.2	0.0001
Excessive bleeding	241 ± 82	134 ± 69	0.0001	68.4	1.2	0.0001
Any OR, PACU, ASU event	191 ± 83	124 ± 60	0.0001	5.7	0.4	0.0001
Total	134 ± 69			1.2		

* Values are expressed as mean ± SD.

Discussion

This study on 17,638 ambulatory surgical patients showed that the incidence of adverse events was low: 4.0% in the OR and 9.6% and 7.9% in the PACU and the ASU, respectively. The published incidence rates of intraoperative and postoperative adverse events vary extensively. In a previous study of 6,914 ambulatory surgical patients in four Canadian centres, the incidence rates of intraoperative and postoperative adverse events were similar.¹⁶ However, in a study from Finland, the rates of intraoperative events (hypotension, 16%, and bradycardia, 14%) were much higher than in our study (0.39% and 0.44%, respectively).¹⁷ On the other hand, there was a lower rate of intraoperative events and a higher rate of postoperative pain and nausea and vomiting in an Australian study.²⁰ This wide variation could represent real differences due to different characteristics of patients, surgical procedures, and anesthetic techniques, or could be a result of different definitions used in these studies.

The results of our study, showing that 27% of the ambulatory patients were 65 yr or older, reflect the generally observed trend that, with the improvement of surgical and anesthetic techniques, more elderly patients are undergoing ambulatory surgery.^{5,7,9,16,20,21} One of the frequently mentioned advantages of ambulatory surgery is that it allows patients to return to their regular lifestyle and environment immediately. At an older age, when the ability to adapt to new situations is decreased, it is important to avoid separation from the usual environment and to prevent disruption of normal daily routines caused by a hospital admission.

The distributions of the type of surgery and the type of anesthesia were different between the elderly and the younger patient populations. As a result of these differences in the types of procedures between the two groups, the comparison of the observed (unadjusted) rates of adverse events between the elderly and younger populations are confounded, therefore, we cannot draw clear conclusions based

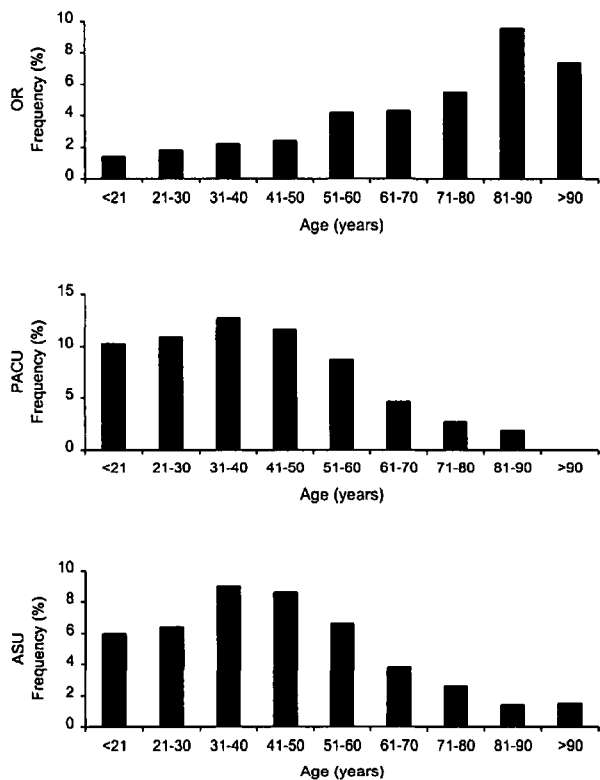


FIGURE 1 Frequency of intraoperative and postoperative adverse events by age group.

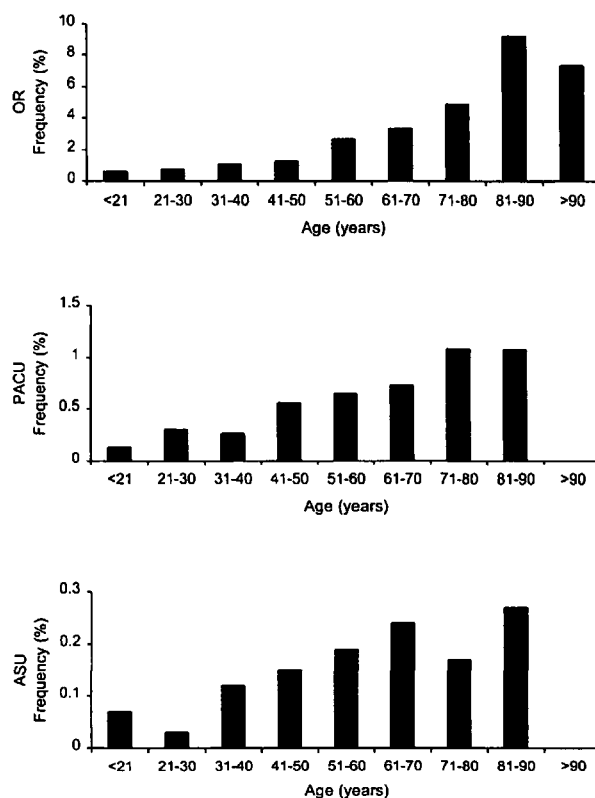


FIGURE 2 Frequency of intraoperative and postoperative cardiovascular adverse events by age group.

these unadjusted rates alone. It was also necessary to make an adjusted comparison between these two groups using multiple logistic regression. Multiple logistic regression is a statistical technique, which is used to control for the different distributions of potentially confounding variables between the compared groups.

Our initial data exploration showed that increasing age was associated with an increasing frequency of intraoperative adverse events and a decreasing frequency of postoperative adverse events. These opposing trends could be explained by the following reasons. Cardiovascular events were the most frequent intraoperative events, which were more prevalent among the elderly, whereas pain and nausea and vomiting were the most frequent postoperative events, which occurred more frequently among younger patients. Furthermore, the younger population tended to undergo mainly gynecological and orthopedic procedures, which frequently caused postoperative pain, whereas the elderly mostly underwent ophthalmic procedures, which caused minimal postopera-

tive pain. The use of opioids associated with the treatment of postoperative pain also induced postoperative nausea and vomiting, which partly explained why the younger population had a higher incidence of postoperative events. These findings reflected the dominant effect of postoperative pain and pain management on postoperative events.

We controlled for the various types of surgery by comparing the incidence of perioperative adverse events in the younger population and the elderly within the particular surgical subspecialties. Again, the elderly had a higher incidence of intraoperative events, whereas the younger population had a higher incidence of postoperative events.

Perioperative adverse events occurred with different frequencies in different procedures. The incidence of intraoperative adverse events among elderly patients was higher in ENT/dental, urological, orthopedic, and ophthalmic surgery. The frequency of adverse events is expected to be higher with the most intensive operative trauma. In this study, however, the type of surgery was coded by subspecialty, rather than by spe-

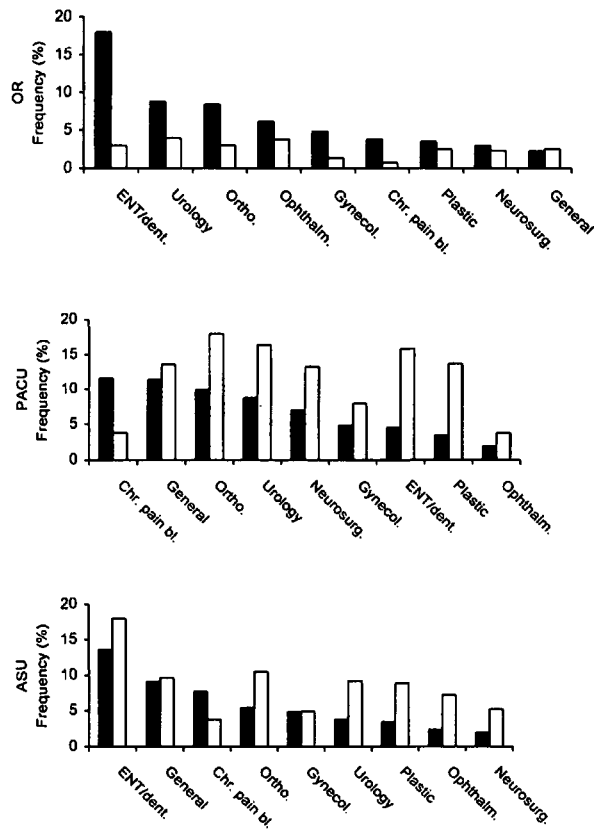


FIGURE 3 Frequency of intraoperative and postoperative adverse events by age in different types of surgery. (Solid bars: patients 65 yr and older; open bars: patients under 65 yr.)

cific surgical procedure. Despite the large sample size, coding by specific procedures would have resulted in extremely sparse data, preventing meaningful analysis. In addition, 85% of the elderly patients in this study underwent ophthalmic surgery, resulting in a very small number of events in the other surgical categories. More patients are needed to measure the incidence of perioperative adverse events in elderly patients undergoing nonophthalmic surgery, and to allow multivariable modeling in determining the role of surgery with regard to perioperative adverse events in the elderly.

The multiple logistic regression models showed that elderly patients, when compared with younger patients, had a higher risk of intraoperative adverse events (odds ratio, 1.4), which was due mainly to the increase in cardiovascular events. The elderly had a lower risk of postoperative adverse events in the PACU (odds ratio, 0.43) and in the ASU (odds ratio, 0.36), which was mostly associated with their lower frequency of suffering from nausea and vomiting and

excessive pain. Elderly patients were, numerically, at higher risk of cardiovascular events than were younger patients in the PACU and the ASU, but the difference was not significant, which may be due to the relatively small number of cardiovascular events in the PACU and the ASU.

The risk of cardiovascular adverse events increased with age. Increased age is associated with the presence of additional cardiovascular risk factors, such as hypertension, ischemic heart disease, lower cardiopulmonary reserve, and compensatory capacity. Our results demonstrated a significant trend of increasing frequency of intraoperative cardiovascular events with increasing age. The frequency of postoperative cardiovascular events showed similar pattern by age, however, it did not reach statistical significance.

The lower risk of all other intraoperative and postoperative events among older patients is more difficult to understand. It is possible that the elderly are more tolerant to stimuli causing pain, nausea and vomiting, or dizziness. Furthermore, there may be a differential underestimation of the rate of some postoperative adverse events in elderly patients. This could be attributed to the elderly patients' reluctance to complain or to a discrepancy between the patients' perception and the objective assessment by health care providers.

Did the occurrence of intraoperative and postoperative adverse events affect the outcomes of these ambulatory surgical patients? Our comparisons showed that the intraoperative and postoperative adverse events were associated with a longer duration of postoperative stay and a higher rate of unanticipated hospital admission after surgery. Therefore, minimizing or preventing intraoperative and postoperative adverse events can reduce the duration of postoperative stay and decrease the rate of unanticipated hospital admissions.

In summary, the incidence of intraoperative adverse events, which were mainly cardiovascular events, and postoperative events, predominantly pain and nausea and vomiting, was moderately low. Elderly patients had a higher risk of cardiovascular events but a lower risk of all other adverse events, both intraoperatively and postoperatively. The borderline increase in the risk of any intraoperative event (odds ratio, 1.4) and the twofold increase in the risk of intraoperative cardiovascular events does not constitute a contraindication for the elderly to undergo ambulatory surgery. However, the increase in intraoperative risk indicates the need for careful intraoperative cardiovascular management of elderly patients.

References

- 1 *White PF*. Ambulatory anesthesia and surgery: past, present and future. *In: White PF (Ed.). Ambulatory Anesthesia and Surgery*. London: WB Saunders, 1997: 3–34.
- 2 *Korttila K*. Recovery from outpatient anaesthesia. Factors affecting outcome. *Anaesthesia* 1995; 50 (Suppl): 22–8.
- 3 *Henderson JA*. Ambulatory surgery: past, present, and future. *In: Wetchler BV (Ed.). Anesthesia for Ambulatory Surgery*. Philadelphia: Lippincott Co., 1991: 1–27.
- 4 *Weintraub HD, Kekoler LJ*. Demographics of aging. *In: McLeskey CH (Ed.). Geriatric Anesthesiology*. Baltimore: Williams and Wilkins, 1997: 3–11.
- 5 *Bouré B, White PF*. Outpatient anesthesia for geriatric patients. *In: McLeskey CH (Ed.). Geriatric Anesthesiology*. Baltimore: Williams and Wilkins, 1997: 441–57.
- 6 *Warner MA, Hosking MP, Lobdell CM, Offord KP, Melton LJ III*. Surgical procedures among those \geq 90 years of age. *Ann Surg* 1988; 207: 380–6.
- 7 *Lagoe RJ, Bice SE, Abulencia PB*. Ambulatory surgery utilization by age level. *Am J Public Health* 1987; 77: 33–7.
- 8 *Natof HE*. Complications associated with ambulatory surgery. *JAMA* 1980; 244: 1116–8.
- 9 *Pedersen T, Eliassen K, Henriksen E*. A prospective study of mortality associated with anaesthesia and surgery: risk indicators of mortality in hospital. *Acta Anaesthesiol Scand* 1990; 34: 176–82.
- 10 *Warner MA, Shields SE, Chute CG*. Major morbidity and mortality within 1 month of ambulatory surgery and anesthesia. *JAMA* 1993; 270: 1437–41.
- 11 *Cohen MM, Duncan PG, Tate RB*. Does anesthesia contribute to operative mortality? *JAMA* 1988; 260: 2859–63.
- 12 *Fortier J, Chung F, Su J*. Unanticipated admission after ambulatory surgery - a prospective study. *Can J Anaesth* 1998; 45: 612–9.
- 13 *Fancourt-Smith PF, Hornstein J, Jenkins LC*. Hospital admissions from the Surgical Day Care Centre of Vancouver General Hospital 1977-1987. *Can J Anaesth* 1990; 37: 699–704.
- 14 *Gold BS, Kitz DS, Lecky JH, Neuhaus JM*. Unanticipated admission to the hospital following ambulatory surgery. *JAMA* 1989; 262: 3008–10.
- 15 *Tong D, Chung F, Wong D*. Predictive factors in global and anesthesia satisfaction in ambulatory surgical patients. *Anesthesiology* 1997; 87: 856–64.
- 16 *Duncan PG, Cohen MM, Tweed WA, et al*. The Canadian four-centre study of anaesthetic outcomes: III. Are anaesthetic complications predictable in day surgical practice? *Can J Anaesth* 1992; 39: 440–8.
- 17 *Heino A, Vainio J, Turunen M, Lahtinen J*. Results of 500 general surgery patients operated on in the ambulatory surgery unit. *Ann Chirurg Gynaecol* 1992; 81: 295–9.
- 18 *Chung F*. Are discharge criteria changing? *J Clin Anesth* 1993; 5: 64S–8.
- 19 *Chung F*. Discharge criteria - a new trend. *Can J Anaesth* 1995; 42: 1056–8.
- 20 *Osborne GA, Rudkin GE*. Outcome after day-care surgery in a major teaching hospital. *Anaesth Intensive Care* 1993; 21: 822–7.
- 21 *Meridy HW*. Criteria for selection of ambulatory surgical patients and guidelines for anesthetic management: a retrospective study of 1553 cases. *Anesth Analg* 1982; 61: 921–6.

Appendix I

INTRAOPERATIVE ADVERSE EVENTS

Cardiovascular

- Hypotension: < 80 mm systolic x 5 min
- Hypertension: > 200 mm systolic x 5 min
- Ischemia: > 1 mm ST depression, inversion of T waves x 1 min
- Tachycardia: regular sinus rhythm with rate > 120/min x 10 min
- Bradycardia: regular sinus rhythm with rate < 40/min x 10 min
- Dysrhythmia: NEW A. fib. SVT heart block or > 5 PVCs x 1 min
- Cardiac arrest: no output, requiring CPR
- Intraoperative death: (Exclude organ donors)

Respiratory

- Desaturation: $\text{SaO}_2 < 90$ x 1 min/ $\text{PaO}_2 < 60$
- Hypercarbia: $\text{EtCO}_2 > 55$ x 5 min/ $\text{PACO}_2 > 50$
- Hypocarbia: $\text{EtCO}_2 < 20$ x 5 min/ $\text{PACO}_2 < 25$
- Laryngospasm: Stridor + airway obstruction
- Bronchospasm: exp. wheezes heard
- High Paw: > 40 cm H_2O x 5 min
- Regurgitation: gastric contents on oropharynx
- Aspiration: gastric contents suctioned from cords/endotracheal tube
- Pneumothorax: Dx on intraoperative x-ray, needle or CT aspiration of air

Intubation related

- Difficult: > 2 laryngoscopic attempts by staff
 - a. successful
 - b. failed
 - c. alternative approach
- Endotracheal tube (ETT) blocked: Tube kinked and/or filled with secretions
- Endobronchial intubation: noted after taping of tube or positioning of patient
- Unintentional extubation

Esophageal intubation at any time

Unplanned intubation

Dental damage

Fluid/metabolic

Hypovolemia: hypotension, tachycardia, and/or oliguria responding to > 1 liter of fluid

Oliguria: < 0.5 ml·kg⁻¹·hr⁻¹ urine for the duration of case

Vomiting: active expulsion of gastric contents

Hypothermia: < 34°C skin or < 35°C nasal/oral

Regional related

Block abandoned: stopped prior to injection

Failed block: required general anesthesia: block inadequate for surgery

Unplanned spinal tap

Unplanned *iv* injection of local anesthetic

Neurological

Excessive preop sedation: confused, unable to answer questions

Excessive preop agitation: interfering with monitor placement

Seizure

Miscellaneous

Surgery cancelled owing to inadequate workup

Unplanned admission to critical care unit

Muscle rigidity

Drug incident: unintentional drug injection

Anaphylaxis: hives + urticaria + hypotension + bronchospasm

Malignant Hyperthermia crisis: suspected/actual

Malignant Hyperthermia crisis

Skin injury: from positioning, cautery, etc.

Technical

Other

Appendix II

PACU Adverse Events

Cardiovascular

Hypotension: < 20% preop systolic > 15 min or < 50% preop systolic on 1 reading

Hypertension: >20% preop systolic > 15 min or > 50% preop systolic on 1 reading

Bradycardia: < 50 bpm > 15 min

Tachycardia: > 120 bpm > 15 min

Dysrhythmia: rhythm different than preop or PVCs > 5/min for > 5 min

Ischemia: clinically suspicious chest pain or new ST depression > 1 mm new T wave inversion

Cardiac arrest: no palpable pulse requiring CPR, no cardiac output, asystole

Respiratory

Desaturation: SaO₂ < 90% at any time and/or cyanosis and/or PaO₂ < 60 mmHg

Hypovolemia: Respiratory Rate < 8·min⁻¹ and/or PaCO₂ > 50 and/or P_{ET}CO₂ > 55 mm Hg

Upper airway problem: problem requiring intervention, e.g., stridor, obstruction, laryngospasm

Arrive intubated: ETT *in situ* at time of admission to PACU

Reintubated in PACU

Pulmonary edema: coughing or suctioning up frothy sputum, bilateral fluffy infiltrates on CXR, crackles

Bronchospasm: wheezes on expiration

Pneumothorax: x-ray confirmation in PACU (not previously noted)

Aspiration: visualization of gastric contents below cords or x-ray confirmation

Fluid/renal/metabolic

Hypovolemia: requiring any fluid bolus (including blood products) in the PACU

Oliguria: < 0.5 ml·kg⁻¹·hr⁻¹ output through Foley catheter (excluding chronic renal failure)

Urinary retention: inability to void, necessitating catheterization

Abnormal blood work

Neurological

Excessive pain: moaning or writhing in pain at any time in PACU or initial nursing care dominated by pain control or requiring more analgesic than ordered

Excessive agitation: unable to be settled or calmed by verbal assurance

Relaxant problem: unable to lift head x 5 seconds, weakness, no cough, diminished train of 1, dimin. sust. tetany

Confusion: new disorientation in time, place, name > 30 min post-awakening

Motor deficit: unexpected inability to lift upper or lower extremity x 1 hr (exclude spinals)

Sensory deficit: unexpected inability to feel pin prick in upper/lower extremity x 30 min

Seizure: tonic-clonic movements of face or extremity

Excessive drowsiness: unable to be roused > 30 min post-anesthetic

Miscellaneous

Nausea and vomiting: any volunteered complaint of nausea, observed active retching requiring antiemetics, or NG tube insertion

Hypothermia: <36.5°C tympanic or <35°C skin or <36°C rectal or <35.5°C oral

Shivering: inability to obtain pulse oximeter reading and/or BP by auscultation OR shivering >15 min post- PAR adm.

Unplanned discharge: unexpected hospital admis-

sion for outpatient or critical care unit for inpatient

Anaphylaxis: ± hives, ± urticaria, ± hypotension, ± bronchospasm

Excessive bleeding: bleeding that requires intervention: e.g., return to OR, fluids, blood, special maneuvers

Other surgical complications: problem that requires special intervention in PACU

Other

Appendix III

ASU ADVERSE EVENTS

Pain, operative site

More analgesics than ordered, initial nursing care dominated by pain, moaning or writhing in pain in Ambulatory Surgical Unit

- a. requiring parenteral or oral analgesics
- b. requiring admission

Nausea

- a. no treatment
- b. requiring antiemetics
- c. requiring admission

Vomiting

- a. no treatment
- b. requiring antiemetics
- c. requiring admission

Aches

- a. headache
- b. muscle aches
- c. sore throat
- a. fluid or blood

Bleeding

Bleeding that requires intervention e.g., return to OR, administering fluids or blood, special maneuvers

- b. reinforce dressing
- c. return to OR
- d. other

HYPERTENSION

>20% preop systolic > 15 min or >50% preop systolic on one reading

- a. no treatment
- b. analgesic
- c. antihypertensives

Hypotension

<20% preop systolic >15 min or <50% preop systolic on one reading

- a. no treatment
- b. crystalloid
- c. other treatment

Dizziness

Fainting/vertigo/tinnitus lightheadedness/orthostatic

- a. no treatment
- b. requiring bed rest
- c. requiring treatment with drugs, fluids, other measures
- d. requiring admission

symptoms

Drowsiness

Prefers to sleep when not stimulated, patients are difficult to ambulate

- a. no treatment
- b. requiring repeated stimulation
- c. admission to hospital

Other

- a. chills
- b. fever
- c. inability to void
- d. others (specify)

Delayed discharge

- a. escort late
- b. waiting for surgeon
- c. due to complication
- d. other

Unanticipated admission

1. Medical

- a. preexisting disease
- b. perioperative complications
- c. other

2. Surgical

- a. more extensive surgery
- b. positive biopsy
- c. misadventure
- d. intractable pain
- e. other

3. Anesthesia

- a. persistent nausea or vomiting
- b. slow recovery and prolonged somnolence
- c. other

4. Social

- a. patient request
- b. surgeon request
- c. no escort

Signed self out

Cancellations

No surgery completed

- a. medical reasons
- b. not NPO
- c. patient changed mind
- d. inadequate OR time
- e. no escort
- f. other