Factors Affecting Discharge Time in Adult Outpatients

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Discharge time (total recovery time) is one determinant of the overall cost of outpatient surgery. We performed this study to determine what factors affect discharge time. Details regarding patients, anesthesia, surgery, and recovery were recorded prospectively for 1088 adult patients undergoing ambulatory surgery over an 8-mo period. The contribution of factors to variability in the discharge time was assessed by using multivariate linear regression analysis. In the last 4 mo of the study, nurses indicated the causes of discharge delays ≥50 min in Phase 1 or ≥70 min in Phase 2 recovery. When all anesthetic techniques were included, anesthetic technique was the most important determinant of discharge time (R^2 = 0.10–0.15; P = 0.001), followed by the Phase 2 nurse. After general anesthesia, the Phase 2 nurse was the most important factor (R^2 = 0.13; P = 0.01–0.001). In women, the choice of general anesthetic drugs was significant (R^2 = 0.04; P = 0.002). The three most common medical causes of delay were pain, drowsiness, and nausea/vomiting. System factors were the foremost cause of Phase 2 delays (41%), with lack of immediate availability of an escort accounting for 53% of system-related delays. We conclude that efforts to shorten discharge time would best be directed at improving nursing efficiency; ensuring availability of an escort for the patient; and preventing postoperative pain, drowsiness, and emetic symptoms. The selection of anesthetic technique and anesthetic drug seems to be of selective importance in determining discharge time depending on patient gender and type of surgery. **Implications:** The relative importance of anesthetic and nonanesthetic factors were evaluated as determinants of discharge time after ambulatory surgery. Postoperative nursing care was the single most important factor after general anesthesia; anesthetic drugs, anesthetic technique, and prevention of pain and emetic symptoms were of selective importance depending on patient gender and type of surgery.

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Discharge time indicates the length of time elapsed from the end of surgery until a patient is discharged home after outpatient surgery. It is often used as a measure of efficacy when comparing anesthetics (1–5), but it may be influenced by a variety of nonanesthesia-related factors and, thus, may be a relatively poor measure of efficacy. However, discharge time is relevant in an absolute sense to patients in planning for assistance on the day of surgery, and it has a direct bearing on cost of recovery after surgery, which is relevant to insurers, hospital administrators, and patients.

The aims of this study were to determine the relative importance of various factors commonly thought to affect discharge time. Clearly, the choice of anesthesia is but one of many factors that influence variability in discharge time. Given the variety of other factors involved, does the choice of anesthesia matter? A second and related goal was to identify specific causes of delayed discharge that might be amenable to systematic prevention or treatment to facilitate more rapid recovery and discharge.

Methods

The study was designed to prospectively evaluate the relative importance of anesthetic and nonanesthetic factors in determining discharge time after outpatient surgery. The nonanesthetic causes studied included patient demographic factors (age, weight, gender), type and duration of surgery, average level of activity in the recovery unit (as exemplified by time of day, day of the week), and individual nurses providing recovery room care. The anesthetic factors studied included the anesthetic technique (general, regional, or local anesthesia with monitored anesthesia care) and, for general anesthesia, the anesthetic drugs used

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for the induction and maintenance of anesthesia. Multivariate linear regression analysis was used to apportion the fractional (percent) contribution of individual factors to the overall variability in discharge time.

Approval was obtained from the institutional review board at the University of Washington School of Medicine to perform a prospective observational surveillance study. We studied 1088 adult patients (≥18 yr) who underwent elective outpatient surgery under general or regional anesthesia or monitored anesthesia care at the University of Washington Medical Center from October 1994 to May 1995.

Information was recorded prospectively by the anesthesia care team on a preprinted form regarding patient age, gender, weight, type and duration of anesthesia, and type and duration of surgery. Duration of anesthesia was defined as the time that the anesthesiologist indicated the patient was ready for surgical preparation until surgery was completed and anesthetic delivery stopped. Duration of surgery was defined as the time of incision to the time of completion of wound closure. Discharge time was defined as the length of time from entry into a recovery unit until the patient was discharged home. This information was routinely recorded by nurses caring for the patient.

Anesthesia was administered by 65 different anesthesia residents and by 14 nurse anesthetists in conjunction with 39 different anesthesia attending faculty. The choice of anesthetic drugs was made by those administering anesthesia. Nursing care during recovery was performed by 31 different nurses in the postanesthesia care unit (Phase 1 recovery) and by 17 nurses in a dedicated outpatient recovery unit (Phase 2 recovery). Both units had been in existence for >13 yr at the time of study. Criteria for transfer from Phase 1 to Phase 2 recovery included an Aldrete score (6) of 8–10, stable vital signs, temperature >35°C, an adequate airway, and patients being alert and responsive, with controlled pain and nausea. Criteria for discharge from Phase 2 to home included: the ability to take liquids PO, ambulate, and void with minimal pain, nausea, or surgical drainage. Discharge medications and written instructions were provided before discharge. An escort was required to take the patient home.

During the second 4 mo of the study, nurses completed a questionnaire identifying the causes of delays in discharge for all patients who stayed ≥50 min in Phase 1 recovery or ≥70 min in Phase 2 recovery. Causes of discharge delay were selected from a preprinted list that included both medical and system-related factors and were prioritized in order of importance if there was more than one cause. Nurses were informed that their responses would be analyzed anonymously without fear of reprisals. The questionnaire was completed when the patient was discharged from the nurse's care.

The association of each of several variables with discharge time was analyzed by univariate and multivariate linear regression analysis (7). The details of the analysis are described in Appendix 1. Analysis of variance was used to determine the association between categorical variables and discharge time. For categorical data, frequencies were compared by using χ^2.

Results

A total of 1184 patients were included in the initial database. This represented 58% of the 2026 patients who received anesthesia services for outpatient surgery during that time. Thirty-six patients were not included in the final analysis because of missing data or because the anesthetic techniques did not fit into major categorical groups used in the analyses. Thirty-seven patients <18 yr of age and 23 patients who were unexpectedly admitted to the hospital were also excluded. The remainder were not studied because their anesthesia providers did not wish to participate. Therefore, the final analysis was performed on 1088 patients, although somewhat smaller numbers of patients appear in some analyses because of missing values.

A broad array of surgical procedures was performed using a variety of anesthetic techniques (Table 1). For general anesthetics, the airway was managed by endotracheal intubation in 72%, a laryngeal mask in 22%, and a plain face mask in 6% of patients. Spinal anesthetics (n = 84) were performed with lidocaine (n = 53) or bupivacaine (n = 31), epidurals (n = 23) were performed with lidocaine. Peripheral nerve blocks included IV regional anesthesia (n = 102), axillary blocks (n = 14), and other blocks (n = 12). Patients with peripheral blocks were discharged when they were otherwise ready without waiting for resolution of blocks. Local anesthesia (n = 271) was accompanied by monitored anesthesia care (MAC) with or without sedation.

Because preliminary analysis suggested that men and women behaved differently and often underwent different types of surgery, the data for men and women were analyzed separately. The mean (± SE) duration of surgery was 58 ± 1.4 min; the duration of anesthesia was 76 ± 1.5 min. For general anesthesia, the times were 68 ± 2.1 min and 83 ± 2.2 min, respectively.

The initial analyses involved all patients in the dataset regardless of type of anesthesia. In Table 1, the demographics of the population and mean discharge times are displayed for all patients in relation to the factors predictive of discharge time. Using univariate linear regression analysis, the amount of variability in discharge time that could be explained by a single factor without correcting for other factors is represented by the values of R^2_{uncor}. The value of R^2 is

Table 1. Discharge Times and Regression Analyses for Variables Predictive of Discharge Time for Various Types of Anesthesia

	Men			Women		
Factor	n	Discharge time (min)	R^2, P value	n	Discharge time (min)	R^2, P value
All patients	479	151 ± 4	—	609	157 ± 3	—
Age (yr)						
18–35	150	168 ± 7	R^2_{uncor} = 0.04, P = 0.001	225	175 ± 6	R^2_{uncor} = 0.05, P = 0.001
36–55	179	150 ± 5	R^2_{unique} = 0.00, P = 0.7	240	157 ± 5	R^2_{unique} = 0.00, P = 0.5
56–75	111	141 ± 7		108	137 ± 7	
76+	39	114 ± 12		36	110 ± 10	
Surgery duration (h)						
<1	274	134 ± 4	R^2_{uncor} = 0.08, P = 0.001	413	147 ± 4	R^2_{uncor} = 0.06, P = 0.001
1–<2	159	160 ± 6	R^2_{unique} = 0.01, P = 0.01	145	168 ± 7	R^2_{unique} = 0.03, P = 0.001
2–<3	32	231 ± 15		33	208 ± 19	
3+	14	199 ± 15		17	223 ± 15	
Surgical procedure						
Ortho	135	137 ± 6	R^2_{uncor} = 0.19, P = 0.001	126	150 ± 8	R^2_{uncor} = 0.16, P = 0.001
Gyne/gen surg	67	170 ± 10	R^2_{unique} = 0.03, P = 0.003	168	179 ± 6	R^2_{unique} = 0.01, P = 0.1
Otol	40	206 ± 13		41	194 ± 13	
Ophth	63	118 ± 11		61	91 ± 5	
Oral/plas	63	149 ± 9		84	171 ± 9	
Other	111	156 ± 7		129	148 ± 7	
Surgery duration and procedure interaction			R^2_{uncor} = 0.03, P = 0.03[a] R^2_{unique} = 0.02, P = 0.01			R^2_{uncor} = 0.03, P = 0.01[a] R^2_{unique} = 0.02, P = 0.08
Anesthetic procedure						
GA	230	184 ± 5	R^2_{uncor} = 0.37, P = 0.001	346	185 ± 4	R^2_{uncor} = 0.27, P = 0.001
SAB/LEP	61	202 ± 9	R^2_{unique} = 0.15, P = 0.001	46	213 ± 13	R^2_{unique} = 0.10, P = 0.001
PNB	72	96 ± 5		56	104 ± 8	
MAC	114	89 ± 4		157	99 ± 5	
Phase 2 nurse						
Range of means	371	101–225	R^2_{uncor} = 0.16, P = 0.001 R^2_{unique} = 0.05, P = 0.003	460	110–200	R^2_{uncor} = 0.12, P = 0.001 R^2_{unique} = 0.07, P = 0.001
>1 nurse	101	196 ± 7		133	197 ± 9	
Day of week						
Mon	101	146 ± 7	R^2_{uncor} = 0.04, P = 0.001	90	142 ± 7	R^2_{uncor} = 0.03, P = 0.002
Tues	79	171 ± 9	R^2_{unique} = 0.01, P = 0.1	106	174 ± 8	R^2_{unique} = 0.00, P = 0.7
Wed	73	137 ± 9		90	135 ± 10	
Thur	92	128 ± 7		185	166 ± 6	
Fri	134	165 ± 8		138	158 ± 7	
Time left OR						
≤10 AM	143	141 ± 6	R^2_{uncor} = 0.04, P = 0.001	234	153 ± 6	R^2_{uncor} = 0.02, P = 0.01
10 AM–12 PM	129	174 ± 8	R^2_{unique} = 0.01, P = 0.01	144	176 ± 8	R^2_{unique} = 0.01, P = 0.004
12 PM–2 PM	107	153 ± 8		112	152 ± 7	
>2 PM	100	133 ± 6		119	150 ± 6	

Values are mean ± SE.

R^2_{uncor} = variance of recovery time explained by the given predictive factor considered alone, R^2_{unique} = unique contribution to the R^2 with the additional variance of recovery time explained by the given predictive factor that is not explained by the other model variables (i.e., it is the increase in R^2 based on adding the term into a model that includes all main effects: age, surgery duration, surgical procedure, anesthetic procedure, surgery center nurse, day of week, time left OR, but does not include the given term), GA = general anesthesia, SAB/LEP = spinal anesthesia or lumbar epidural, PNB = peripheral nerve block, MAC = monitored anesthesia care, OR = operating room, Ortho = orthopedic, Gyn/gen = gynecologic/general, otol = otologic, ophth = ophthalmic, plas = plastic.

[a] Increase in R^2 when interaction term is added to model with two main effects only.

presented as a fraction: the maximum is 1.0, but it can be converted to a percentage by multiplying by 100. Similarly, multivariate analysis provided an estimate of the amount of variability that could be uniquely attributed to a single factor when corrected for all other factors. The estimate is expressed as a fraction (R^2_{unique}). A global model for recovery duration constructed using all variables accounted for 45% of the variability in women (R^2 = 0.45; P < 0.001), and 54% in men (R^2 = 0.54; P < 0.001). The individual factors most predictive of recovery duration in women (unique percentage contributions) were type of anesthesia (10%), Phase 2 nurse (7%), and duration of surgery (3%). Similar values were obtained in men for type of anesthesia (15%), Phase 2 nurse (5%), and type of surgery (3%). The time of day that surgery was

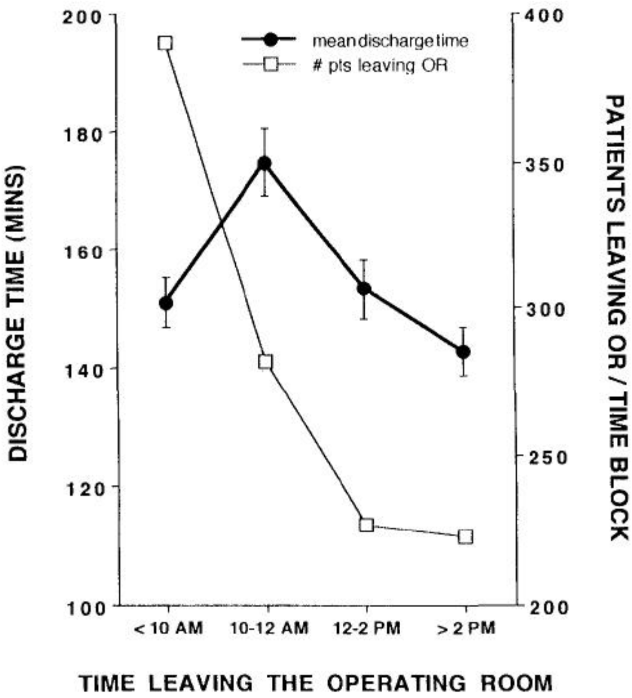

Figure 1. Relationship of discharge time to the time of day that patients left the operating room to enter a recovery unit. OR = operating room, pts = patients.

completed (as a reflection of the general level of business in the recovery unit) also accounted for a small portion of the variability (1%) (Figure 1).

In Table 2, recovery duration is compared for different anesthetic techniques in which two techniques were often used for the same surgical procedure. The comparisons were corrected for the duration of surgery and for the nurse providing Phase 2 care (using a nurse efficiency score; see Appendix 1). General anesthesia was the reference group for each type of surgery. The coefficient (± SE) represents the expected difference from general anesthesia based on the linear regression model. Thus, the discharge time after spinal-epidural anesthesia for lower extremity orthopedics was nearly equivalent to that for general anesthesia in men, but it was 44 min longer in women compared with general anesthesia ($P = 0.04$). Similarly, recovery from urologic surgery was longer after spinal than after general anesthesia in men ($P = 0.006$). For plastic surgery, local anesthesia (MAC) reduced predicted recovery by 65 ($P = 0.005$) and 87 ($P = 0.007$) min compared with general anesthesia for men and women, respectively; for upper extremity surgery, peripheral blocks reduced predicted recovery by 74 ($P = 0.001$) and 71 ($P = 0.001$) min, respectively.

In Table 3, the results of a similar analysis are shown only for those patients who received general anesthesia. In this analysis, patients were divided into four groups based on anesthetic induction and maintenance drugs, as follows: thiopental induction with isoflurane maintenance or propofol induction with maintenance by isoflurane, desflurane, or propofol. In total, 87% of patients received nitrous oxide and 88% received opioids (92% fentanyl, 8% alfentanil) as part of their anesthetic. A global model of recovery duration after general anesthesia constructed using all predictive factors noted in Table 3 accounted for 36% of overall variability in women ($R^2 = 0.36$; $P < 0.001$) and 41% in men ($R^2 = 0.41$; $P < 0.001$). The single most important determinant of variability identified was the Phase 2 nurse caring for the patient (13%). The unique contribution of surgical duration was also significant ($P = 0.02–0.001$) when corrections were made for all other factors. Surgical procedure (3%–5%) was significant in men ($P = 0.01$). In women, the choice of anesthetic drug accounted for 4% of variability.

In Table 4, a model-based estimate of change in discharge time that corrects for all identified predictive factors is presented for all cases by anesthetic drugs. The model predicts that recovery in women after thiopental induction/isoflurane maintenance would take 30 min longer than after propofol induction/propofol maintenance.

In Table 5, data are presented by surgical procedure for a select group of patients in which all four anesthetic options were used (with one exception) in different patients for the same surgical procedures. We performed an analysis of covariance for discharge time among the patients described in Table 5, with main effects of surgical procedure and type of general anesthetic, and with covariates of duration of surgery and nurse efficiency score (Appendix 1). The type of general anesthetic was statistically significant for women ($P = 0.04$) but not for men ($P = 0.3$). In Figure 2, the cumulative distribution of discharge times is presented for women from the same select groups, demonstrating maximal differences of 40 and 61 min for the 50th and 90th percentiles.

Neither age nor body weight was a significant predictor of discharge time. For gender-neutral surgery with general anesthesia, there was no difference in discharge times between men and women (182 ± 6.2 for women, 189 ± 7.0 for men).

In Table 6, the reported causes of delays in discharge are presented for 633 patients in the last 4 mo of the study. Persistent pain, nausea, and drowsiness were the most frequently reported medical causes of delay. System factors contributed to Phase 2 delays in 41% of cases: 53% of these were delayed by lack of immediate availability of an escort, 20% by nurses too busy to facilitate discharge, and 17% because discharge medications were not ready. Of 408 patients who went to Phase 1, 293 (72%) were delayed, with primary reasons cited in 59%. In the remainder, no cause was identified either because nurses did not complete the survey forms or because no specific cause could be identified. In Phase 2, in which 388

Table 2. Comparison of Mean Discharge Times by Anesthetic Procedure[a]

	General anesthesia	Spinal/epidural		Peripheral nerve block		Local/MAC			
Surgical procedure	*n*	*n*	Coefficient[b]	*n*	Coefficient[b]	*n*	Coefficient[b]	ΔR^2	*P* value
Men									
Lower extremity orthopedic	17	32	3 ± 18					0.0	1.0
Upper extremity orthopedic	11			67	−74 ± 17			0.19	0.001
Urologic	31	9	73 ± 25					0.21	0.006
Plastic surgery	9					13	−65 ± 20	0.28	0.005
Women									
Lower extremity orthopedic	29	22	44 ± 21					0.07	0.04
Upper extremity orthopedic	12			51	−71 ± 20			0.18	0.001
Plastic surgery	10					16	−87 ± 18	0.33	0.001

MAC = monitored anesthetic care.
[a] Adjusted for duration of surgery and nurse efficiency score. The increase in R-square due to type of anesthesia is 0.20 ($P = 0.001$) and 0.23 ($P = 0.001$), for men and women, respectively, for all surgical procedures combined.
[b] Coefficient = expected difference in discharge time from the reference group based on linear regression (mean ± SE).

patients were delayed, a primary cause was cited for 348 patients, with secondary and tertiary reasons provided for 114 and 41 patients, respectively.

In Table 7, the frequency of delays due to pain, nausea, and voiding problems are presented separately by surgical procedure and anesthetic technique. The frequencies observed suggest practical groupings for the purposes of targeting prophylactic therapy or conducting future studies.

Drowsiness in Phase 1 was more common in women in the thiopental induction with isoflurane maintenance group compared with the combined other general anesthetic groups (54% vs 14% had persistent drowsiness as a cause of delayed Phase 1 discharge; $P = 0.0003$, χ^2).

In Phase 2, when all patients were considered regardless of anesthetic technique, nausea/vomiting was more common in women (6% of all men versus 12% of all women experienced nausea/vomiting sufficient to contribute to delayed discharge from Phase 2; $P = 0.01$, χ^2). There was no difference between genders in frequency of pain or ability to void. Younger age (<45 yr) was more often associated with persistent drowsiness ($P = 0.0009$, χ^2), and nausea ($P = 0.004$, χ^2) sufficient to delay discharge from Phase 2. Inability to void was most often cited as a cause of Phase 2 delay after spinal anesthesia and after hernia surgery (19% and 23%, respectively).

Discussion

Animal studies and controlled studies in human volunteers suggest that there are differences in the speed of recovery from various anesthetics (8,9). This may be expected to translate into differences in discharge time. However, such differences are not necessarily transferable to the general surgical patient population of a busy operating room. In fact, many studies have identified differences in intermediate end points of recovery (i.e., emergence, time to take oral fluids or ambulate, recovery of cognitive function) but have found no difference in discharge time or failed to report final discharge times (5,10–12). One of the goals of this study was therefore to identify factors other than anesthetic drugs that influence the speed of recovery and that may account for baseline variability, possibly overwhelming any differences due to type of anesthesia. A second goal was to estimate the importance of these factors in determining discharge time relative to the effects of the anesthetic itself.

The results of this study indicate that major factors determining discharge time when all types of anesthesia were considered are (in order of importance based on R^2_{unique}): the anesthetic technique (general versus local, peripheral nerve block, or spinal-epidural anesthesia), the nurse administering Phase 2 care, the type and duration of surgery, and the time of day that surgery was completed.

When only patients receiving general anesthesia were considered, the nurse administering Phase 2 care was the single most important factor for patients of either gender, accounting for ≥13% of the total variability in discharge time. In women who received general anesthesia, additional factors of significance (in order of importance) are the surgical duration and the type of general anesthetic administered. In men, the type of surgery and surgical duration were significantly correlated with discharge time.

The data suggest that efforts to improve nursing efficiency and reduce system factor delays, may reduce discharge time. However, the data also indicate that the choice of anesthetic technique plays a significant role in determining discharge time when there are equally acceptable alternatives for a given surgical procedure. In particular, the use of local anesthesia with MAC or peripheral nerve blocks reduced recovery duration by 65–87 min compared with general

Table 3. Discharge Times and Regression Analyses for Variables Predictive of Discharge Times After General Anesthesia

	Men			Women		
Factor	n	Discharge time (min)	R^2, P value	n	Discharge time (min)	R^2, P value
All patients	230	184 ± 5	—	346	185 ± 4	—
Age (yr)						
18–35	76	203 ± 9	R^2_{uncor} = 0.04, P = 0.03	156	191 ± 7	R^2_{uncor} = 0.005, P = 0.5
36–55	100	173 ± 7	R^2_{unique} = 0.02, P = 0.2	139	180 ± 6	R^2_{unique} = 0.012, P = 0.2
56–75	46	174 ± 10		45	179 ± 9	
76+	8	199 ± 38		6	206 ± 32	
Surgery duration (h)						
<1	101	161 ± 6	R^2_{uncor} = 0.08, P = 0.001	209	173 ± 5	R^2_{uncor} = 0.07, P = 0.001
1–<2	91	191 ± 8	R^2_{unique} = 0.02, P = 0.02	99	194 ± 8	R^2_{unique} = 0.07, P = 0.001
2–<3	25	246 ± 16		27	223 ± 20	
3+	13	205 ± 15		11	250 ± 16	
Surgical procedure						
Ortho	28	181 ± 12	R^2_{uncor} = 0.11, P = 0.001	41	174 ± 12	R^2_{uncor} = 0.06, P = 0.001
Gyne/gen surg	46	169 ± 10	R^2_{unique} = 0.05, P = 0.01	127	190 ± 7	R^2_{unique} = 0.03, P = 0.2
Otol	36	217 ± 12		38	200 ± 14	
Ophth	14	220 ± 31		9	140 ± 12	
Oral/plas	48	173 ± 10		64	192 ± 10	
Other	58	178 ± 9		67	174 ± 10	
Surgery duration and procedure interaction			R^2_{uncor} = 0.07, P = 0.05[a] R^2_{unique} = 0.004, P = 0.1			R^2_{uncor} = 0.04, P = 0.06[a] R^2_{unique} = 0.03, P = 0.2
Anesthetic group						
Thio/iso	31	196 ± 12	R^2_{uncor} = 0.005, P = 0.8	36	200 ± 11	R^2_{uncor} = 0.02, P = 0.05
Pro/iso	124	181 ± 7	R^2_{unique} = 0.001, P = 1.0	164	187 ± 6	R^2_{unique} = 0.04, P = 0.002
Pro/des	42	186 ± 11		88	192 ± 10	
Pro/pro	33	186 ± 12		58	161 ± 7	
Phase 2 nurse						
Range of means	173	127–291	R^2_{uncor} = 0.19, P = 0.001 R^2_{unique} = 0.13, P = 0.01	266	130–234	R^2_{uncor} = 0.15, P = 0.001 R^2_{unique} = 0.13, P = 0.001
>1 nurse	55	215 ± 9		71	234 ± 10	
Day of week						
Mon	53	168 ± 10	R^2_{uncor} = 0.05, P = 0.03	46	178 ± 8	R^2_{uncor} = 0.005, P = 0.8
Tues	45	183 ± 10	R^2_{unique} = 0.01, P = 0.4	74	194 ± 10	R^2_{unique} = 0.009, P = 0.4
Wed	33	176 ± 12		33	187 ± 16	
Thur	34	174 ± 12		129	183 ± 6	
Fri	65	208 ± 10		64	184 ± 10	
Time left OR						
≤10 AM	48	192 ± 9	R^2_{uncor} = 0.05, P = 0.006	117	181 ± 8	R^2_{uncor} = 0.021, P = 0.06
10 AM–12 PM	62	204 ± 11	R^2_{unique} = 0.02, P = 0.1	87	203 ± 10	R^2_{unique} = 0.022, P = 0.02
12 PM–2 PM	61	183 ± 9		65	184 ± 8	
>2 PM	59	158 ± 7		77	172 ± 6	

Values are mean ± SE.
R^2_{uncor} = variance of recovery time explained by the given predictive factor considered alone, R^2_{unique} = unique contribution to the R^2 with the additional variance of recovery time explained by the given predictive factor that is not explained by the other model variables (i.e., it is the increase in R^2 based on adding the term into a model that includes all main effects: age, surgery duration, surgical procedure, anesthetic procedure, surgery center nurse, day of week, time left OR, but does not include the given term), GA = general anesthesia, SAB/LEP = spinal anesthesia or lumbar epidural, PNB = peripheral nerve block, MAC = monitored anesthesia care, OR = operating room, Ortho = orthopedic, Gyn/gen = gynecologic/general, otol = otologic, ophth = ophthalmic, plas = plastic.
[a] Increase in R^2 when interaction term is added to model with two main effects only.

anesthesia for plastic surgery or upper extremity surgery. These results are consistent with the article of Dexter and Tinker (13), who reported faster recovery after local anesthesia with MAC or peripheral blocks versus general anesthesia. However, they did not compare the effects of anesthetic technique on discharge time when different techniques were used for the same types of surgery.

After general anesthesia, we observed that the discharge time in women was fastest after propofol induction/propofol maintenance and slowest after thiopental induction/isoflurane maintenance. The faster discharge after propofol in women may, in part, be explained by a trend toward fewer emetic symptoms in women who receive propofol for the induction and/or maintenance of anesthesia as reported in

Table 4. Model-Based Estimated Increase or Decrease in Discharge Time by Drugs Used for Anesthesia for All Patients Receiving General Anesthesia

Anesthetic procedure	Men *n*	Men Increase or decrease	Women *n*	Women Increase or decrease
Thio/iso	31	3 ± 11	35	8 ± 8
Pro/iso	122	−4 ± 5	160	1 ± 5
Pro/des	42	0 ± 10	87	6 ± 8
Pro/pro	33	6 ± 9	54	−22 ± 6

Mean ± SE of observed minus expected discharge time (min) is presented. Expected value is based on residuals from a model including age, duration of surgery, surgical procedure, surgery center nurse, day of week, time left OR, and the interaction of duration and surgical procedure. The means are weighted by the number of patients in each surgical procedure across all surgical procedures, and the standard errors are based on the weighted means. Including all variables, the global model for men had a R^2 value of 0.41 ($P < 0.001$) and for women had a R^2 value of 0.36 ($P < 0.001$).
Thio = Thiopental, iso = isoflurane, pro = propofol, des = desflurane.

other studies (14,15)[1], although differences in emetic symptoms as a cause of delay were not statistically significant in our study. The small differences in the frequency of prophylactic antiemetics among groups (45% for thiopental induction/isoflurane maintenance, 20% for propofol induction/desflurane maintenance, 40% for propofol induction/isoflurane maintenance, and 25% for propofol induction/propofol maintenance) may have modified the natural frequency of emetic symptoms attributable to the anesthetics alone. However, emetic symptoms *per se* do not seem to be the sole explanation for the expedited recovery in the women whose anesthesia was maintained by propofol. The incidence of drowsiness delaying discharge from Phase 1 was also greater in women who received thiopental versus propofol for induction, consistent with reports by MacKenzie and Grant (16) that cognitive function is depressed longer by thiopental than by propofol compared for the induction of general anesthesia. Similar observations have been made by Rashiq et al. (14) in women undergoing general anesthesia for laparoscopic surgery. Thus, in our study, differences in discharge time in women seem to be related to a variety of factors acting together, rather than to any single identifiable mechanism. An additional factor may also be that patients were not randomly assigned to anesthetic groups. Although selection bias may have affected outcome in some manner, the analyses were corrected for differences in demographic characteristics and type and duration of surgery.

We observed no significant difference of the discharge times for men among anesthetic groups. The reason for the differential effect between men and women is not immediately apparent. In an analysis of factors associated with delayed awakening after propofol anesthesia, Apfelbaum et al. (17) reported that men were 1.4 times more likely than women to have delayed awakening. Subtle pharmacokinetic differences have also been observed between men and women in the distribution and elimination of propofol (18), which may account for some of the apparent differences in the effects of propofol between men and women in our study.

In the second 4 mo of the study, we tried to determine factors that contributed to delayed discharge of individual patients from Phase 1 and Phase 2 recovery areas. The criteria for discharge delay were set before the study as ≥50 min in Phase 1 and ≥70 min in Phase 2. Although seemingly arbitrary, these criteria were selected as being representative of the times required to permit recovery and discharge in uncomplicated cases in our institution. In fact, 20%–36% of patients undergoing general anesthesia met these criteria during the study. By contrast, Chung (19) reported that 82% of patients were discharged within 120 min of surgery; however >50% of patients in that study underwent simple vaginal procedures.

The main medical factors identified by nurses as contributing to discharge delay in our study were uncontrolled pain, nausea/vomiting, drowsiness, unresolved regional block, and inability to void. Pain, emetic symptoms, drowsiness, and voiding problems were also the most frequently identified symptoms associated with delayed discharge in the study by Chung (19). Inability to void as a cause of delay in our study was, in part, a result of the requirement that all patients void before discharge. It was most often observed after spinal anesthesia and hernia repair (18% and 23%, respectively). Subsequent studies have verified that urinary retention is relatively common after spinal-epidural anesthesia and hernia or perirectal surgery but is relatively rare after nonpelvic surgery performed with general or local anesthesia. Thus, the requirement that patients void before discharge may have unnecessarily delayed discharge in 5%–11% of patients in whom neither the type of anesthesia nor the type of surgery predisposed them to urinary retention.

System factors were the most common cause of discharge delays in Phase 2, accounting for 41% of all delays. Of these, 53% were due to the lack of immediate availability of an escort for the patient, consistent with a similar incidence of 28%–38% reported for a multicenter study by Chung (19).

The results of this analysis suggest that intensive efforts to prevent pain and emetic symptoms in high-risk populations before recovery room entry would reduce overall discharge time. Thus, the preemptive use of local anesthesia, opioids, and/or nonsteroidal

[1] Jobalea N, Machieu A. A meta-analysis of published studies confirms decreased postoperative nausea/vomiting with propofol [abstract]. Anesthesiology 1994;81:33.

Table 5. Residual Duration of Recovery for General Anesthesia Patients Separated by Anesthetic Group for Selected Surgical Procedures

	Thio/iso		Pro/iso		Pro/des		Pro/pro	
Surgical procedure	*n*	Mean ± SE	*n*	Mean ± SE	*n*	Mean ± SE	*n*	Mean ± SE
Men								
Orthopedic	4	7 ± 28	11	−1 ± 17	7	6 ± 21	6	−10 ± 15
Ophthamologic			6	39 ± 46	6	−39 ± 18		
ESS/ear	7	23 ± 27	16	0 ± 22	4	−19 ± 21	9	−9 ± 15
Oral/nasal/dental	5	4 ± 25	21	−8 ± 14	11	13 ± 21	2	2 ± 3
Total[a]	16	13 ± 15	54	−2 ± 10	28	2 ± 11	17	−8 ± 9
Women								
Orthopedic	4	19 ± 21	18	−1 ± 15	14	0 ± 24	5	−14 ± 34
Vaginal	4	22 ± 30	18	−3 ± 13	18	11 ± 14	9	−25 ± 14
Laparoscopy	6	44 ± 33	17	−33 ± 9	15	25 ± 23	11	−6 ± 15
General/plastic	4	15 ± 31	7	2 ± 8	4	12 ± 10	6	−20 ± 17
ESS/ear	2	16 ± 40	21	1 ± 18	7	12 ± 46	7	−20 ± 20
Oral/nasal/dental	8	−7 ± 16	18	−8 ± 11	13	20 ± 17	4	−16 ± 7
Total[a]	28	18 ± 11	99	−9 ± 6	71	14 ± 9	42	−16 ± 7

Values are adjusted for duration of surgery and nurse efficiency score.
thio = thiopental, pro = propofol, iso = isoflurane, des = desflurane, ESS = endoscopic sinus surgery.
[a] The total mean ± SE values are weighted by the number of patients in each type of surgical procedure by gender. Total mean residuals for discharge time are different for women ($P = 0.04$, analysis of covariance with main effects of surgical procedure and type of anesthetic with covariates of duration of surgery and nurse efficiency score). For men, differences were not significant ($P = 0.3$).

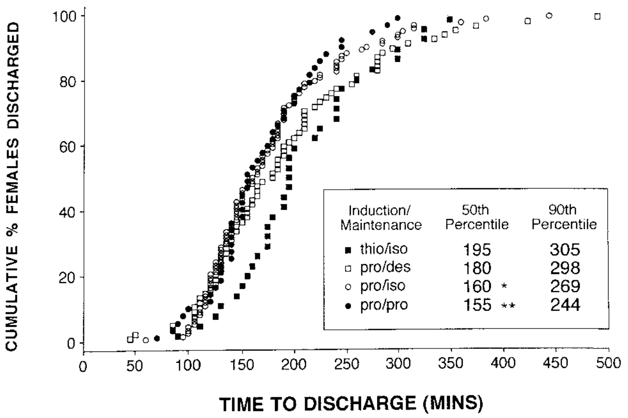

Figure 2. Distribution of discharge time in women after general anesthesia separated into groups by anesthetic drugs used for induction and maintenance of anesthesia. The discharge times are presented as a cumulative percent distribution plot. The 50th and 90th percentiles are indicated in the legend. Thio/iso = thiopental induction/isoflurane maintenance; pro/des, pro/iso, pro/pro = propofol induction/maintenance by desflurane, isoflurane, or propofol, respectively. Discharge times were significantly different ($P = 0.03$ by Kruskal-Wallis). **Pro/pro < thio/iso ($P = 0.007$), *pro/iso < thio/iso ($P = 0.005$ by Mann-Whitney *U*-test). Included in the analyses were surgical categories in which each of the four anesthetic choices were used on two or more occasions. This included all patients from Table 5 except male patients undergoing ophthalmic procedures.

antiinflammatories would be predicted to be of particular benefit for hernia repair, laparoscopy, or plastic surgery based on the results of this and other studies (20). Similarly, the prophylactic use of antiemetics as part of anesthesia for laparoscopy or endoscopic sinus/ear surgery seems to be indicated by our data. The latter is supported by other studies that document a relatively high incidence of emetic symptoms after laparoscopy and otologic surgery (21,22).

The method of assignment of factors that delayed discharge may be criticized as being subjective and open to observer bias. To minimize bias, nurses were assured that their responses would be anonymous and would not be used against them in any fashion. Nevertheless, nurses may have minimized the importance of delays related to their own skills or motivation. In the analysis of causes of discharge delays, nurses often commonly failed to complete questionnaires when discharge times approached the threshold criteria for discharge delay. Thus, the data relating to causes of delay in the last 4 mo of study may be slightly biased toward describing patients with the longest recovery times.

Other methodologic issues that could have influenced our analysis of factors affecting discharge time include selection bias, the failure to include unplanned admissions, the failure to evaluate the effects of Phase 1 nurses or anesthesia care providers, and the use of simple models in multivariate analysis, which may not hold for all combinations of covariate variables. Cases were not studied if anesthesia caregivers failed to participate by completing data forms. Other possible sources of selection bias include the nonrandomized choice of anesthetic techniques or drugs, which could affect the extent to which our results predict outcome in other patient populations. The role of the Phase 1 nurse was not studied as a final determinant of discharge time because a significant proportion of patients (34%) bypassed Phase 1. Similarly, the role of the anesthesia provider was not evaluated because of the large number of possible combinations of residents

Table 6. Reasons for Duration of Recovery ≥50 Minutes in Phase 1 and ≥70 Minutes in Phase 2

Reasons	Phase 1 recovery: Primary reason[a]	Phase 1 recovery: Contributing reason(s)[b]	Phase 2 recovery: Primary reason[a]	Phase 2 recovery: Contributing reason(s)[b]
Medical				
Pain	16	23	14	19
Drowsy	14	23	10	15
Nausea/vomiting	4	11	10	15
Block unresolved	6	6	7	9
Inadequate ventilation	5	7	1	2
Cardiovascular problems	4	2	2	4
Shivering	2	4	0	0
Other	1	2	7	11
Unable to void	NA	NA	8	12
Other				
System factors	9	12	24	41
Surgical factors	0.3	0.3	2	36
Unspecified	41	41	10	10

NA = not applicable.

[a] Frequency of primary reasons is expressed as a percentage of all causes cited as the primary reason for discharge delay. The total is 100%. Of the patients, 408 went to Phase 1 and 293 (72%) were delayed in Phase 1 (excluding patients who bypassed Phase 1); 617 patients went to Phase 2, and 388 (63%) were delayed in Phase 2.

[b] Frequency of contributing reasons is expressed as the percentage of all delayed patients in whom a given reason was cited as one of the causes contributing to delay. The total is >100% because the causes are not mutually exclusive, i.e. there may be more than one cause for delay. Patients who were not delayed ≥50 min in Phase 1 or ≥70 min in Phase 2 were not included in the denominator for this analysis.

Table 7. Symptoms That Contributed to Delayed Discharge from Phase 2 as a Function of Anesthetic Technique and Type of Surgery[a]

	n	Delayed ≥70 mins	Pain	Nausea/vomiting	Unable to void
Anesthetic technique					
MAC	153	55	5	3	5
PNB	76	59	13	5	5
SAB/EPID	68	81	11	6	19
GA	320	64	15	14	6
Type of surgery with GA					
Hernia	13	100	39	8	23
Female cysto/urethral	12	75	33	17	17
Plastic	19	63	32	26	0
Gyn laparoscopy	25	84	24	24	8
Oral/nasal	48	63	15	13	0
Endoscopic sinus/ear	37	73	14	19	0
Upper extremity ortho	15	53	13	7	11
Gyn vaginal	24	46	8	13	8
Lower extremity ortho	27	59	7	7	11
Male cysto/urethral	20	40	0	0	10

[a] Symptoms sufficient to be cited as a cause of delay are expressed as a percentage of all patients undergoing a given type of anesthetic, or surgery, to permit comparisons between groups (the denominator is the total number of patients in each anesthetic or surgical group).

MAC = monitored anesthesia care, PNB = peripheral nerve block, SAB/EPID = spinal or epidural, GA = general anesthesia, cysto = cystoscopic, gyn = gynecologic, ortho = orthopedic.

and certified registered nurse anesthetists with anesthesia attending staff. The global model for all causes constructed without these factors accounted for 45% and 54% of variability in discharge times in women and men, respectively. Presumably, the remainder of variability is related to individual patient differences, as well as to the effects of Phase 1 nurses and anesthesia providers.

The relevance of this study and the extent to which our observations can be applied to other practices vary depending on case mix and institutional practices. This study was performed in a university teaching center, in which the duration of surgery is typically long compared with a private setting. However, because the duration of surgery was a relatively minor determinant of discharge time, it may have limited importance in determining outcome. The discharge times observed in our study after general anesthesia for laparoscopy (206 min) are similar to those reported by Chung et al. (201 min) (23) and Rashiq et al. (160–205 min) (14); for lower extremity surgery, our times were 176 min, compared with 208 min reported by Parnas et al. (24), 200–211 min reported by Linden and Enberg (25), and 95 min reported by Patel et al. (26); for hernia surgery, comparable times were 302 min (25) versus 206 min in the current study. This study may serve as a basis for indicating future directions of study with regard to discharge time after outpatient surgery.

In summary, results of the present study indicate that the Phase 2 nurse was the single most important factor in determining discharge time after general anesthesia, which suggests that adequate training of nurses, standardization of practices, provision of feedback, and incentives to improve efficiency may be predicted to have the greatest effect in decreasing discharge time. Another important factor that could decrease discharge time is the immediate availability of an escort for patients when they are ready for discharge. From the anesthetic standpoint, preventing pain, emetic symptoms, and drowsiness seem to be the most relevant factors; the choice of anesthetic technique and anesthetic drug plays a selective role in decreasing recovery duration that is dependent on type of surgery and patient gender.

Appendix 1

Methodology for Multivariate Analysis of Data

All variables except duration of surgery were converted to categorical variables as indicated in the Tables. The categories were represented in the regression analysis by using dummy variables (7). Duration of surgery was used as a continuous variable in the regression analysis but is represented by categories for descriptive purposes in some Tables. Because duration of surgery and duration of anesthesia were closely correlated, only the duration of surgery was included in the analysis. Duration of surgery was chosen because the type of surgery was more strongly correlated to recovery duration. Two types of regression analysis were performed. In the first type, discharge time was regressed on a given variable alone (e.g., type of surgery), and the value of R^2 was noted. This uncorrected value of R^2 (R^2_{uncor}) represents the proportion of variation in discharge time that can be explained by a variable considered alone, without controlling other factors. R^2 can be expressed as a decimal fraction or as a percentage. The second regression analysis was a comparison of two models for discharge time. One model incorporated all study variables, including the given variable as independent variables, and a second model incorporated all study variables but excluded the given variable. The increase in R^2 from the model without the given variable to the model with the given variable indicates the unique proportion of variation (R^2_{unique}) that the variable can explain after controlling for all other study factors. Values of R^2 serve as a means of comparing the contribution of variables, such as surgical procedure and anesthetic procedure, on time of discharge. The statistical significance of R^2_{uncor} or R^2_{unique} was determined by using the standard *F*-test. A common set of cases without any missing values was used in these R^2 calculations.

The effect of anesthetic technique was evaluated in select groups. For surgical procedures in which there was a common elective alternative to general anesthesia, we compared discharge time between general anesthesia and the alternative using multivariate regression (Table 2). For example, the difference between two different anesthetic techniques used for the same type of surgery was determined for local anesthesia versus general anesthesia with the dichotomy represented as a dummy independent variable. The analysis was performed separately for each surgical procedure, with duration of surgery and a nurse efficiency score used as control variables in each regression analysis. The R^2 change and its statistical significance were calculated based on adding the dummy variable to a model with control variables only. The change in R^2 and its significance for all the procedures in Table 2 combined were calculated by pooling the appropriate sums of squares across types of surgery for each gender.

The nurse efficiency score was calculated as the tertile (scored 1, 2, or 3) of the ranked nurse-specific mean of the residuals of recovery time from a regression model including all study factors except the nurse. The residuals were produced separately for male and female patients, and the mean of residuals was calculated for each nurse separately for male and female patients. These nurse mean residuals were ranked separately for male and female patients, and the mean rank for a nurse was calculated using both genders. In the regression analysis, the tertiles of the mean rank were represented by dummy variables.

Finally, the effect of the type of general anesthesia on recovery time was illustrated by using the mean value of the observed minus the expected discharge time as predicted by a global model for general anesthesia based on regression analysis of all general anesthesia cases for each gender. Four different general anesthetics were used: thiopental induction/isoflurane maintenance and propofol induction with maintenance by isoflurane, desflurane, or propofol. As described for anesthetic technique, we compared discharge time for general anesthetic groups in a select group of patients in which at least two of the four anesthetic combinations were often used for a given type of surgery.

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