Anesthesiology 2002; 97:66–74

Eliminating Intensive Postoperative Care in Same-day Surgery Patients Using Short-acting Anesthetics

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Background: **A multidisciplinary effort was undertaken to determine whether patients could safely bypass the postanesthesia care unit (PACU) after same-day surgery by moving to an earlier time point evaluation of recovery criteria.**

Methods: **A prospective, outcomes research study with a baseline month, an intervention month, and a follow-up month was designed. Five surgical centers (three community-based hospitals and two freestanding ambulatory surgical centers) were utilized. Two thousand five hundred eight patients were involved in the baseline period, and 2,354 were involved in the follow-up period. Outcome measures included PACU bypass rates and adverse events. Intervention consisted of a multidisciplinary educational program and routine feedback reports.**

Results: **The overall PACU bypass rate (58%) was significantly different from baseline (15.9%, $P < 0.001$), for patients to whom a general anesthetic was administered (0.4–31.8%, $P < 0.001$), and for those given other anesthetic techniques (monitored anesthesia care, regional or local anesthetics; 29.1–84.2%, $P < 0.001$). During the follow-up period, the average (SD) recovery duration for patients who bypassed the PACU was significantly shorter compared to that for patients who did not bypass, 84.6 (61.5) *versus* 175.1 (98.8) min, $P < 0.001$, with no change in patient outcome. Patients receiving only short-acting anesthetics were 78% more likely ($P < 0.002$) to bypass the PACU after adjusting for various surgical procedures.**

Conclusions: **This study represents a substantial change in clinical practice in the perioperative setting. Same-day surgical patients given short-acting anesthetic agents and who are awake, alert, and mobile requiring no parenteral pain medications and with no bleeding or nausea at the end of an operative procedure can safely bypass the PACU.**

This article is featured in "This Month in Anesthesiology." Please see this issue of ANESTHESIOLOGY, page 5A.

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For the list of study sites, please see Appendix 2. Submitted for publication July 25, 2001. Accepted for publication January 2, 2002. Supported in part by a grant from Glaxo Wellcome, Incorporated, Research Triangle Park, North Carolina. Presented in part at the annual meeting of the American Society of Anesthesiologists, San Diego, California, October 21, 1997.

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NEWER anesthetics have the pharmacokinetic and pharmacodynamic advantages of a shorter duration of action and a more rapid rate of recovery, which permit faster emergence from anesthesia. However, their use in routine clinical practice is often challenged because of higher drug acquisition costs. Showing the value of these agents is required to increase their acceptance and to foster further development. Less than 30 yr ago, it was unthinkable that patients would be able to return home on the day of surgery. Today, advances in surgery and anesthesiology make it possible to perform 50–70% of all surgical procedures, safely and effectively, on an ambulatory basis.[1] In today's cost-sensitive healthcare environment, the processes of ambulatory surgical care must be continually reevaluated to take advantage of advances in medicine and to optimize the efficiency of the surgical center without detriment to patient safety and satisfaction.

Traditionally, ambulatory surgical patients go from the operating room to an intensive care setting (postanesthesia care unit [PACU] or recovery unit) for their immediate postoperative recovery from anesthesia and then to a second-stage recovery unit (SSRU) for preparation for home readiness.[1,2] The PACU is traditionally an expensive, labor-intensive environment that monitors postsurgical patients intensively. After a set of recovery criteria[3–5] are met in the PACU, the patient is usually transferred to the SSRU. In the SSRU, the patient-to-nurse ratio is considerably higher (*i.e.*, nursing care in the SSRU is less labor intensive) than in the PACU. Only basic monitoring and observation are performed as the patient and his or her escort are prepared for home readiness. Because of the rapid recovery of patients undergoing anesthesia with this new class of anesthetics, some have questioned whether all ambulatory surgical patients need to receive intensive postoperative care in the PACU setting or whether recovery from anesthesia can be achieved in the operating room. This study evaluates the impact of selective patient bypass of the PACU on both the outcomes of ambulatory surgical patients and the use of resources in the surgical arena.

Materials and Methods

Intervention

A prospective, outcomes research study design was used to evaluate the clinical and economic effectiveness

of a new paradigm of anesthesia care. This paradigm proposes the likelihood that ambulatory surgical patients could safely bypass the first-stage recovery room or PACU and be transported directly to the SSRU. The study was conducted over a consecutive 3-month period at each of five sites. The study protocol consisted of 1 month to record baseline patient outcome data (baseline period); 1 month to educate physicians, nurses, support staff, and administration on the new process of care and to begin implementation of the bypass strategy (intervention period); and 1 month to monitor the impact of the intervention (follow-up period).

The intervention in this study consisted of moving, to an earlier time, the assessment of the patient's recovery from anesthesia. This time point was immediately at the end of surgery while the patient was still in the operating room. The recovery criteria used in the operating room were identical to recovery criteria used in the PACU. After evaluation of recovery by the anesthesiologist in the operating room, if all the recovery criteria (table 1) were met, the patient was to bypass the PACU and be transported directly to the SSRU. Patients receiving anesthetics with short-acting pharmacologic properties (table 2) were compared to those patients given anesthetics with less favorable pharmacokinetic and pharmacodynamic recovery profiles in regard to the ability to bypass the PACU.

A multidisciplinary advisory board was convened; it consisted of anesthesiologists, nurse anesthetists, epidemiologists, econometricians, and administrators. The short-acting, fast-emergence recovery criteria were formulated by the study advisory board using already rigorously established recovery criteria in use at their surgical centers and those published in the literature.[3–5] Recovery criteria were standardized across the participating sites. This board determined which pharmacologic agents would be considered short-acting, fast-emergence agents for purposes of this study. Anesthesia providers were free to choose the anesthetic regimen most appropriate for the patient, without regard to whether it was considered short acting. The decision to bypass the PACU rested on meeting all recovery criteria (table 1) and on the anesthesiologist's medical judgment with regard to specific details of the patient's medical history and surgical procedure.

Table 1. Short-acting, Fast-emergence Recovery Criteria* for Admission to the Second-stage Recovery Unit

Patient should be awake, alert, oriented, responsive (or returns to baseline state).
Pain should be minimal (unlikely to require treatment with parenteral medications).
No active bleeding should occur (unlikely to require professional treatment).
Vital signs should be stable (unlikely to require pharmacologic intervention).
Nausea should be minimal.
No vomiting should occur.
If nondepolarizing neuromuscular blocking agent has been used, patient should now be able to perform a 5-s head lift, *or* train-of-four monitoring should indicate no fade.
Oxygen saturation should be 94% or higher on room air (3 min or longer) *or* oxygen saturation should return to baseline on room air.

* During the follow-up period, the patient should be evaluated in the operating room, immediately before discharge, using the above criteria regarding recovery from anesthesia. To bypass the postanesthesia care unit, a patient must meet *all* of these criteria and, in the judgment of the anesthesiologist, be capable of transfer to the second-stage recovery unit.

Table 2. Pharmacologic Agents Defined as Short Acting for Purposes of This Study*

Class of Pharmacologic Agent	Short-acting Pharmacologic Agents
Preinduction medications	Midazolam, fentanyl, alfentanil, sufentanil
Sedative/hypnotics and induction agents	Propofol
Opioids	Fentanyl, alfentanil, sufentanil
Anesthetic gases	Desflurane, sevoflurane, nitrous oxide
Neuromuscular blocking agents	Mivacurium, succinylcholine

* The above pharmacologic agents were defined as short-acting, fast-emergence (SA) for this study. Use of the SA agents for ambulatory surgery produces a higher probability of transfer of such patients from the operating room directly to the second-stage recovery unit rather than the first-stage postanesthesia care unit, as is the usual practice, with no decrease in quality of care.

All five sites received expedited approval for participation in the study by their institutional review board. This study limited itself to abstracting of patient medical records, monitoring for drug effects, and recording of observations on a standardized data collection form. The study collected only data that was obtained as part of the routine care of the patients. Because the only risk to the patient was a possible breach of confidentiality, strict safeguards were implemented to protect the identity of patients monitored during the study. None of the study requirements involved patient care activities that were outside the current standard of care governing surgical practices.

Sites

Hospital-based and freestanding ambulatory surgical centers were evaluated. Five sites were selected after a two-tier screening survey process, a teleconference, and a site visit. The screening surveys obtained objective and subjective operational data about each site. Sites were eligible for participation in the study if all of the following criteria were met.

The site had to be willing to make changes in patient flow through surgical services and to reallocate perioperative personnel, if necessary.

At least 50% of the surgical procedures had to be performed on an ambulatory basis.

If a system included both ambulatory surgical cases and inpatient cases, the site had to differentiate the two types of patients.

The site had to be willing and able to implement a policy, if one did not exist, that permitted patients to bypass the PACU if they met the short-acting, fast-emergence recovery criteria listed in table 1.

The short-acting, fast-emergence anesthetic agents shown in table 2 had to be available to anesthesiologists without restrictions for use.

The site had to be willing to provide detailed economic data related to surgical costs (*e.g.*, salary and overtime expenses, drug and medical/surgical expenses, and other variable direct expenses).

The site had to be capable of mounting the prospective data collection process required for obtaining information on each and every patient admitted for ambulatory procedures during the study period.

If the above criteria were met, commitment from the site was initially evaluated by teleconference. A subsequent site visit evaluated the physical layout of the sites to determine whether any logistical features might hamper the flow of patients from the operating room directly to the SSRU. Once the sites were selected, a project team consisting of members of the advisory board traveled to the site to orient surgeons, anesthesiologists, certified registered nurse anesthetists, nurses, technicians, support staff, and administration; to review the specific details of initiating the study; and to educate the practitioners on using the PACU bypass paradigm. The project team remained a resource for the duration of the study and made subsequent visits to the site.

Inclusion and Exclusion Criteria

All patients were eligible for enrollment if they were undergoing elective ambulatory procedures and were healthy or had stable comorbidities as defined by American Society of Anesthesiologists (ASA) physical status I, II, or III.[6] Patients were excluded if they were inpatients, same-day admission patients, or 23-h overnight-stay patients; were undergoing emergency procedures; or had ASA physical status classification IV or V.[6]

Data Collection

The following data were collected during both the baseline and follow-up periods for every patient: demographic information (*e.g.*, age, sex, race, ASA classification, weight of the patient); preexisting medical conditions, surgical procedure, and anesthetic regimen and technique; time of critical events; the length of stay in postoperative recovery units; and the occurrence of adverse events. The adverse events monitored included bleeding, drowsiness, headache, hypertension or hypotension requiring treatment, hypoxemia requiring treatment, inability to void, itching, muscle ache, nausea, vomiting, inadequate pain control, postdural puncture headache, prolonged neuromuscular blockade, and sore throat. In addition, data on unplanned hospital admissions, PACU admission from the SSRU, or unplanned return to the operating room was collected. Reasons for not bypassing the PACU were recorded during the follow-up period.

To ensure the quality of data collection during the baseline period, reports were sent daily to the sites accentuating the data that each provider had omitted for each patient. Teleconferences and site visits were conducted to improve compliance with data capture, and quality assurance reports were reduced to a weekly basis as compliance was met. Communication was maintained with the sites throughout the study to discuss reports and to answer any study questions. A random sample of 10% of the data collection forms was compared with patient medical records to verify the accuracy of the data submitted.

Data Feedback

At the end of the baseline month, each site was given a comprehensive report summarizing details, such as their patient and procedure demographics, use of anesthetics, postoperative events, and type of procedures. The type of anesthetics and the length of time patients

Table 3. Site Characteristics

	Site 1	Site 2	Site 3	Site 4	Site 5
Type of site	Community hospital	Community hospital	Freestanding surgical center	Freestanding surgical center	Community hospital
Region of country	Midatlantic	Midatlantic	Midwest	Midwest	Midatlantic
No. of cases per year	6,434	10,407	12,139	7,617	7,560
Percent of ambulatory cases	60	60	90*	100	50
No. of ORs	7	14	17	10	9
No. of PACU beds	8	16	37	9	12
No. of SSRU beds	13	3	0	0	16
No. of SSRU recliners	15	8	20	10	8

* Ten percent of the surgical cases were preplanned 23-h admission cases.

OR = operating room; PACU = postanesthesia care unit; SSRU = second-stage recovery unit.

spent in the PACU were profiled by each provider. During the intervention and follow-up months, the site was sent weekly reports summarizing details, such as the percentage of patients who had bypassed the PACU in the previous week; these details were stratified by anesthetic procedure and anesthesia provider. Cumulative data were also reported to show the trend in the bypass rates. After all sites finished collecting clinical data, a final benchmark report comparing outcome measures across the participating sites was generated and presented to the sites during an exit interview.

Statistical Analysis

The data collection forms were scanned using Nestor® (Nestor Inc., Providence, RI), an optical character recognition software program, and were input into a mini SQL (structured query language) database. The SAS® (SAS Institute, Cary, NC) statistical software package was used to analyze the data.

The primary outcome measures for the analysis were the PACU bypass rates and the total length of time the patient spent in the recovery units. The chi-square test was used to compare PACU bypass rates for the baseline and follow-up periods, and the Wilcoxon rank sum test was used to compare the length of time in the recovery unit for those who bypassed the PACU *versus* those who did not. Patient demographics and rates of adverse events were compared between groups using the chi-square test or Fisher exact test, where appropriate. Statistical significance was defined as $P < 0.05$.

A multivariable, stepwise, logistic regression model was built to evaluate the interrelationship of factors related to patients who bypassed the PACU. This analysis was performed for the subgroup of patients to whom a general anesthetic was administered. A P value of 0.05 was used for entry and removal of a factor from the model.

Results

Demographics

The five centers span a range of facilities providing ambulatory surgical procedures. These centers do differ in characteristics as shown in table 3. A total of 2,508 patients were observed during the baseline period, and 2,354 ambulatory surgical patients were assessed for eligibility to bypass the PACU during the follow-up period. At two sites, demographic information during the baseline period differed only slightly from that during the follow-up period; no other differences were found between the baseline and follow-up periods. Specifically, site 2 experienced a 20.3% increase in male patients ($P = 0.02$), and site 3 experienced a 10.9% decrease in monitored anesthesia care procedures ($P = 0.02$) and a 25.1% increase in general anesthetic procedures ($P < 0.01$). Of the ambulatory surgical patients, 68.3% were given only short-acting anesthetics. This figure did not change significantly from the baseline to the follow-up period for individual sites ($P > 0.05$), with the exception of site 3, which increased the use of only short-acting agents from 55.2% to 67.5% ($P < 0.01$). The mean (SD) duration from closure of surgical incision to arrival in the recovery unit was similar between baseline and follow-up periods, 17.4 (13.7) *versus* 18.0 (15.0) min, respectively ($P = 0.092$).

Table 4 compares demographic information during the follow-up period for the patients at each of the sites. The five sites differed significantly regarding patient age and sex; the types of anesthetic procedures used; and the number of patients given only the short-acting, faster-emergence (SA) agents listed in table 2. The most common types of surgical procedures were orthopedic (20.0%); ophthalmologic (16.2%); gynecologic (10.0%); ear, nose, and throat (9.5%); and nonintraabdominal

Table 4. Demographic Information for Patients Monitored during the Follow-up Period

Demographics	Site 1 n (%)*	Site 2 n (%)*	Site 3 n (%)*	Site 4 n (%)*	Site 5 n (%)*
No. of patients	368	387	759	499	341
Age (yr)					
≤ 19	37 (10.2)	33 (8.5)	31 (4.2)	107 (21.4)	43 (12.7)
20–65	252 (69.2)	227 (58.7)	522 (70.6)	249 (49.9)	215 (63.2)
> 65	75 (20.6)	127 (32.8)	186 (25.2)	143 (28.7)	82 (24.1)
White	327 (90.3)	324 (83.9)	687 (93.5)	494 (100.0)	321 (94.7)
Female	213 (59.2)	202 (52.3)	491 (65.7)	284 (57.0)	189 (55.6)
Anesthetic procedure					
General anesthesia	145 (39.4)	194 (50.1)	307 (40.5)	317 (63.5)	173 (50.7)
Monitored anesthesia care	70 (19.0)	144 (37.2)	350 (46.1)	32 (6.4)	156 (45.8)
Other	153 (41.6)	49 (12.7)	102 (13.4)	150 (30.1)	12 (3.5)
Anesthetic regimen					
Non-SA	144 (39.8)	101 (26.8)	224 (32.5)	77 (17.2)	94 (27.7)
SA only	218 (60.2)	276 (73.2)	466 (67.5)	372 (82.9)	246 (72.4)

* The denominator of the fraction making up the percentage is the total number of cases for which information was available regarding the characteristic of interest.

Non-SA = the use of drugs other than the short-acting, fast-emergence drugs listed in table 2; SA only = the use of only the drugs listed in table 2.

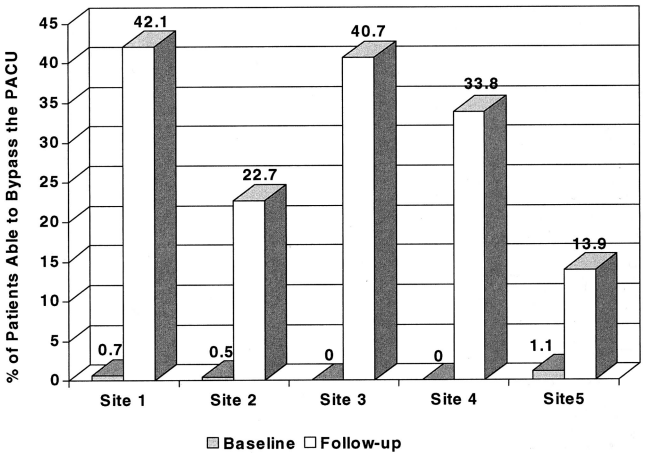

Fig. 1. This figure shows the percentage of patients given *general anesthesia* who bypassed the postanesthesia care unit (PACU) and were transferred directly to the second-stage recovery unit after ambulatory surgery. For five sites, the percentages of such patients were compared before (baseline) and after (follow-up) performance of the intervention.

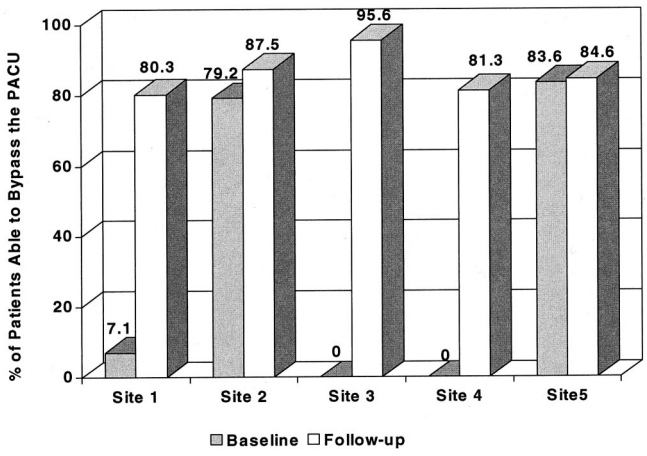

Fig. 2. This figure shows the percentage of patients receiving a *monitored anesthesia care technique* who bypassed the postanesthesia care unit (PACU) and were transferred directly to the second-stage recovery unit after ambulatory surgery. For five sites, the percentages of such patients were compared before (baseline) and after (follow-up) performance of the intervention.

(8.6%). The frequency of these procedures differed significantly among sites.

Bypass Rates

The overall bypass rate increased from 15.9% (399 of 2,508) for the baseline month to 58.9% (1,387 of 2,354) for the follow-up month ($P < 0.0001$). The site-specific bypass rates across anesthetic procedures during the follow-up month were 71.0, 53.9, 71.7, 51.9, and 48.4% for site 1 through site 5, respectively.

There were 1,151 (45.8%) patients given a general anesthetic during the baseline period, and 1,136 (48.3%) patients given a general anesthetic during the follow-up period. The bypass rate of patients given a general anesthetic increased from 0.4% (4 of 1,151) to 31.8% (361 of 1,136) ($P < 0.0001$). As shown in figure 1, the site-specific bypass rates during the follow-up period ranged from 13.9 to 42.1% of the patients. In this subgroup of patients, a multivariable logistic regression model showed the following factors related to either an increased or a decreased likelihood of bypassing the PACU. Patients given SA agents (odds ratio [OR] = 1.78, $P < 0.0002$) and patients undergoing a gynecologic procedure (OR = 2.68, $P < 0.0001$) or an ophthalmologic procedure (OR = 2.07, $P < 0.0459$) were more likely to bypass the PACU. Patients undergoing an ear, nose, or throat procedure (OR = 0.64, $P < 0.0221$) or laparoscopy (OR = 0.39, $P < 0.0003$) were less likely to bypass the PACU. In the model, patient demographics did not differ statistically between those who bypassed the PACU and those who did not.

There were 916 (36.5%) and 778 (33.1%) patients given a monitored anesthesia care technique during the baseline and follow-up months, respectively. The overall PACU bypass rate for this subgroup of patients increased from 32.1% (294 of 916) to 89.7% (698 or 778) ($P < 0.0001$). As shown in figure 2, during the follow-up period, at all five sites, more than 80% of patients bypassed the PACU.

For other types of anesthetic procedures, patients were able to bypass the PACU at the following rates. The bypass rate increased from 1.7% in the baseline period to 97.3% in the follow-up period for patients to whom a straight local anesthetic was administered. Of those given intravenous sedation, the PACU bypass rate increased from 0 to 92.9% from baseline to follow-up periods, respectively. Of the patients undergoing a plexus block or a spinal block, the bypass rates increased from 7.3 to 82.4% and 0 to 9.9%, respectively.

There were a total of 967 patients who did not bypass the PACU during the follow-up period. The reasons for not bypassing the PACU are listed in table 5, stratified by anesthetic procedure.

Outcomes During the Follow-up Period

Perioperative Durations. The mean (SD) duration from surgical closure to arrival in the recovery unit was similar in the patients who bypassed the PACU *versus* those who did not, 18.5 (16.9) *versus* 17.3 (11.9) min ($P = 0.858$). The average total on-site recovery time (SD) at all sites was significantly less for patients who bypassed the PACU than for those who did not, 85 (62) *versus* 175 (99) min, ($P = 0.001$). At individual sites, the reduction in total length of on-site recovery ranged from 39.2 to 51.7%, ($P < 0.0001$). This trend was similar for the different anesthetic procedures and anesthetic regimens (fig. 3). The variability in total recovery time between sites correlated with length of stay in the SSRU (R = 0.91; $P = 0.001$). The average (SD) time spent in

Table 5. Reasons for Not Bypassing the PACU

	General Anesthesia (N = 775) n (%)	MAC (N = 80) n (%)	Other (N = 112) n (%)
Not sufficiently awake, alert, oriented, or responsive	536 (69.2)	33 (5.7)	11 (1.9)
More than minimal pain	174 (22.5)	4 (5.0)	9 (8.0)
More than minimal nausea	74 (9.6)	2 (2.5)	4 (3.6)
Oxygen saturation of less than 94%	67 (8.7)	9 (11.3)	10 (8.9)
Some bleeding	27 (3.5)	2 (6.1)	4 (3.6)
Vomited or at high risk of vomiting	21 (2.7)	1 (1.3)	5 (18.5)
Unstable vital signs	13 (1.7)	1 (1.3)	10 (8.9)
Unable to sustain a 5-s head lift	18 (1.9)	0	0
Met all recovery criteria	131 (16.9)	38 (47.5)	84 (75.0)

More than one criteria was allowed to be checked for not bypassing the postanesthesia care unit (PACU).
MAC = monitored anesthesia care; Other = other anesthetic procedures.

the SSRU was significantly shorter for patients who bypassed the PACU than for those who did not, 84.4 (60.9) *versus* 125.3 (86.1) min ($P < 0.001$).

Safety Data. The overall adverse event rate, defined as any recorded event on the data collection form, was 14.7%. The adverse event rates at sites 1 to 5 were 8.2, 9.6, 17.5, 16.8, and 18.32%, respectively. Specific adverse events were compared between patients who bypassed the PACU and those who did not. The patients who bypassed the PACU had significantly fewer events, *e.g.*, drowsiness (1.87 *vs.* 4.03%, $P = 0.002$); inability to void (0.43 *vs.* 1.65%, $P = 0.002$); nausea (1.80 *vs.* 6.62%, $P = 0.001$); vomiting (0.87 *vs.* 3.52%, $P = 0.001$); and inadequate pain control (3.10 *vs.* 9.82%, $P = 0.001$). Of those patients transferred to the PACU, 1.7% (40) patients had an unplanned hospital admission, as compared with 0.17% (4) of the patients who bypassed the PACU ($P < 0.001$).

Discussion

Traditional models of care need to be challenged as new medicines and technologies are made available. In fact, modifying age-old, policy-ridden processes of care may be more difficult than developing new medicines and technologies. However, as demonstrated in this study and others,[7] the use of outcomes-based studies in routine clinical practice is one way to make these modifications possible and successful.

New anesthetics with improved pharmacokinetic and pharmacodynamic properties, specifically a shorter elimination half-life, permit a faster emergence from anesthesia and allow the evaluation of immediate postoperative recovery at an earlier time point. The surgical centers in this study differed with each other with respect to the types of surgical and anesthesia procedures used and the demographic profile, yet they were still able to achieve an overall PACU bypass rate of 84.2% for patients not

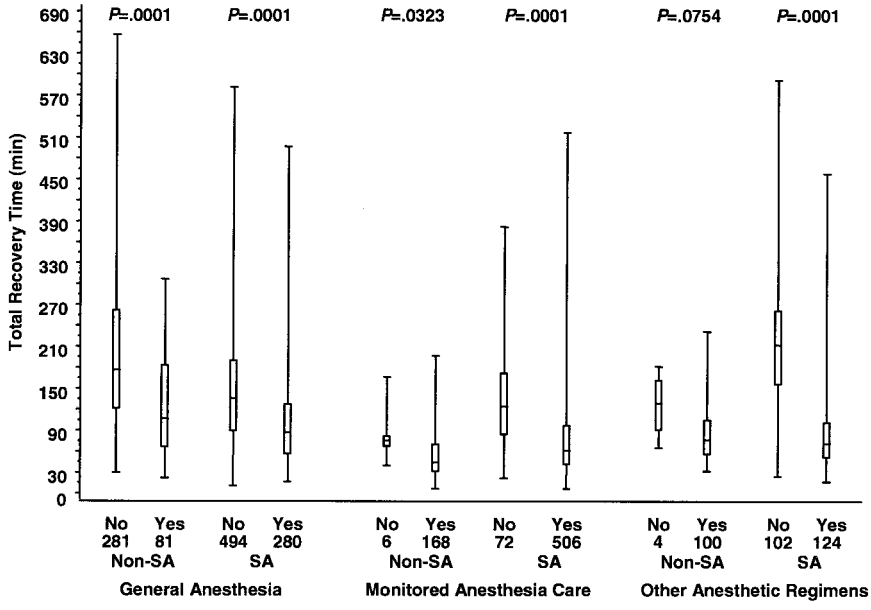

Fig. 3. This figure shows the total length of time patients at five sites spent in recovery units (both the postanesthesia care unit [PACU] and the second-stage recovery unit [SSRU]) after ambulatory surgery. This information is first stratified by anesthetic procedure—general anesthesia *versus* monitored anesthesia care *versus* other anesthetic regimens. The information is further stratified according to the use (SA) or nonuse (non-SA) of only the short-acting, fast-emergence agents listed in table 2. Finally, the information is broken down according to those who bypassed the PACU, designated as Yes, and those who did not, designated as No. The box represents the median duration, first and third quartiles. The lines extend to the minimum and maximum durations.

undergoing general anesthesia or central neuroaxis block. Of the patients who had general anesthesia, 31.8% bypassed the PACU. As revealed by a multivariable logistic regression model, there were only a few subgroups of the general anesthesia patients who were more likely or not as likely to bypass the PACU. Patients receiving solely SA agents were almost twice as likely to bypass the PACU than patients who received agents that included anesthetics not listed as short acting in the protocol after we adjusted for surgery types. Since surgical centers do differ by specialty, a closer evaluation of the types of patients who bypass the PACU at a particular institution will help when creating educational materials that prepare the patient for postoperative recovery.

Of the patients who did not meet the short-acting, fast-emergence recovery criteria, 60% were not able to do so because they were not sufficiently awake, alert, oriented, or responsive. This lack of cognitive function may be due in large part to the direct effect of the anesthetic. Hence, there may be opportunity for more patients to bypass the PACU, as more patients receive an SA anesthetic regimen and anesthesia providers refine their skills in titrating the rapid recovery anesthetics at the end of the procedure.

Given these developments in anesthesia practice, it is important to keep the components of healthcare costs in perspective. As many as 27 million patients annually undergo surgery and procedures with anesthesia in the United States. Thus, anesthesiologists have influence over 3–5% of total healthcare costs.[8] The vast majority of these costs, however, are associated with personnel costs and facilities. Only 2–7% of anesthesia costs and expenses apply to drugs, equipment, and supplies.

The PACU represents an important component of the costs associated with a perioperative center. Important differences in recovery time have been demonstrated for various agents within the classes of anesthetic drugs. However, some analyses, including a simulation model developed by Dexter and Tinker,[9] did not show these differences translating into PACU cost savings. This simulation study by Dexter and Tinker showed that personnel costs depend on the peak number of patients in the PACU and account for almost all PACU costs. They suggest that simply reducing the time spent in the PACU for all patients undergoing general anesthesia will not necessarily reduce the peak number of patients in the PACU. This and other studies[10] document that personnel costs are the single most expensive item in postoperative recovery units, and costs savings are obtainable by changing nursing ratios, reducing the peak number of patients, changing the nursing skill mix, and controlling PACU admission times.

The change in process in this study went beyond reducing time spent in the PACU to eliminating the time spent in the PACU while not increasing the time spent in the operating room or the SSRU. In fact, the average (SD) time spent in the SSRU was significantly shorter for patients who bypassed the PACU than for those who did not bypass the PACU. The overall bypass rate was 58.9% in the follow-up period *versus* 15.9% in the baseline period. The average total on-site recovery time for patients who went to the PACU was 175 min *versus* 85 min for the patients who did not. In another simulation study by Dexter *et al.*,[11] different cost savings were estimated based on the nursing compensation structure, the number of patients a center sees in a day, and nursing schedules. These savings could be realized in different ways at different facilities. During the third month of monitoring, full-time PACU staff was not reduced pending results of the full implementation of the bypass paradigm. An exit interview of surgical center administration provided details of PACU restaffing as a result of the 58% reduction in same-day surgery patients who no longer went to the PACU for immediate recovery. The full impact of actual cost savings would need to be studied over a year in which projected budgets and actual expenses were collected from multiple departments.

The physical structure of the facility also plays a role in the process change. In future planning, less space may need to be allocated to the PACU and more space may need to be allocated to the SSRU, as was accomplished at one facility, based on the direct results of this study. In fact, some have suggested the PACU could even be eliminated,[10] although ideally, the goal should be to design postoperative recovery space that is flexible enough to accommodate the full range of postoperative requirements. If one is to implement this paradigm, it is important to evaluate the physical constraints and logistical details of the new patient flow. For example, at one facility, the usual method of transportation of the patient had to be changed during the study because a gurney could not be turned in the hallway that led to the SSRU; instead, the patients were transferred *via* a comfortable reclining chair that had wheels.

One important finding of this study is that the changes in process were able to succeed rapidly in community hospitals and freestanding surgical centers where no special research knowledge or technical data gathering skills were necessary. With the application of benchmarking data and timely feedback, the paradigm shift can be realistically implemented at any type of surgical center.

The study design consisted of an open-label, nonrandomized, clinical evaluation that used a baseline and a follow-up period at five sites. This design, in which the treatment group serves as its own control, has a number of limitations. One limitation is that the Hawthorne effect, or the result of collecting data and knowing the data were being monitored, could have produced an effect, all by itself, on the flow of patients through the process that would not have occurred otherwise. Such an effect could have confounded not only the efforts to evaluate

the effect of the protocol on patient outcomes but also the efforts to attribute that effect directly to the anesthetic agents. For this reason, our major hypothesis was framed in terms of the set of policies and procedures that would allow patients to bypass the PACU safely, and that would produce resource savings for the surgical center. It still remains to be tested whether this paradigm works without continued feedback, or how much feedback is necessary to institute continual improvement.

The alternative to this design would have been a randomized controlled clinical trial. Randomizing to anesthetic regimen or bypassing of the PACU were two options that were not viable for our purposes. Randomizing to specific anesthetic regimens would have severely limited the number of patients and procedures allowed at one site. Since evaluation of resource allocation was an important outcome, it would not have been possible to adequately evaluate or produce this outcome given these restraints. Randomizing patients to bypass the PACU would be clinically unethical. The safety for patients who the anesthesia providers selected to bypass the PACU was expected to be identical to those not selected to bypass the PACU. The number of patients and the costs of such a randomized controlled clinical trial to show a difference in adverse outcome would have been extremely high.

This study did not measure patient satisfaction as an outcome of the change in process. However, it is not expected that there would be a change. First, the new anesthetics were already part of the anesthetic regimen and are known to produce less grogginess, nausea, and vomiting, plus a better anesthetic experience, than older anesthetics.[12] Second, the same criteria for transfer to the SSRU are used in the operating room and the PACU. The incidence of recovery complications was lower for patients who bypassed the PACU than for those who did not. Although postdischarge complications were not monitored, a similar result would be expected after discharge of the patient. For example, a study of 38,598 ambulatory surgical patients found overall morbidity (14 of 18,037 patients) and mortality rates (1 of 22,545 patients) to be very low within 1 month of surgery involving anesthesia.[13] Further research on patient satisfaction and postdischarge complications to substantiate these assumptions is warranted.

In this study, 58.9% of the patients undergoing elective, same-day surgery did not require intensive postoperative care and bypassed the PACU. This resulted in a significant reduction in the on-site recovery time for patients who bypassed the PACU. PACU bypass was also associated with fewer adverse events, which may be an indication of the appropriateness of bypassing the PACU. In conclusion, optimizing the pharmacologic properties of short-acting, fast-emergence anesthetic agents in routine clinical practice improves the efficiency of a perioperative center by allowing anesthesia providers to identify selectively and appropriately those surgical patients to bypass the postanesthesia care unit and to be prepared for home readiness in the second-stage recovery unit.

The authors thank Meredith Saluzzo (Logistical Data Manager, Outcomes Research), Monika Sokolowski (SAS Programmer, Data Management), and Leona Lackie (Senior Data Clerk, Outcomes Research from Cognigen Corporation, Buffalo, New York) for project coordination and programming support; and Pauline Snider (Medical Editor, St. Augustine, Florida) for assistance in the preparation of this manuscript.

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Appendix 2: SA Study Sites and Advocates

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