Complications Occurring in the Postanesthesia Care Unit: A Survey

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To identify and quantitate complications occurring in the postanesthesia care unit (PACU), a prospective study evaluated 18,473 consecutive patients entering a PACU at a university teaching hospital. Using a standardized collection form, the incidence of intraoperative and PACU complications was determined. The combined PACU and intraoperative complication rate was 26.7%. Data showed a PACU complication rate of 23.7%, with an overall intraoperative complication rate of 5.1%. Nausea and vomiting (9.8%), the need for upper airway support (6.9%), and hypotension requiring treatment (2.7%) were the most frequently encountered PACU complications. Patients in whom PACU complications developed were analyzed by ASA physical status. Of all patients experiencing nausea and vomiting (n = 1571), the highest percentage were ASA physical status II patients (n = 831). Likewise, in the group of 1450 patients who demonstrated a need for upper airway support, 792 were ASA physical status II. In patients experiencing a major cardiovascular complication, for example, variables associated with a greater risk of developing any PACU complications were ASA physical status (status II), duration of anesthesia (2–4 h), anesthetic technique, emergency procedures, and certain types of surgical procedures (orthopedic or abdominal). For patients admitted with a temperature of <35°C the duration of the PACU stay was 152 ± 46 min compared with 116 ± 65 min for patients with a temperature ≥36°C ($P < 0.01$). In conclusion, events occurring during the PACU period continue to be a source of patient morbidity.

(Anesth Analg 1992;74:503–9)

Historically, efforts to define and identify factors associated with increased patient morbidity have focused on the intraoperative period. Few studies have examined the relationship between intraoperative factors and events occurring later during the postanesthesia period (1–6). Studies by Cohen et al. (7) and Zelcer and Wells (1) have demonstrated that the overall incidence of complications occurring during the postanesthesia care unit (PACU) stay may be higher than previously expected (10%–18%). To establish a baseline rate of anesthesia-related events occurring both in the PACU and in the operating room, Cooper et al. (8) compiled data on 17,088 patients. They evaluated the incidence of "recovery room–impact events" (RRIE). An RRIE was defined as "an unanticipated, undesirable, possibly anesthesia related effect that required intervention, was pertinent to recovery room care, and did or could cause mortality or at least moderate morbidity." Although this study provided RRIE data, only 75% of all PACU admissions were included as participation was voluntary (at the discretion of the attending anesthesiologist). In addition, this study did not specifically record the overall PACU complication rate or identify specific variables that might be associated with development of these PACU complications. Therefore, to identify more precisely and to quantitate events associated with PACU complications, we conducted a prospective study to investigate the incidence of intraoperative and postoperative complications among 18,473 consecutive patients admitted to the PACU at a university-based hospital. We also hypothesized that a relationship may exist between intraoperative events and PACU complications. Therefore, the incidence of intraoperative complications and their impact on PACU events were also determined.

Methods

After approval from Yale University's Human Investigation Committee, a prospective study was performed on 18,473 consecutive patients (age range, 3 wk–92 yr) admitted to the PACU during the period from October 1986 through June 1989. Patients re-

Accepted for publication October 31, 1991.

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Table 1. Intraoperative and Postanesthesia Care Unit Complication Data Base—Definitions

Complication (%)
Any complication
Hypertension*
Hypotension*
Fluid challenge
Vasopressor
Dysrhythmia requiring treatment
Atrial fibrillation
Premature atrial contractions
Premature ventricular contractions
Tachycardia*
Bradycardia*
ST-segment changes
Other
Nausea/vomiting
Drug reaction
Sore throat
Stridor
Aspiration
Wheezing
Upper airway support
Short-term endotracheal tube
Pharyngeal
Manual
Nasal
Verbal
Major respiratory difficulty
Reintubation
Rule out myocardial infarction
Major cardiac event
Cardiorespiratory arrest
Angina
Myocardial infarction
Pulmonary edema
Shock
Ischemia
Other
Altered mental status
Confusion
Somnolence
Other

*Defined criteria: hypertension, diastolic pressure >110 mm Hg; hypotension, mean pressure <60 mm Hg; tachycardia, heart rate ≥100 beats/min; bradycardia, heart rate ≤50 beats/min.

quiring direct admission to an intensive care unit (ICU) after operation were excluded from the study. Complications were divided into the following categories: intraoperative, PACU, and combined (PACU and intraoperative) complications. A standardized form was used to collect data from the Anesthesia Care Team and the PACU staff, and a defined group of complications was identified (Table 1). The results of these were merged with a departmental data base. Data are expressed as percentage mean ± standard deviation. Statistical analysis was performed using χ^2, Student's-t test for unpaired data, and analysis of variance with $P < 0.05$ considered significant.

Results

Intraoperative Complications

The combined PACU and intraoperative complications rate was recorded at 26.7%. The overall intraoperative complication rate was recorded at 5.1% and the PACU rate was 23.7%. The proportion of patients sustaining both intraoperative and PACU complications was 1.6 times that of patients with a PACU complication alone (36.0% vs 22.1%). Of all complications encountered during the intraoperative period, hypertension and hypotension were associated with the greatest potential for the development of complications during the PACU stay. The proportion of patients who experienced both intraoperative hypertension and any PACU complication was 1.5 times (33.4% vs 22.7%) that of patients with PACU complications in whom intraoperative hypertension did not develop. Similarly, the development of intraoperative hypotension was associated with a 1.6 times larger increase in the overall PACU complication rate ($P < 0.01$). In addition, patients who sustained an intraoperative complication remained longer in the PACU than did those without intraoperative complications (135 ± 21 vs 110 ± 26 min, respectively; $P < 0.01$).

Variables found to affect the incidence of intraoperative complications are ASA classification, duration of anesthesia, anesthetic technique, emergency or elective procedure, and type of surgical procedure. The highest percentage of intraoperative complications was seen in the following patient groups: ASA status III patients (49.5%, $n = 3812$), those undergoing emergent surgical procedures (53.4%, $n = 3155$), or abdominal surgery (20.8%, $n = 3750$), or those undergoing procedures with a duration between 2 and 4 h (48.2%, $n = 10,144$), ($P < 0.01$).

PACU Complications

During this 2.5-yr study period, the overall PACU complication rate was 23.7% (combined PACU and intraoperative complication rate, 26.7%). A higher incidence of PACU complications was seen in those patients who received a general anesthetic than in those who were given either a regional or monitored anesthetic ($P < 0.001$). Of the patients studied, 15,213 (82.3%) received a general anesthetic; of these 25% experienced a PACU complication. Of the 2763 patients (18.1%) who were given regional anesthesia, only 13.5% had a PACU complication ($P < 0.01$).

The type of surgical procedure performed was found to have a considerable impact on the overall incidence of PACU complications. The complication rates accompanying vascular, chest, orthopedic, ab-

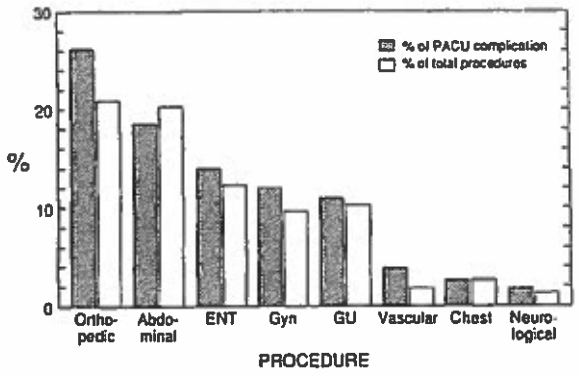

Figure 1. Percentage of PACU complications by surgical procedure and percentage of patients undergoing a specific procedure. It is evident that the greatest percentage of PACU complications occurred in patients having either abdominal (18.6%) or orthopedic procedures (26.2%).

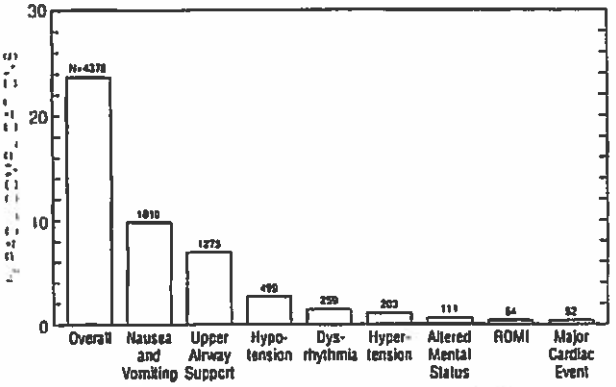

Figure 2. Major PACU complications by percentage of occurrence and number (above the bar) of patients experiencing each complication. Nausea and vomiting was the most frequently observed PACU complication, occurring in 9.8% or 1610 patients.

dominal, neurosurgical, otolaryngologic, urologic, and gynecologic procedures are shown in Figure 1. Abdominal and orthopedic procedures were associated with a statistically significant increase in the overall PACU complication rate when compared with all other surgical procedures ($P < 0.01$). Abdominal procedures resulted in a PACU complication rate of 18.6%, whereas orthopedic procedures were associated with a rate of 26.2%.

The major PACU complications by percent occurrence are illustrated in Figure 2. Of all recorded complications, nausea and vomiting was the most frequently observed (9.8%). Nausea and vomiting is influenced more by the operative procedure (i.e., abdominal, gynecologic vs orthopedic or urologic, $P < 0.01$) than by the choice of anesthetic technique (i.e., general vs regional). Upper airway support was required in 6.9% of patients. Further examination of these data (patients requiring upper airway support)

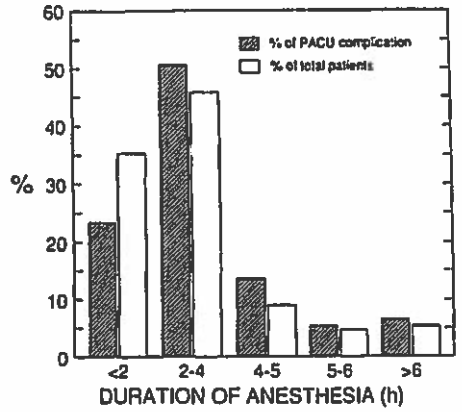

Figure 3. Anesthetic duration and its impact on PACU complications. Patients whose anesthetic duration ranged between 2 and 4 h experienced the greatest number of PACU complications (51.2%).

shows that 47% of the patients were managed with nasal airway support whereas 24% received pharyngeal airway support. Only 21 of all patients requiring prolonged airway support (0.02%) required tracheal reintubation (which was the subject of a separate report) (9). Pulse oximetry was not routinely available during the early phase of the study at our institution; therefore, data on the overall incidence of hypoxemia was not collected. However, during the last 6 mo of the study, oxygen saturation monitoring was performed continuously on all PACU patients. A total of 3540 patients included in our data base of 18,473 were examined after the introduction of this routine pulse oximetry monitoring. Of these patients, the percentage that had a room air saturation <90% at the time of discharge was only 3.2% (421 patients).

With regard to specific cardiovascular complications, hypotension requiring treatment was observed in 2.7% (498 patients) of the entire study population. Dysrhythmias requiring treatment and, most frequently, sinus tachycardia occurred in 1.4% (259 patients). Hypertension requiring treatment of diastolic pressure ≥110 mm Hg was recorded in 1.1% (203 patients) of the patients studied. Major cardiac events defined as either pulmonary edema or myocardial ischemia had the lowest recorded complication rates of 0.1% (18 patients) and 0.3% (54 patients), respectively. Although these specific cardiovascular complications were observed during the PACU period, no cardiac arrests occurred during the study period.

The largest number of PACU complications occurred among patients with a duration of anesthesia between 2 and 4 h, 51.2% ($P < 0.01$) (Figure 3). Of those patients whose anesthetic duration was less than 2 h, only 22.6% sustained a PACU complication, whereas a complication rate of 13.4% was seen with an anesthetic duration between 4 and 5 h. In addi-

Table 2. PACU Complications by ASA Physical Status

ASA physical status	I	II	III	IV	V	n
Patients studied	4214	9749	3812	684	15	18,473
Nausea and vomiting	473	831	206	11	0	1521
Upper airway obstruction	291	792	318	49	9	1275
Hypertension	5	93	99	16	0	213
Hypotension	73	286	148	40	1	548
Dysrythmias	40	164	136	32	0	372

tion, 11.5% of patients whose anesthetic duration exceeded 5 h sustained a PACU complication.

Physical status as assessed by ASA physical status classification was an important factor in determining the incidence of overall and specific PACU complications (Table 2). In this study population, 76% of the patients (13,963) studied were ASA status I and II with the remaining 24% (4510) representing ASA status III–V. With regard to ASA status, 12.6% of ASA I and II patients experienced a PACU complication, whereas only 4.8% of those in ASA class III and IV were noted to have a complication during this period. Patients who experienced nausea were compared on the basis of their ASA physical status (Table 2). Using these criteria, 54.5% were ASA II, 31.1% were ASA I, and 13.5% were ASA III. Similarly, in patients requiring prolonged upper airway support, 54.6% were ASA II; 21.9%, ASA III; and 20%, ASA I. When cardiovascular complications were analyzed based on physical status, the following was observed: hypertension—46.5% ASA III, 43.5% ASA II, 7.5% ASA IV, 2.4% ASA I; hypotension—52.2% ASA II, 27.1% ASA III, 13.3% ASA I, 7.3% ASA IV; dysrhythmias—44.1% ASA IV, 36.6% ASA III, 10.8% ASA I, 8.6% ASA II.

The requirement for an emergency operative procedure (vs an elective procedure) also increased the risk for the development of PACU complications ($P < 0.01$) independent of ASA physical status, operative procedure, or anesthetic technique. For example, the relative risk of sustaining any PACU complication was 1.52 times as great for an emergent compared with elective procedure.

Temperature was an additional factor affecting PACU events. The duration of PACU stay correlated with the patient's body temperature at admission (Figure 4). Of all patients entering the PACU during the study period, the mean tympanic membrane temperature on admission was 36.6 ± 0.85°C. However, if the tympanic temperature on admission to the PACU was less than 35°C, patients remained for 152 ± 46 min ($P < 0.01$). The duration of the PACU stay for a patient with temperature between 35° and 36°C at admission was 129 ± 60 min. For a patient whose

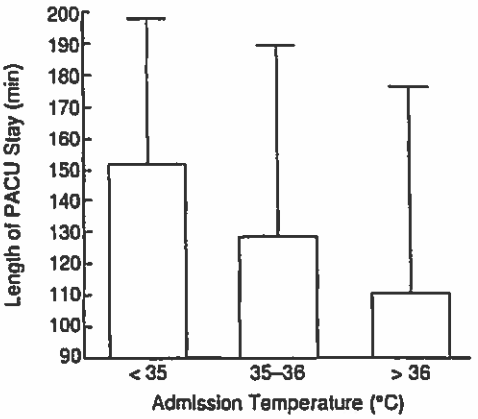

Figure 4. The patients' body temperature at admission also had an effect on the development of PACU complications. The duration of PACU stay as a function of temperature at admission is shown. The duration of PACU stay was significantly reduced in patients whose temperature at admission was ≥36°C ($P < 0.01$).

temperature was ≥36°C on arrival at the PACU, the duration of stay decreased to 111 ± 65 min.

In addition to identifying PACU complications, the incidence of unscheduled postoperative ICU admissions was also recorded. Of all patients studied, 18 required an unscheduled ICU admission. Of these, 5 were admitted to rule out myocardial infarction (ROMI). Of note, only four of the patients admitted to the ICU for ROMI actually sustained a postoperative myocardial infarction. However, two of these four patients (50%) died during their hospital stay of complications associated with their myocardial infarction. The remaining two patients were transferred to the ICU, having undergone a more extensive surgical procedure than was initially planned.

Discussion

The original concept for a postanesthesia care area is credited to Florence Nightingale (10). Traditionally known as the "recovery room," this area was initially designed as a place for observing postoperative patients (11,12). As the nature of patient care has become increasingly complex, interest in identifying complications that occur during this period has increased (13,14). Early studies were aimed primarily at defining the incidence of overall morbidity and mortality. Cohen et al. (7) described the outcome of a 9-yr postanesthetic follow-up program at a teaching hospital between the time periods 1975–1978 and 1979–1983. Their data showed a 7.6% intraoperative complication rate and a 3.1% PACU complication rate for 1975–1978. During the time period of 1979–1983, there was an increase in both intraoperative and PACU complication rates to 10.6% and 5.19%, respec-

tively (7). Zelcer and Wells (1) examined the frequency of PACU complications occurring during a 1-mo period. This prospective study showed that 30% of patients admitted to the PACU had at least one complication; the most frequently observed were abnormal cardiovascular variables (either hypotension, hypertension, or arrhythmias) in 68 of 443 patients (15.3%), nausea and vomiting in 24 of 443 patients (5.4%), and respiratory complications (cyanosis, hypoventilation, reintubation, and laryngeal spasm) in 10 of 443 patients (2.3%).

Despite this early interest in postanesthesia complications, more recent studies have been concerned with evaluating a specific practice or technique rather than defining or identifying particular complications occurring during the PACU period (15–18). To provide a more global assessment of the frequency of PACU complications, this present study combines a large prospective patient population with a detailed data collection system. The data from this study demonstrates that approximately one in five patients (23.7%) experience a PACU complication. Our data show a larger incidence of PACU complications than has been previously reported by either Cooper et al. (8) (18%) or Cohen et al. (7) (9.4%). This may reflect differences in reporting techniques or patient populations, or both. Despite anesthetic and pharmacologic advances, nausea and vomiting is still the most frequently encountered postanesthetic problem (9.8%). As reported in previous studies, the incidence of nausea varies from 5% to 60% depending on the type of surgical procedure performed (19–22). Although various pharmacologic regimens have been advocated to reduce postoperative nausea and vomiting, our data show that nausea and vomiting continues to be a major source of patient morbidity (23,24).

Of all classes of respiratory events (airway obstruction, hypoxemia, and hypercapnia) studied here, prolonged upper airway support (to treat or prevent upper airway obstruction) was the most frequently encountered complication (6.9% of 18,473 or 1275 patients). The average duration of this support, which was either manual support of the jaw or insertion of oral or nasal airway, was 39.9 ± 8.6 min. However, only 0.02% of the PACU patients required reintubation in the PACU (9). The incidence of airway obstruction in our study is significantly larger than in previous reports (2%–4%) (25,26). As this study was performed in a tertiary referral hospital with an anesthesia residency program, the higher incidence of airway obstruction might be partly related to reporting techniques and/or to the degree of training and experience of the persons providing anesthesia. Indeed, a study of Mandel et al. (27) demonstrated that the incidence of PACU complications was affected by the training level of the anesthesia residency staff and the time of the academic year.

Although upper airway obstruction was the most frequently observed PACU complication in this study, clinical signs of hypoxia were infrequently noted. A recent report by Moller et al. (26) showed that as many as 55% of patients may experience hypoxia (diagnosed as oxygen saturation (Spo_2) < 90% by pulse oximetry) during the PACU period. The difference between the percentage of patients who experienced a reduction in Spo_2 in the two studies (i.e., 3.2% of patients in this study compared with 55% of patients in Moller's study) may reflect a difference in data collection techniques. In Moller's study, Spo_2 values were continuously monitored by strip chart recording. However in our study, Spo_2 measurements were only intermittently recorded by the nursing staff.

The significance of perioperative cardiovascular events has recently become a source of great interest (28–30). Although hypotension requiring treatment was encountered in 2.7% of the study patients, only 20% of patients required the administration of a vasopressor. The majority of hypotension events (80%) were successfully treated by volume administration. The potential risks of perioperative hypertension and tachycardia have been well documented (30–32). The overall incidence of PACU dysrhythmias and hypertension was low in our study (1.4% and 1%, respectively); these were the most frequently cited reasons for an unscheduled ICU admission (for ROMI). The appearance of a new ventricular dysrhythmia was associated with statistically greater risk ($P < 0.01$) for myocardial infarction to develop. Of the 54 patients in this study who experienced a new perioperative ventricular dysrhythmia and were admitted to the ICU for ROMI, four had electrocardiographic or enzymatic evidence consistent with a perioperative myocardial infarction. That two of these four patients (50%) died during their hospital stay as a result of complications from their recent myocardial infarction emphasizes the potential clinical importance of new-onset perioperative dysrhythmias. Of the 54 patients admitted for ROMI, 23 were ASA II, 16 were ASA III, and 15 were ASA IV. The most frequent reason for these patients' ROMI admission was the onset of *new dysrhythmias in the PACU or intraoperative hypertension*. Only two of these patients who were admitted for ROMI because of new-onset arrhythmias had a history of dysrhythmias. Of the two patients who died, both had a history of previous myocardial infarction but not within the last year. Both patients who sustained a perioperative myocardial infarction had electrocardiographic evidence of ischemia associated with ventricular and atrial arrhythmias intraoperatively or in the PACU. Only one

patient had electrocardiographic changes suggestive of ischemia in the intraoperative period.

The importance of maintaining normothermia has long been recognized (33). Hypothermia during the PACU period may prolong the effects of pharmacologic agents and cause shivering, resulting in an increased myocardial oxygen consumption and patient discomfort. The physiologic implications of hypothermia (i.e., increased myocardial oxygen consumption and metabolic rate) are compounded by the increased dollar cost incurred by these hypothermia patients owing to a prolonged PACU stay (34). Although others have postulated that hypothermia may affect PACU stay, our data demonstrate the significance of the impact of hypothermia on PACU duration. The mean duration of the PACU stay was recorded at 102 ± 56 min. Patients admitted to the PACU with a temperature of ≤35°C had a significantly longer PACU stay (159 ± 46 min) than did those with a temperature of ≥35°C (116 ± 65 min). These data suggest the importance of using devices that reduce cutaneous heat loss (such as warming blankets) during the intraoperative period (35–38).

The ability of intraoperative events to be associated with PACU complications was also demonstrated in this study. Although operating room complications had an overall rate of only 5.1%, they significantly increased the risk (1.6–1.8 times greater, depending on ASA physical status and PACU complication) of experiencing a PACU complication. This is evidenced by the incidence of PACU complications being higher with intraoperative hypertension and hypotension.

In summary, results from this study show that complications occurring in the PACU remain a significant source of patient morbidity. Nausea and vomiting and upper airway obstruction continue to represent the most frequently observed PACU events. Several factors were identified as potential predictors of PACU complications. These included the site of surgical procedure, duration of anesthesia, ASA physical status, anesthetic technique, and elective versus emergent procedure. This study showed that patients who were ASA I and II experienced more PACU complications than did those patients who were ASA III or greater. There are several possible explanations for this. First, all patients requiring a direct admission to the ICU were excluded from the study, greatly reducing the number of ASA III and IV patients that were included in the study population. Second, the most frequently observed PACU complications were nausea and vomiting and the need for combined upper airway support. As many of the patients in the ASA physical status III–V groups may have arrived in the PACU tracheally intubated, they would not have been at risk for these complications to develop. The data from this study strengthen and support the importance of vigilant patient monitor during the postanesthesia period.

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