A Description of Intraoperative and Postanesthesia Complication Rates

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This article reviews the current rate of intraoperative and postanesthesia complications in an acute care hospital and Level II Trauma center. One thousand patients were assessed for intraoperative and postoperative complications and compared with a previous study from 1991 in a different institution. The overall rate of complications in this current study indicated an overall complication rate (combined intraoperative and PACU) of 26% with an intraoperative rate of 3.8% and a PACU rate of 23.4%. Although a slight improvement from a study in 1991, there continue to be many similarities.

EFFORTS TO IDENTIFY factors associated with increased mortality of postanesthesia patients have focused on intraoperative and postanesthesia adverse reactions. Anesthesia care has changed dramatically in the past decade.[1] Among the significant improvements are various airway devices available such the laryngeal mask airway, the development of quickly reversible inhalation drugs such as sevoflurane, new reversal agents such as flumazenil, and the use of the transesophageal echo to better assess patients' tolerance of anesthesia. The use of pharmacologic agents now includes the administration of prophylactic antiemetics, pre-emptive analgesia, as well as new and improved short-acting anesthetic agents.[2]

As Cooper[3] noted in a 1987 study, the overall incidence of complications in the PACU may exceed the 10% to 18% rate for the incidences of "recovery-room impact events" (complications). Impact events were defined as "unanticipated, undesirable, possibly anesthesia related effects that required intervention, were pertinent to recovery room care and did or could cause mortality or at least moderate morbidity."[3] In still another study of 37,071 patients published in the *Canadian Journal of Anesthesiology*, the authors reported respiratory complications as high as 15.2%, cardiovascular 12.3%, and postoperative nausea and vomiting 9.4%.[2]

This current study revisited the most commonly observed intraoperative adverse reactions and the occurrence of PACU Phase I complications. For the purpose of this study a recovery impact event is referred to as a complication. The author then compared the rates to the Yale University School of Medicine study published in 1991.[4] Most studies of mandatory case reporting are either more than 10 years old, or group intraoperative and postoperative problems together in the study. Until more studies are completed or mandatory reporting is required in every state, these complication rates can be used internally for quality comparisons. If an event occurs more commonly than is acceptable, the process can be analyzed and corrective measures implemented, and quality measurements repeated.

Costly Complications—A Ripple Effect

In a study performed by the Agency for Healthcare Research and Quality,[5] data on eighteen

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complications that were sometimes caused by medical errors were analyzed, and the results were surprising. The agency found that postoperative complications contribute to 2.4 million extra days spent in the hospital every year. More than 32,000 US hospital deaths and more than nine billion dollars in extra costs per year are attributed to postoperative infections and surgical wounds that accidentally reopen, and other preventable complications.[5]

When severe enough, complications may require unplanned admission to the hospital, lengthen recovery time, set up the possibility for further complications, and cause financial burdens. Needless to say these aspects negatively affect patient and family satisfaction levels as well as healthcare costs. In a more recent study by Barclay,[6] 28 of 1,055 patients assessed had a postoperative complication within 7 days of elective nonthoracic surgery. The mean age of the group was 55 years. Of those 28 patients with complications, 13 patients developed respiratory complications requiring invasive ventilatory support with a mean length of stay of 27.9 days. Those who did not have a complication had an average stay of 4.5 days.

Definitions

Anesthesia types were classified as general, regional, and sedation with monitored anesthesia care only.[7] General anesthesia is commonly referred to as inhalation anesthesia using agents such as enflurane, desflurane, forane, or sevoflurane with nitrous oxide.[8] Regional anesthesia refers to the use of local anesthetic agents to block nerve conduction in an extremity or a region of the body. This type of anesthesia can reduce the transmission of painful impulses for 2-6 hours. The patients with regional anesthesia in this study received spinal regional blocks.

Sedation anesthesia with "monitored anesthesia care" refers to patients requiring intravenous agents such as barbiturates (sodium pentothal or brevital), nonbarbiturates (etomidate, propofol), and tranquilizers (diazepam, midazolam, or lorazepam). In addition, an opioid was often added to the regime accompanied by local anesthesia administered by the surgeon. Drugs in this category include meperidine, morphine, and fentanyl. The anesthesia provider will frequently combine several agents to produce pain relief, amnesia, and decreased anxiety. One of the benefits of sedation with or without local anesthesia is that of minimal airway support required from the anesthesia provider.

Methods

After approval from the Institutional Review Board (IRB) of Sharp Memorial Hospital, a prospective study was performed on 1,000 randomly selected patients between September 2004 and January 2005. Patient consent was waived by the IRB and only a portion of the medical record number was used as an identifier. The average number of patients admitted to this PACU is 600/month with ages ranging from 17 to 89 years. The nurses were assigned to collect data by lottery fashion. Of the 7 to 8 PACU nurses working on a particular day, the names of two nurses were randomly selected. Those nurses then recorded data on every patient they were assigned to care for in the PACU during their eight-hour shifts. The nurse used a different numbered paper form to record patient data. A standardized collection tool was used to collect data. The data and definitions for complications were based on the Yale study.[4] Because the criteria were well defined the nurse was able to establish, through the verbal report from the anesthesia provider and review of the intraoperative vital signs and treatment rendered, whether the patient qualified as having experienced a complication during the intraoperative phase. Each individual complication was counted only once either observed in the operating room, the PACU, or both. For example, if a patient met the criteria for hypotension, requiring an intervention in the operating room, and suffered the same complication in the PACU, that was only counted as one incident.

Table 1. Definition of Complications Observed Requiring Treatment

Interventions
• Hypertension (defined as diastolic pressure >110 mm Hg)
• Hypotension (defined as a mean arterial pressure <60 mm Hg)
• Tachycardia (heart rate ≥ 100 beats/minute)
• Bradycardia (heart rate ≤ 50 beats/minute)
• Upper airway support with either maneuvers or adjunct equipment
• Reintubation and mechanical ventilation
Major Events
• Cardiorespiratory arrest
• Angina
• Myocardial infarction
• Pulmonary embolism

Only patients arriving between the hours of 7:00 AM and 11:00 PM were included in the study. Exclusion criteria included pregnant patients and those designated for admission to an ICU. Therefore, the group used for data collection excluded patients after heart surgeries, craniotomies with intracranial pressure devices, and open abdominal aortic aneurysm resections. Obstetric patients also were excluded because their care is provided at another hospital on campus dedicated to women's health issues.

Demographics

Of the 1,000 patients evaluated, 49.2% were male and 50.8% were female. No cardiac arrests or deaths were noted. Emergent cases accounted for 6.8% of the patients evaluated, and elective cases 93.2%. All anesthesia care providers were physicians from the same anesthesia group.

Classification of complications was reviewed before beginning data collection. The Yale study classified cardiac events by symptoms such as tachycardia, whereas respiratory complications were noted by the type of treatment rendered, such as reintubation. The decision was made to remain with the classifications used by Yale for this study (Table 1).

Intraoperative Phase

Results

In this study the combined OR/PACU complication rate was 26%. Data indicated the overall intraoperative complication rate was 3.8%. The majority of complications were hypertension 1.8%, hypotension 1.2%, and tachycardia 0.8% (Table 2).

Variables found to affect the development of intraoperative complications were ASA classification, duration of anesthesia, anesthesia type, and surgical procedure performed. The highest percentage of intraoperative complications was noted in patients with an ASA II status classification (251 of the 502 ASA II patients) followed by ASA class III patients (97 of 307), ASA class I (13 of the 113), and finally ASA IV (6 of 78) (Fig 1).

Of the 38 patients with intraoperative complications, orthopedic surgical interventions were the most common surgery type, followed by abdominal surgeries, renal procedures, urologic procedures, and other types measured (3.1%) (Fig 2). Examples of procedure types associated with complications were:

- Orthopedic: total hip arthroplasty, total knee arthroplasty, ORIF of the hip and ulna;

Table 2. Comparison of Intraoperative Complication Rates Yale (1991) and Sharp Memorial (2005)

	Yale Medical Center 1991 (n = 18,473)	Sharp Memorial Hospital 2005 (n = 1,000)
Intraoperative complication rate	5.1%	3.8%
Hypertension	2.2%	1.8%
Hypotension	1.6%	1.2%
Tachycardia	1.3%	0.8%

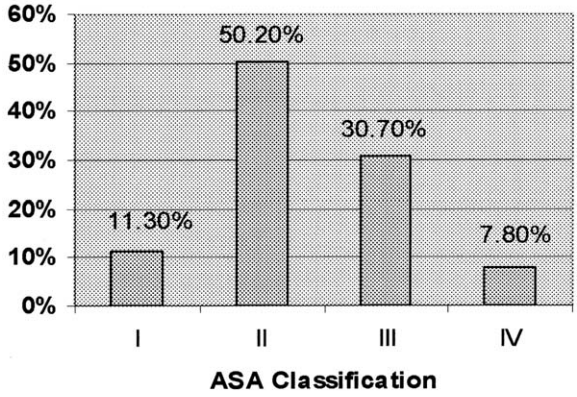

Fig 1. Intraoperative complication rates by ASA class, Sharp Memorial 2005.

- Abdominal: laparoscopic cholecystectomy, laparoscopic and open hemicolectomy, exploratory laparotomy, and ventral hernia repair;
- Renal: renal transplant recipient, donor and nephrectomy;
- Urologic: prostatectomy, cyctoscopy; and
- Other: AV graft revisions, femoral-popliteal bypass grafting, cardiac ablation, endovascular aortic aneurysm repair, laryngectomy, thyroidectomy, and mastectomy.

While reviewing the duration of anesthesia, complications in the operating room phase were most prevalent for anesthesia lasting between 2 and 4 hours. Patients with complications undergoing anesthesia for 2 to 4 hours were 362 of 540, anesthesia lasting 4 to 5 hours were 76 of 362, and finally anesthesia less than 2 hours were 7 of 66 (see Fig 3). Rose[9] noted an

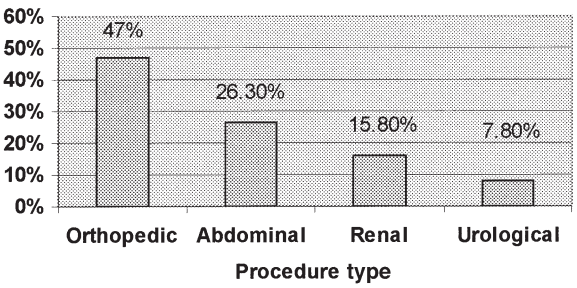

Fig 2. Comparison of complication rates by type of surgical procedures, Sharp Memorial 2005.

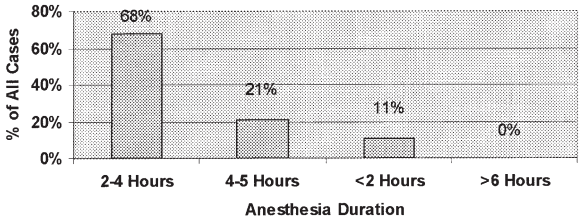

Fig 3. Intraoperative complication rate by duration of anesthesia, Sharp Memorial 2005.

increase in pulmonary complications with an anesthesia duration of >2.5 hours that also was noted in this study.

Discussion

Proper planning, assessment, and evaluation of patients undergoing anesthesia are optimal to achieving the best outcome.[9] It was interesting to note that the group of patients undergoing emergent procedures did not present with an abnormally increased number of adverse reactions. Patients in the emergency group included impending airway obstruction, perforated viscus, or dead bowel and trauma patients. These patients received the minimal level of preoperative testing usually ordered by the anesthesia provider immediately before the procedure such as blood work, electrocardiograms, chest radiographs, medication history, diagnostic testing, patient education, and verification of a fasting state.[10,11] In some cases the only history available was that of the paramedic team or the patient's family. Proposed reasons for the low incidence of complications in this group include the skill and experience of the anesthesia provider, OR, and PACU teams in dealing with a large number of trauma patients admitted to this facility.

PACU Phase I

Overall Results

The PACU overall complication rate was measured at 23.4% (234 patients). During the PACU Phase I period the most common complications observed were the need for upper airway support to achieve a patent airway 39.5%, nausea and vomiting 30.5%, tachycardia 13%, hyperten-

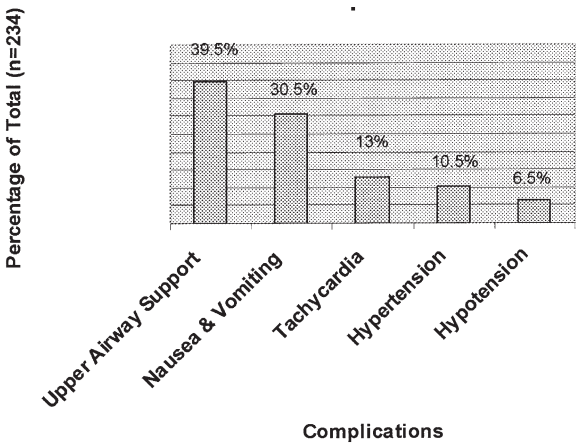

Fig 4. PACU complications.

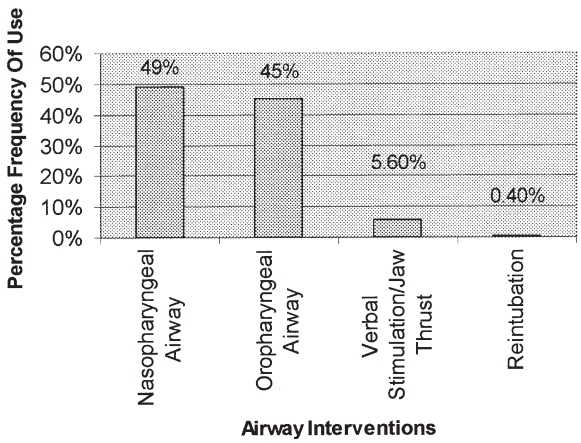

Fig 6. PACU airway interventions.

sion 10.5%, and hypotension 6.5% (Fig 4). Of the 234 patients who had a complication while in the PACU, 79% received general anesthesia, 15.8% received spinal regional anesthesia, and 5.2% received sedation with monitored anesthesia care only. The type of surgery performed also affected the overall PACU complication rate and was higher for patients who were postabdominal surgery, followed closely by renal surgery and urologic surgery (Figs 4 and 5).

Airway Support

Of the 234 patients who had postoperative complications, 50.8% (119) cases required some airway assistance. Of those 119 patients, 76% occurred in patients after receiving general anesthesia, 18% after receiving regional/spinal anesthesia, and 6% in the group after receiving intravenous sedation. Of the 119 patients requiring airway assistance, 94% required either a nasal or oropharyngeal airway; 5.6% verbal stimulation, manual jaw thrust, or a combination of techniques; and 0.4% required reintubation (Fig 6). Of this subset group that needed airway support, 66.7% were male and 33% were female. None of the patients requiring upper airway support were emergency procedures. The majority of patients were classified as ASA Class III (54%), followed by ASA II (21.2%), ASA IV (19%), and finally ASA I (5.8%). Average duration of anesthesia was 2.2 hours.

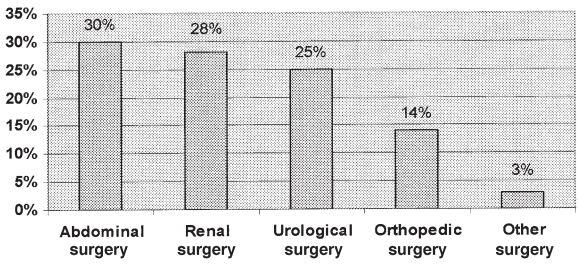

Fig 5. PACU complications by surgical procedure.

Respiratory complications are among the most frequently observed difficulties in the postanesthesia period.[12] Hypoventilation is commonly related to the effects of residual inhalation agents. PACU nursing staff are highly trained in implementation of various airway adjuncts and are able to quickly identify complications such as incomplete neuromuscular blockade reversal, laryngospasm, and stridor. These nurses are competent to institute emergency standing orders in lieu of an anesthesia provider's presence and can prepare and administer nebulized inhalation bronchodilator agents as indicated. This may account for the low rate of reintubations noted in the PACU.

Nausea and Vomiting

Nausea and vomiting were noted in 4.0% of the population who presented with complications and was influenced more by the type of anesthesia than the surgical procedure itself. Of the 40 patients presenting with nausea, only 5%

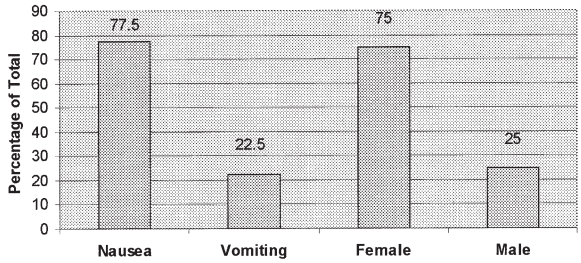

Fig 7. Postoperative nausea and vomiting.

received regional/spinal anesthesia; all others received general anesthesia. No increased incidence of nausea and/or vomiting was associated with any particular type of surgery. Of the 40 patients who had nausea and/or vomiting, nausea was reported in 77.5% patients and vomiting occurred in 22.5% of cases. Of this group, 25% were male and 75% were female (Fig 7).

Of this group of 40 patients, 67.5% were elective surgeries. As for ASA risk classification, the majority were ASA II (52.5%), followed by ASA III (32.5%), ASA I (11%), and ASA IV (4%). The average length of anesthesia was 2.7 hours. Nausea was treated with ondansetron 48%, metoclopramide 22%, dolasetron 18%, dexamethasone 14%, and/or promethazine 10%. All patients received an intraoperative prophylactic dose of at least one antiemetic including either ondansetron, dolasetron, metoclopramide, or a combination.

Risk factors associated with increased incidence of postoperative nausea and vomiting include long duration of anesthesia, inhalation anesthetics, intraoperative opioids, reversal agents, and even specific elective procedures that include gynecologic, laparoscopic, middle ear, orchiopexy, termination of pregnancy, and strabismus surgery. Other preexisting factors that increase the chances of postoperative nausea and vomiting are female gender, the premenstrual period, smoking, use of opioids, diabetes, and a history of postoperative nausea and vomiting and/or motion sickness. Postoperative risk factors that have been identified include the presence of pain, hypotension, hypoxemia, hypoglycemia, gastric bleeding, increased intracranial pressure, inadequate hydration,[9,13] use of opioids, anxiety, and early oral intake.[14] If postoperative nausea and vomiting is untreated, one third of postoperative patients will be affected.

The low rate of postoperative nausea and vomiting observed was in part due to optimal hydration by the anesthesia team accompanied by the judicious use of opioids, especially in patients with a known history of nausea and vomiting. Of the patients reporting nausea or experiencing emesis in the PACU, the input and output record indicated the patients were in a positive fluid balance by an average of 1,200 mL.

Because the antiemetics are similarly effective and act independently, the safest or least expensive agents should be used first with prophylaxis rarely warranted in low-risk patients. Moderate risk patients may benefit from a single intervention (drug) and multiple agents should be reserved for high-risk patients.[15] This adverse reaction to anesthesia needs to be treated aggressively to improve patient satisfaction and decrease hospital costs. The cost of treating postoperative nausea and vomiting in the United States has been estimated to cost several hundred million dollars per year.[15]

Hypertension

Hypertension was observed in 12% of the patients with complication. Among this group, 50% received general anesthesia, 33.3% received regional anesthesia, and 16.7% received sedation. Of the 28 patients with hypertension, 25% were ASA class II, 25% were ASA III, and 50% were ASA IV. Among the patients who required treatment for hypertension, 58.3% were male and 41.7% were female.

The average length of anesthesia was 2.7 hours. Treatment chosen by the anesthesia care team included one or more agents such as labetalol (92%) and/or hydralazine (50%). None of the

cases observed in the PACU with hypertension required continuous infusions of intravenous antihypertensives. Some procedures, including abdominal aneurysm repair, carotid endarterectomy, and intracranial surgery, have been associated with a higher incidence of hypertension.

More than half of the patients who developed hypertension during the PACU phase had a preexisting history of hypertension. If hypertension occurs it is most likely to occur within the first 30 minutes after admission.[7] In postanesthesia care, this increase in blood pressure can be induced by pain, urinary retention, hypothermia, nausea, hypoxia, hypercarbia, myocardial ischemia, or the impairment of blood flow to any major system.[7,14] Postoperative hypertension is often found in conjunction with arteriosclerotic disease.[16] Arteriosclerosis is thought to promote an exaggerated response to stimuli that may generate vasoconstriction.[7]

The relatively low incidence of postoperative hypertension may well be due to the thorough preanesthesia assessment performed by the anesthesia team who frequently manage patients with high cardiac risk factors. The PACU nursing staff is also adept at rapid physical assessment of these patients, identification of the most commonly seen causes of hypertension, and timely institution of treatments while observing the postoperative electrocardiogram.

Tachycardia

Tachycardia was observed in 12% of these patients. All patients who experienced this complication received general anesthesia with the duration of anesthesia averaging 2 hours. Of these patients, 33% were male and 67% were female. Fifty percent were ASA Class II, 26% were ASA Class III, and 15% and 9% were ASA Class IV and ASA Class I, respectively.

When evaluating surgical procedure types that were related to the tachycardia, appendectomies accounted for 42% followed by thyroid resections (25%). Tachycardia was treated successfully with volume challenge concurrently with opioid analgesics such as hydromorphone and beta blockade such as metoprolol.

Common causes for tachycardia in the PACU include pain, hypovolemia, anemia, fever, hypoxia, and hypercapnia.[7] Pain in the PACU is probably the most common cause of tachycardia.[2] Pain may originate not only from the surgical incision site, but may also be present due to an overdistended bladder or even a strain resulting from positioning during the procedure. The nursing staff continually assess postoperative clients for commonly observed causes of tachycardia and intervene aggressively to prevent tachycardia while maintaining an adequate cardiac output and peripheral perfusion as indicated by adequate urine output, peripheral pulses, and brisk capillary refill.

Hypotension

Hypotension was observed in the PACU in only 6.5% of the patients with complications. Of this subset, 54% received general anesthesia and 44% regional spinal anesthesia. Hypotension occurring in the OR did not necessarily result in hypotension in the PACU. In the group of patients with documented hypotension, 44 patients were post total knee replacement surgery, 11 underwent transurethral prostate resections, and 10 were post laparoscopic nephrectomy. Hypotension was treated with one or more of the following: the administration of fluid challenges (crystalloids and 5% albumin solutions) (77%); neosynephrine boluses administered by the anesthesia providers (8%); and phenylephrine administration (25%). The total percentage was greater than 100% because a combination of therapies were used with some of the patients.

New-onset hypotension in the PACU is almost always a sign of an unwanted medication interaction, hypovolemia, or blood loss.[13,14] Other causes can include expo-

sure of body cavities for prolonged periods, the handling of bowel and mesentery, as well as dissections in the retroperitoneal space. The specific treatment of hypovolemic hypotension is to restore adequate circulating intravascular volume.[7] This team of anesthesia providers and surgeons strive to offer state-of-the-art pain management. Because many of the patients undergoing total joint hip and knee replacements received a spinal regional block along with a dose of intrathecal opioid, it is very common to note some degree of hypotension. The postanesthesia orders from physicians include specific individualized interventions for treatment of symptomatic hypotension, such as volume boluses and ephedrine as needed. Most patients receive a postoperative hemoglobin and hematocrit level to guide in the decision of whether to transfuse blood products. The use of autotransfusion devices is also commonly observed.

Conclusion

Since the advent of anesthesia delivery there have been complications. Studies in the late 1970s described a complication rate of 7.6% intraoperatively, with 3.1% occurring in the PACU.[9] These reported rates of adverse reactions from anesthesia have steadily increased. In 1987, Zelcer and Wells[17] reported a 30% complication rate for 443 patients admitted to the PACU. Cardiovascular effects were cited in 15.3%, nausea and vomiting in 5.4%, and respiratory complications in 2.3%.

The slight differences noted in this current study as it relates to the 1991 Yale study may reflect differences in patient selection/ASA grouping, improved techniques of anesthesia delivery, and preemptively treating the patient for the most commonly seen complications. Another difference between the studies is the total number of patients who were a part of this study (1000) compared with the Yale study (18,473). This paper has analyzed the frequency of various types of complications. It remains an important challenge to define and record those adverse events that are best suited as indicators of the quality of the anesthesia process.

In future studies, other institutions should perform their own studies of adverse perioperative events to serve as a baseline determination. The most frequent complications can be identified, interventions modified, and the results can then be measured and analyzed. Other studies should include admission temperatures and pulse oximetry readings and the correlation to postoperative events, especially those related to respiratory impairment.

This study continues to reinforce that the PACU is a critical care setting. Although the percentages of some complications have improved, they still occur. It is imperative for the PACU clinician to monitor patients closely, report adverse reactions, and intervene promptly by instituting nursing and medical interventions. Despite advances in both pharmacologic agents and anesthesia techniques, the rate of complications is similar to the studies in the 1990s.

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References

1. Backman S. Perioperative considerations for anesthesia. In: Simon S, ed. *American College of Surgery: Principles and Practices.* New York, NY: Web MD Professional Publishing; 2005:36-39.

2. Mayson K. The incidence of postoperative complications in the PACU [abstract]. *Can J Anesth* 2005;52:A62.

3. Cooper JB. Effects of information feedback and the incidence of postanesthesia complications. *Anesthesiology* 1987;67:686-694.

4. Hines R. Complications occurring in the postanesthesia care unit—A survey. *Anesth Analg* 1992;74:503-509.

5. Zhan C, Miller MR. Excess length of stay, charges, and mortality attributable to medical injuries during hospitalization. *JAMA* 2003;290:1868-1874.

6. Barclay L. Postoperative complications. *Anesth Analg* 2004;99:140-145.

7. Drain C. *Perianesthesia nursing: A critical care approach.* 3rd ed. Philadelphia, PA: Saunders; 2003.

8. Cheney F. Changing trends in anesthesia-related death. *Am Soc Anesthesiol* 2002;66:6.

9. Rose K. Planned and unplanned postoperative admissions to the ICU. *Can J Anesthesiol* 1996;43(4):333-340.

10. Rashig S. Preoperative patient assessments. *Can J Anesthesiol* 2003;50:348-354.

11. DeLamar L. Preparing your patient for surgery. *J Adv Pract Nurs* 2005;5:1.

12. McAlister F. Pulmonary complications after nonthoracic surgery. *Am J Crit Care Med* 2005;171:514-517.

13. Holte K. Liberal versus restrictive fluid administration. *Ann Surg* 2004;240(5):892-899.

14. White P. Prevention of postoperative nausea and vomiting—A multimodal solution to a persistent problem. *N Engl J Med* 2004;350:2441-2450.

15. Gan TJ. Postoperative nausea and vomiting—Can it be eliminated? *JAMA* 2002;287(10):1233-1236.

16. Cooperman LH. Hypertension in the immediate postoperative period. *Br J Anesth* 1975;47(1):70-74.

17. Zelcer J, Wells DG. Anaesthesia related recovery room complications. *Anaesth Intensive* 1987;15:168-174.