Rapid Recovery from Ambulatory Surgery: The New Paradigm in Ambulatory Anesthesia

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INTRODUCTION
Ambulatory surgery continues to expand with complex patients having several comorbid conditions undergoing complex and invasive surgical procedures. Simultaneously, there is emphasis on enhanced postoperative recovery that has been shown to facilitate early discharge home and early resumption of normal daily activities. The process of enhanced recovery starts preoperatively and continues until the patient returns to activities of daily living. It involves preoperative optimization of patients’ health, use of anesthetic techniques that optimize surgical conditions while ensuring rapid recovery with minimal side effects, prevention of common postoperative complications, and aggressive rehabilitation with the aim of restoring the patient to the best health possible. This requires a multidisciplinary approach to perioperative care in which the anesthesiologist can play a lead role. The aim of this presentation is to discuss the current evidence for optimal perioperative care that would allow rapid recovery after ambulatory surgery in adults.

PREOPERATIVE ASSESSMENT AND OPTIMIZATION
Preoperative assessment and optimization of comorbid conditions is associated with improved perioperative outcome. Also, this avoids delays and cancellations on the day of surgery. Similarly, appropriate patient selection is critical for reducing perioperative complications and improving outcome. Patient selection for ambulatory surgery depends upon several factors including patient-related factors (i.e., presence and severity of coexisting comorbidities), surgery-related factors (i.e., invasiveness of surgery and surgeon’s experience), anesthesia-related factors (i.e., type of anesthesia), and venue-related factors (i.e., hospital-based ambulatory surgery, free-standing ambulatory surgery center with or without overnight stay, and office settings).

ANESTHETIC TECHNIQUES FOR RAPID RECOVERY
An ideal anesthetic technique should provide smooth and rapid onset, optimal operating conditions, and rapid recovery, with minimal (if any) side effects. The choice of anesthetic technique (i.e., general versus regional anesthesia) is an important determinant of recovery after ambulatory surgery. Use of local anesthetic techniques including peripheral nerve blocks with or without sedation/analgesia allows rapid recovery, reduces time to home readiness, provides postoperative analgesia, and reduces opioid requirements. However, use of spinal anesthesia may prolong the postanesthesia care unit (PACU) stay as well as delay ambulation and time to home-readiness. Therefore, while the role of local/peripheral nerve blocks is increasing, the role of spinal anesthesia in ambulatory surgery is diminishing.

There is a lack of evidence regarding superiority of a specific general anesthetic technique (e.g., inhaled versus total IV anesthesia [TIVA]) with respect to discharge home after ambulatory surgery. The benefits of TIVA include the ability to provide general anesthesia without the need for an anesthesia machine. On the other hand, inhaled anesthetics exert some neuromuscular blocking effect, which may reduce the need for muscle relaxants and the potential for residual muscle paralysis.

It is necessary to avoid deep anesthesia, as it may delay emergence from anesthesia. Because different types of surgical stimuli (e.g., skin versus intracavity incisions) result in different degrees of hemodynamic response, the anesthetic and analgesic requirements may vary at different stages of the surgical procedure. However, determining the optimal anesthetic concentrations that would parallel the varying surgical stimuli, while preventing intraoperative awareness, remains challenging. Recent evidence suggests that titration of inhaled anesthetics using end-tidal concentrations (0.7–1.3 minimum alveolar concentration [MAC] values) and propofol TIVA using Bispectral Index monitoring should prevent intraoperative awareness with recall.

Airway Management
Supralaryngeal devices (e.g., laryngeal mask airway) have gained widespread popularity as general-purpose airway devices and are increasingly used for routine elective surgical procedures. Compared with the tracheal tube, these devices do not require muscle relaxation and laryngoscopy, and thus may prevent complications associated with tracheal intubation. These devices are tolerated at lower anesthetic concentrations than the tracheal tube and therefore allow titration of anesthetic concentrations to the surgical stimulus. With the patient breathing spontaneously, opioid requirements can be based on the respiratory rate while dosing requirements of sedative-hypnotic anesthetics can be titrated to end-tidal concentrations of inhaled anesthetics or brain function monitor. This may allow for an earlier emergence from anesthesia and improve perioperative efficiency. Although the safety of supralaryngeal devices in healthy patients has been established, their use in patients at high risk of regurgitation of gastric contents (e.g., gastroesophageal reflux disease, morbid obesity, laparoscopy, and lithotomy/prone position) remains controversial.

Inhaled Anesthetics
The choice of inhaled anesthetics (i.e., desflurane versus sevoflurane) remains controversial. Although clinical differences between desflurane and sevoflurane, with respect

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time to home readiness, appear to be small, several studies have reported more rapid emergence from anesthesia with desflurane. A study analyzing data from published randomized trials as well as data from an electronic database found that desflurane reduced the average tracheal extubation time and the variability of extubation time compared with sevoflurane.

**Nitrous Oxide**

Because of its amnestic and analgesic properties, nitrous oxide (N₂O) can reduce the requirements of anesthetic and analgesic drugs. However, the routine use of N₂O is questioned due to concerns of increased incidences of postoperative nausea and vomiting (PONV) and pressure effects through expansion of closed spaces. However, the clinical significance of these side effects in modern anesthetic practice has been questioned. A systematic review assessing the emetic effects of N₂O found that the overall impact of avoiding N₂O on the incidence of PONV was modest (absolute 33% vs. 27%). In addition, propofol induction and use of prophylactic antiemetics, which is the current standard of care for ambulatory surgery, may further negate the emetic effects of N₂O.

Another benefit of N₂O is that it facilitates the removal of other inhaled anesthetics (i.e., second gas effect), and allows rapid emergence from anesthesia. Furthermore, the analgesic effects of N₂O should reduce the need for intraoperative opioids and reduce opioid-related adverse effects. Of note, N₂O has been shown to reduce opioid-induced hyperalgesia as well as reduce the incidence and severity of persistent postoperative pain. Interestingly, a recent propensity-matched observational trial reported that N₂O reduced perioperative morbidity and mortality. A systematic review found that omission of N₂O significantly increased the risk of awareness.

Overall, N₂O can improve the quality and safety of induction and maintenance of general anesthesia as well as facilitate recovery with clinically insignificant adverse effects. Thus, there is no convincing reason to avoid N₂O.

**Muscle Relaxants and Reversal of Residual Neuromuscular Blockade**

Several studies have demonstrated that many patients return to the PACU with residual paralysis, defined as a train-of-four (TOF) ratio of <0.9, despite the signs of clinical recovery from neuromuscular blockade. Residual paralysis can increase the incidence of critical respiratory events in the PACU and prolong recovery time as well as increase postoperative morbidity and mortality. Residual paralysis may be particularly detrimental in patients with morbid obesity, sleep apnea and significant pulmonary disease.

The first step in reducing the incidence of residual paralysis is to use the smallest possible dose of muscle relaxant that will provide optimal surgical conditions, rather than to maintain a certain TOF count (e.g., one twitch of the TOF response). Because the clinical indicators currently used to detect return of neuromuscular function are not sensitive or specific and the TOF response has limited value at deeper levels of neuromuscular blockade, it is difficult to recognize residual paralysis in clinical practice. Nevertheless, anesthesia practitioners judge themselves as better skilled at avoiding residual paralysis than they do their colleagues, making them overconfident in their capacity to estimate recovery of neuromuscular function. Therefore, general opinion favors administration of an anticholinesterase inhibitor at the end of anesthesia unless quantitative methods of evaluation of neuromuscular function (e.g., acceleromyography) suggest adequate recovery (i.e., TOF ratio >0.9).

The questions commonly faced at the time of reversal include, should all patients receive a reversal? If so, should we always use a “full” dose of reversal? If not, what is the optimal dose of neostigmine? What is the optimal dose of glycopyrrolate?

Unwarranted administration of neostigmine (i.e., administration after recovery of the TOF ratio >0.9) can result in paralysis suggesting that neostigmine itself may have muscle-relaxant properties. Therefore, routine administration of a full dose of neostigmine may not be appropriate. Current evidence suggests that the dose of anticholinesterase inhibitor should be titrated to the intensity of neuromuscular blockade at the time of reversal. Importantly, TOF monitoring of the ulnar nerve at the wrist, rather than the eye muscles, should be used to determine the dose of neostigmine. A recent study has shown that patients having TOF monitoring of the eye muscles had a more than 5-fold higher risk of postoperative residual paralysis than those who had monitoring of the adductor pollicis. Of note, the ratio of neostigmine and glycopyrrolate should be 1:1 (by volume), in most cases.

Adherence to evidence-based practices related to neuromuscular blockade dosing, monitoring, and reversal has been shown to improve patient outcomes during the early recovery period.

**PERIPHERAL NERVE STIMULATOR ASSESSMENT AT THE ULNAR NERVE**

1. TOF count 4, with no fade - administer neostigmine 20 mcg/kg, ideal body weight
2. TOF count 4, with fade - administer neostigmine 30 mcg/kg, ideal body weight
3. TOF count 3 - administer neostigmine 40 mcg/kg, ideal body weight
4. TOF count 2 - administer neostigmine 50 mcg/kg, ideal body weight
5. TOF count 1 - administer neostigmine 60 mcg/kg, ideal body weight
6. No TOF response - delay reversal.

**Intraoperative Antinoception**

The sympathetic stimulation and hemodynamic responses from noxious surgical stimuli may be reduced by using N₂O, opioids, and non-opioid analgesics (i.e., the analgesic component). Opioids provide intraoperative analgesia, hemodynamic stability, and reduce requirements for hypnotic/sedatives. During induction of general anesthesia, laryngoscopy and tracheal intubation constitute profound noxious stimuli. Therefore, an opioid analgesic is commonly administered concurrently with an IV hypnotic/sedative (e.g., propofol) to provide clinically acceptable hemodynamic control. Also, opioids reduce anesthetic requirements. However, quantification of the drug
interaction (i.e., additive or synergistic) is difficult. There appears to be a “ceiling effect” of opioids in anesthetic interactions, as opioids do not reduce the MAC values of inhaled anesthetics by more than two-thirds.26,27

The questions commonly faced with respect to intraoperative opioid use include, what is the optimal opioid choice and dose at the time of induction of anesthesia. Also, what is the optimal opioid choice and dose in the intraoperative period? What is the optimal opioid choice and dose at the end of surgery that would provide optimal analgesia at the time of emergence without causing respiratory depression and delaying tracheal extubation?

The choice of intraoperative opioid is often based on empirical judgment. A rational opioid selection and dosing should contribute to rapid recovery after anesthesia. Fentanyl is the most commonly used opioid for intraoperative analgesia. Sufentanyl, a fentanyl analog, is approximately 10 times more potent than fentanyl with a similar onset of action. In contrast to fentanyl, the context-sensitive half-time of sufentanil is significantly shorter. Remifentanil has unique pharmacokinetics and ultra-short duration that allows optimal matching of the dose with the varying degree of surgical stimuli at different stages of surgery. In addition, the short and predictable duration of remifentanil make it suitable in the high-risk population such as the elderly, morbidly obese, and those with obstructive sleep apnea. However, there appears to be a learning curve with the use of remifentanil.28 Optimal dosing of remifentanil would include avoidance of bolus dosing and an initial infusion rate of 0.25 µg/kg/min.29 A recent study found that remifentanil 0.5 mcg/kg caused similar ventilatory depression as fentanyl 1 mcg/kg.30 Because of its rapid offset of analgesic effect, it is necessary that a longer-acting opioid or non-opioid analgesic be used to provide postoperative analgesia. The benefits of remifentanil may be realized if a non-opioid analgesic technique can be used.

Optimal opioid dosing at the time of induction and during maintenance of anesthesia remains controversial. It is common practice to use relatively larger opioid doses at induction of anesthesia (“front loading”), particularly in longer surgical procedures. However, the validity of this approach is questionable. Larger opioid doses may result in significant postinduction hypotension and need for pharmacological support. Also, this may increase the potential for acute tolerance as well as delayed hyperalgesia, which may increase the degree of postoperative pain.31 Higher intraoperative opioid doses may increase opioid-related side effects including nausea, vomiting, sedation, bladder dysfunction, and respiratory depression.

The need for intraoperative opioids is commonly based on hemodynamics (heart rate and arterial blood pressure). However, attempts to achieve “tight” hemodynamic control may result in use of larger opioid doses. Because intraoperative opioid overdose can only be recognized at emergence from anesthesia when the patient’s spontaneous ventilation is delayed, it is imperative that opioids are administered judiciously. In addition, the use of non-opioid analgesics to reduce the opioid-related side effects may minimize postoperative complications and expedite recovery.

As a plan for postoperative analgesia, it is common practice to administer a long-acting opioid towards the end of surgery. The choice of long-acting opioid includes morphine and hydromorphone of which hydromorphone is preferable due to its superior pharmacokinetics.32 Compared with morphine, hydromorphone has a shorter plasma:central nervous effect-site equilibration half-life. Hydromorphone has a quicker onset time and the concentrations at the effect-site do not increase after titration has stopped.32 Therefore, hydromorphone may be better suited than morphine for titration of acute pain. Morphine is poorly suited by titration for immediate analgesia, as delayed respiratory depression may result due to the slow transfer of morphine to the effect site.

The dosing for hydromorphone could be based on the studies of morphine. Morphine (2–3 mg every 5–10 min) titrated to achieve a respiratory rate of 12–15 breaths per minute during emergence from anesthesia can enhance postoperative analgesia and reduce PACU stay without increasing the incidence of respiratory depression.33 The total dose of morphine usually required is 0.15 mg/kg. This dose usually does not delay awakening or delay tracheal extubation.33

Intraoperative Mechanical Ventilation

Optimal intraoperative ventilatory strategy would include use of lower tidal volume (6–8 ml/kg, ideal body weight) with positive end-expiratory pressure.34 It is important to avoid hyperventilation as it may result in metabolic alkalosis and lead to postoperative hypoventilation. Most importantly, it is recommended that the end-tidal carbon dioxide (CO2) levels be maintained around 40 mmHg rather than the traditional values of 30–35 mmHg. Higher CO2 levels improve hemodynamics and improve tissue perfusion.

EMERGENCE FROM GENERAL ANESTHESIA

Towards the end of surgery, it is common practice to reduce the respiratory rate in an effort to build up end-tidal CO2 levels and facilitate respiration. However, the reduced minute ventilation resulting from this practice may delay removal of inhaled anesthetic, and thus delay emergence from anesthesia. Therefore, the primary aim at the end of the surgery should be to maintain the minute ventilation in an effort to washout the inhaled anesthetic and facilitate emergence.35 One of the major concerns during emergence from anesthesia, particularly in obese and sleep apnea patients, is the risk of airway obstruction after tracheal extubation. Rapid emergence from anesthesia should prevent this complication.

PREVENTION OF POSTOPERATIVE COMPLICATIONS

One of the major goals of an ideal anesthetic technique is prevention of postoperative complications particularly pain, nausea, and vomiting. The other postoperative complications that can impede recovery include cardiovascular alteration (i.e., hypotension, hypertension, and rhythm disturbances), respiratory complications (i.e., airway obstruction, hypoventilation, bronchospasm, and pulmonary
aspirin, temperature abnormalities, and surgical complications.

**Postoperative Pain Management**

The goal of pain management should be to minimize pain not only at rest, but also during mobilization and physical therapy. An ideal approach to optimal pain management starts with patient education, as it reduces anxiety, allows realistic expectation, and improves patient satisfaction. Procedure-specific, evidence-based analgesic techniques that are incorporated in a clinical pathway have the highest chances of being implemented consistently.36,37

Since the introduction of the IV formulation of acetaminophen, it has been increasingly used as a part of multimodal analgesia.38 An optimal multimodal analgesia technique would include acetaminophen combined with nonsteroidal antiinflammatory drugs (NSAIDs) or cyclooxygenase (COX)-2 specific inhibitors. The combination of acetaminophen and NSAIDs or COX-2 specific inhibitors has been shown to provide superior analgesia compared with either drug alone.39,40 The analgesic efficacy of COX-2 specific inhibitors is similar to that of the traditional NSAIDs. Because the COX-2 specific inhibitors spare the COX-1 enzyme, they do not have any antiplatelet effects. Thus, they can be administered preoperatively, as there is no concern of increased perioperative bleeding. However, in the perioperative period, the cardiovascular and renal adverse effect profile of COX-2 specific inhibitors seems to be equivalent to that of traditional NSAIDs. Of note, acetaminophen exhibits an analgesic ceiling effect similar to NSAIDs and COX-2 specific inhibitors.41

Infiltration of the surgical wound with local anesthetic can provide excellent analgesia that outlasts the duration of action of the drug and is recommended for routine use. Local anesthetic techniques provide pain relief until the onset of oral analgesics. The duration of analgesia can be increased by infusion of local anesthetics through a catheter placed in the layers of the skin. A new formulation of bupivacaine using liposomal technology which is reported to have a duration of up to 72 h has been recently been introduced into clinical practice. This may obviate the need for using continuous wound local anesthetic infusion. In addition, peripheral nerve blocks are increasingly being used to provide intra- and postoperative analgesia. The use of continuous perineural local anesthetic infusions after ambulatory surgery has been shown to extend the duration of analgesia and allow more extensive and painful surgical procedures to be performed on an outpatient basis. However, placement of these blocks may require preoperative and postoperative logistic planning.

Several systematic reviews have reported that dexamethasone 4–8 mg, IV administered either pre- or intraoperatively provides significant pain relief and reduces opioid requirements.42,43 A single dose of dexamethasone has not been shown to increase the incidence of surgical site infections, but it may increase blood glucose levels lasting for up to 24 hours postoperatively. However, the clinical significance of this increase in blood glucose levels is not known. Low-dose ketamine has been reported to reduce postoperative pain scores and opioid consumption as well as delay time to first opioid administration. A recent systematic review revealed that ketamine provided significant analgesic benefits in painful procedures including thoracic, upper abdominal, and major orthopedic surgeries.44 Interestingly, the analgesic effects of ketamine were independent of the type of intraoperative opioid administered, timing of ketamine administration, and the ketamine dose. The authors also concluded that the opioid-sparing effect of ketamine reduced the incidence of nausea and vomiting, but was associated with an increase in the incidence of neuropsychiatric disturbances.45 However, the role of low-dose ketamine as an adjunct to other non-opioid analgesics in ambulatory surgery remains controversial, as the optimal dose and duration of administration is unknown. The role of anticonvulsants (e.g., gabapentin and pregabalin) in the outpatient setting needs to be clarified by further investigation.

These analgesics should be administered on a regular “round-the-clock” basis with opioids used as “rescue” analgesics. Opioids should be used sparingly as opioid-related adverse effects delay recovery and return to activities of daily living. Tramadol, a weak opioid agonist and a weak norepinephrine and serotonin reuptake inhibitor, is commonly used in the perioperative period. Although it is generally well tolerated, side effects include nausea, vomiting, dizziness, and drowsiness. Also, tramadol has a potential to cause seizures, and therefore should be used with caution in patients with increased intracranial pressures, epilepsy, and in patients receiving neuroleptic drugs. It is contraindicated in patients receiving monoamine oxidase inhibitors.

**Postoperative Nausea and Vomiting**

Postoperative nausea and vomiting (PONV) are factors that can delay recovery. Although risk-based approaches for antiemetic therapy have been proposed,45 the compliance with these strategies has been shown to be poor. Therefore, prophylactic multimodal antiemetic therapy should be used in all ambulatory surgical patients. The number of antiemetic combinations could be based on the patient’s level of risk and surgical procedure.46 A combination of dexamethasone 4–8 mg, IV (after induction of anesthesia) and ondansetron 4 mg, IV (at the end of surgical procedure) could be used for most patients. Patients at very high risk of PONV (e.g., history of motion sickness, history of PONV, high opioid requirements for pain relief) may receive additional antiemetic therapy such as preoperative transdermal scopolamine or oral aprepitant. In addition, TIVA may be considered in these high-risk patients. Interestingly, a recent systematic review reported that metoclopramide 10 mg was effective in preventing PONV, and that it should be an alternative drug to prevent PONV.47 Patients requiring rescue antiemetic therapy in the immediate postoperative period could receive low-dose promethazine (6.25 mg, slow IV) or dimenhydrinate (1 mg/kg).

Postdischarge nausea and vomiting (PDNV) are common and are sometimes severe adverse outcomes for ambulatory patients.48 The independent predictors of PDNV include female gender, age younger than 50 years, history of PONV, opioids administered in the PACU, and nausea in the PACU. The overall incidence of PDNV can be determined by the presence of the total number of predictors.48
POSTOPERATIVE COURSE AFTER AMBULATORY SURGERY

In addition to achieving rapid emergence from anesthesia, it is necessary that the recovery process be modified to improve patient throughput. The first step is to change from traditional time-based to clinical-based discharge criteria from the PACU and the phase II unit. Use of appropriate scoring systems allows patients to be safely discharged from the PACU and to be discharged home. If the criteria used to discharge patients from the PACU were met in the operating room, it would be appropriate to consider bypassing the PACU and transferring the patient directly to the phase II unit.

A clearly defined process should be established to ensure safe and timely discharge home. Appropriate modification of current discharge criteria based upon recent literature should allow us to discharge patients expeditiously without compromising safety. The American Society of Anesthesiologists practice guidelines recommend that the ability to tolerate oral fluids should not be part of a routine discharge protocol but may be appropriate for selected patients (e.g., likelihood of complications if fluids are not taken). Similarly, a routine requirement for voiding before discharge should not be a part of a discharge protocol and may only be necessary in selected patients (e.g., the type of surgery performed, history of urinary retention and anesthetic technique used).

A clear and coordinated postdischarge plan is necessary. Patients should be encouraged to ambulate and resume activities of daily living as early as possible. It is important to recognize that home-readiness is not synonymous with street-fitness. Therefore, patients should be given clear instructions and cautioned against performing functions that require complete recovery of cognitive ability. Although a majority of surgical care is being performed on an ambulatory basis, there is limited information regarding outcome after discharge home.

SUMMARY

It is necessary to develop comprehensive, multidisciplinary, procedure-specific clinical pathways that involve the entire perioperative team (e.g., anesthesiologists, surgeons, pharmacists, and nursing). Preoperative patient education with clear instructions sets expectations, reduces patient anxiety and increases their satisfaction. The most important aspect of a general anesthetic technique is its ability to consistently achieve rapid recovery to patients’ normal functioning after termination of surgery. Thus, it is necessary to use anesthetic, analgesic, and muscle relaxant drugs judiciously. Avoidance of residual muscle paralysis is critical. Opioid-related adverse effects may be associated with delayed recovery and thus opioids should be used judiciously, and non-opioid analgesics should be used whenever possible. Prophylactic multimodal analgesia and antiemetic therapy are critical in achieving rapid recovery. Postdischarge planning should include prevention and treatment of postoperative complications particularly pain and antiemetic therapy. Perioperative outcomes (e.g., time to home readiness, time to actual discharge, unanticipated hospital admission, hospital readmission, patient satisfaction, morbidity and mortality) should be recorded.

REFERENCES

35. Joshi GP. The role of carbon dioxide in facilitating emergence from inhalation anesthesia: then & now. Anesth Analg 2012;114:933–4