COURSE #30764 — 15 CONTACT HOURS Release Date: 02/01/24 Expiration Date: 01/31/27

Postoperative Complications

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Faculty

Susan Engman Lazear, RN, MN, received her undergraduate education at the Walter Reed Army Institute of Nursing in Washington, D.C. After completing her BSN, she served as an Army Nurse at Letterman Army Medical Center in San Francisco for four years. She then attended the University of Washington School of Nursing and received a Master's in Nursing, specializing in Burn, Trauma and Emergency Nursing. After receiving her MN, she started Airlift Northwest, the air ambulance service based in Seattle which serves the entire Northwest region, including Alaska. Mrs. Lazear left the air ambulance service to start her own nursing education and consulting business, Specialists in Medical Education. For the past 20 years she has been teaching emergency nursing courses throughout the country. She lives in the Seattle area. Mrs. Lazear continues to teach and publish. She is both an editor and contributing author of Critical Care Nursing, published by W.B. Saunders Company, in June of 1992. She served as an author and reviewer of the Emergency Nursing Core Curriculum 6th Edition, published by W.B. Saunders Company in 2007. She has been named to the Who's Who in American Healthcare list annually since 1992.

Faculty Disclosure

Contributing faculty, Susan Engman Lazear, RN, MN, has disclosed no relevant financial relationship with any product manufacturer or service provider mentioned.

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The division planners and director have disclosed no relevant financial relationship with any product manufacturer or service provider mentioned.

Audience

This course is designed for all nurses and allied professionals involved in the care of patients who undergo surgical procedures, especially those who work in the preoperative area, the operating room, or the postanesthesia unit in hospitals or free-standing surgical centers.

Accreditations & Approvals

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Course Objective

The purpose of this course is to provide nurses and all allied health professionals who care for postsurgical patients the knowledge necessary to recognize and manage common postoperative complications, improving patient care and outcomes.

Learning Objectives

Upon completion of this course, you should be able to:

1. List the steps necessary to obtain an accurate and thorough assessment of patients before, during, and after surgery.
2. Identify information that should always be obtained during the assessment of the preoperative patient.
3. Review the common complications of patients undergoing abdominal, orthopedic, cardiovascular, respiratory, neurologic, obstetric/gynecologic, and genitourinary surgeries.
4. Describe the development, progression, and management of postoperative nausea and vomiting (PONV).
5. Discuss the signs,symptoms, and treatment of malignant hyperthermia.
6. Review the implications of hypothermia, pain, and complications related to positioning in postsurgical patients.
7. List the most common respiratory complications following surgery and how to identify and manage these complications in the postanesthesia care unit (PACU).
8. Describe the cardiovascular complications that may disrupt the postoperative period and the appropriate interventions for each.
9. Discuss the development and management of postoperative neurologic complications.
10. Describe the process to appropriately assess and manage the patient with a volume status complication in the postoperative period.
11. Outline the steps to managing postoperative ileus.
12. Identify the signs andsymptoms, risk factors, and management of postsurgical renal insufficiency.
13. Describe the anatomic and physiologic differences between children and adults and determine how these differences impact postoperative care and complication development.
14. Identify the anatomic and physiologic differences between elderly and adult patients and the impact that these differences have on the development of postoperative complications.
15. Develop a protocol to be instituted in the PACU to limit the development of postoperative complications in the morbidly obese patient.

E B
EVIDENCE-BASED PRACTICE RECOMMENDATION

Sections marked with this symbol include evidence-based practice recommendations. The level of evidence and/or strength of recommendation, as provided by the evidence-based source, are also included so you may determine the validity or relevance of the information. These sections may be used in conjunction with the course material for better application to your daily practice.

INTRODUCTION

Postoperative complications are a constant threat to millions of individuals undergoing surgical interventions. Whether patients are managed in a hospital setting, an ambulatory care facility, or in a free-standing operating suite, the development of postoperative complications can lead to long-term disability and possibly death. Healthcare professionals caring for patients during the postoperative period should be alert to complication risks and institute measures for risk reduction.

Hospital discharge statistics demonstrate changes in hospitalization and trends. While many patients are being treated in the outpatient setting, the elderly population is increasingly using inpatient resources [1]. With the advent of new technology, new medications, and minimally invasive procedures, the frequency of surgical operations continues to increase. The procedure with one of the greatest increases in frequency is knee replacements. In 2014, the American Academy of Orthopaedic Surgeons (AAOS) reported that the rate of knee replacements for patients between 45 and 64 years of age increased by 188% between 2000 and 2009 [2]. Among this age group, this trend is expected to continue, with a projected increase of 149% of total knee replacements between 2020 and 2040 [92]. While knee replacements were originally considered an elderly person's procedure, younger patients have chosen to have the procedure done to enhance their lifestyle. Patients are no longer willing to live with pain and disability when the problem can be fixed. However, with this increase in procedures comes an increase in potential complications. One of the greatest risks for the knee replacement patient is the development of deep vein thrombosis (DVT). The good news is that it is possible to anticipate who is at risk and institute risk reduction measures earlier in the course of care.

In 2010, approximately 35.1 million inpatients were discharged from short-stay hospitals [3]. The patients varied in age from infants to adults older than 100 years of age, with 51.4 million procedures performed [3]. In 2010, procedures on the cardiovascular system were common, with 2.7 million procedures performed. Procedure rates varied by sex; men were more likely to have a cardiovascular procedure, while women were more likely to have an operation on the digestive system [4]. Approximately 43% of all procedures performed on women were obstetrical in nature [4].

Management of postoperative complications requires astute assessment throughout the operative cycle. Preoperative assessment is critical to ascertain which patients are at risk for complication development. Preoperative personnel should evaluate each patient for their medical history, medication use, physical limitations or disabilities, previous surgical and/or anesthesia history, and psychosocial and emotional status. Operating room personnel should be vigilant for factors that increase the risk for postoperative complications, including positioning of the patient, the temperature of the operating suite and equipment used, and the length of the surgical intervention. Certain measures can be instituted while the patient is under anesthesia to prevent complication development in the postoperative phase of care.

The staff caring for the patient in the postoperative environment may have the greatest impact on preventing complication development. Awareness of complication development is the first step in risk reduction. Complications can occur at various periods in the recovery phase. The risk of developing hypotension, myocardial infarction, and respiratory depression is greatest in the first postoperative day. Between days 1 and 3, the risk of congestive heart failure, pulmonary embolus, and respiratory failure increases. Pneumonia generally occurs between days 4 and 7, while cerebrovascular accident and sepsis occur most commonly between 8 and 30 days postoperatively. Other complications, such as cardiac arrhythmias and gastrointestinal (GI) tract bleeding, occur throughout the postoperative period at an equal rate [5; 103].

Postoperative personnel should review the history and physical status of the patient as well as the operative report to identify risk factors. If noted, measures should be instituted to reduce the risk. Identification of at-risk patients is the key to successful risk reduction. This course will provide necessary information in a straightforward approach. Patient assessment will be presented in a logical, step-by-step format. Complications of the major body systems will be discussed, focusing on symptom recognition and risk reduction measures. Finally, a review of postoperative complications in pediatric, elderly, and morbidly obese patients will be offered. It is imperative that any healthcare professional caring for the postoperative patient, whether in the postanesthesia care unit (PACU) or the surgical unit, be aware of these risks. With successful reduction and early recognition of these complications, the patient's risk of life-long disability and/or death will be greatly diminished.

ASSESSMENT OF THE POSTSURGICAL PATIENT

Reducing the risk of postoperative complications can be accomplished with a thorough assessment of the patient upon arrival in the PACU. Risk reduction measures should be instituted early in the course of care to decrease the incidence of complicating factors that can lead to prolonged disability and even death. Awareness of patients who are at risk can alert staff to potential complications. Many of these complications are addressed in detail throughout the remainder of this course and will be introduced here.

A systems assessment should be completed within the first few minutes of arrival in the PACU. A report should be received from the operating room personnel accompanying the patient to the PACU. With this information in mind, a plan of care can be developed to ensure the safety and rapid recovery of the postsurgical patient. Reassessment should be performed on a regular, ongoing basis to ensure that changes in patient condition are recognized and treated early. Readiness for discharge is based on the patient's postoperative status, which should be consistent with the baseline values identified in the preoperative phase of care. Protocols are generally established for such care.

Two phases of care are established for postoperative management. There is also an extended care management phase, but this course will primarily focus on phases I and II [96].

The American Society of Peri-Anesthesia Nurses (ASPAN) defines postanesthesia phase I as the immediate postoperative period. This time is when basic life-sustaining measures are of the highest priority in patient care. Phase I includes airway support, hemodynamic stability, and pain control. During postanesthesia phase II the patient is prepared for discharge home or to an extended care environment for the remainder of recovery [96].

Airway, breathing, and circulatory responses (ABCs) are the first parameters to be assessed. Patients may be admitted to the PACU with an endotracheal tube in place to ensure airway patency. While the patient is transferred from the transport gurney to the PACU bed, this tube may become dislodged; tube patency and location should be checked immediately upon admission. Other patients will be admitted to the PACU without an airway device in place; these patients should be positioned to prevent aspiration, and airway patency should be assessed until the full return of protective reflexes.

Breathing adequacy should be assessed, breath sounds should be auscultated, and oxygen saturations should be monitored continuously. Hypoxemia is one of the most common complications to develop in the postoperative phase of care, and patients at risk can be identified at this early juncture. Patients who received neuromuscular-blocking agents (i.e., paralytic agents) in the operating room are at risk for weak ventilatory effort and the loss of respiratory drive. Assessing patients' return to function can be performed with a nerve stimulator device, if necessary. Supplemental oxygen may be used in the early phase of care to ensure adequate gas exchange.

Postoperative circulatory status should be identified upon admission. Volume depletion or volume overload should be treated early to prevent stressors upon the cardiovascular system. Volume replacement should be continued if ordered, and signs of volume status, including urine output measurements, should be performed. Peripheral tissue perfusion should be evaluated; signs of impending circulatory compromise should be identified and managed early to prevent tissue destruction. Cardiac monitoring should be performed to identify patients at risk for cardiac conduction disturbances, including dysrhythmia formation.

Vital sign assessment is performed on a regular basis. Initial admission vital signs may not be consistent with those obtained in the preoperative phase of care. According to ASPAN, patients' vital signs should be taken every 5 minutes for the first 15 to 30 minutes of initial stabilization in phase I, decreasing to once every 15 minutes for the length of the patient's phase I PACU stay. During phase II postoperative care, the ASPAN recommends that vital signs be taken every 30 to 60 minutes and include admission and discharge vital signs from the PACU. If the patient must remain in the recovery area due to lack of admission placement, vital signs can be obtained in similar fashion of their destination care unit protocol [95].

Inhalation anesthetics have vasodilator capabilities, and it is common for the patient to be initially hypotensive in the recovery phase. Anticholinergic medications, such as atropine, may have been administered; if so, the patient will exhibit an increased heart rate. Respiratory effort may be weak due to residual muscular blockade, and oxygen saturations may be altered secondary to several factors, including hypothermia and hypoxemia. Over the course of care in the PACU, vital signs should normalize and be consistent with those obtained prior to surgery. However, this generalization should be tempered with the statement that not all vital signs obtained before surgery are "normal." A patient who is anxious in the preoperative phase of care may have an abnormally high blood pressure and pulse rate, and the vital signs obtained in the PACU may be more consistent with the true "normals" of the patient.

Postoperative neurologic status is also important to assess, recognizing that the patient will continue to fluctuate from an alert status to a somnolent state. Over the course of care, the patient should begin to awaken and remain lucid. Initially, the patient will not be oriented and will need reminders as to place and time. The risk of emergence delirium is higher in pediatric patients and should always be considered when managing young children. Children may awaken in a state of fear and become combative, increasing the risk of harming themselves. Ensuring a safe recovery environment is critical to preventing these complications. Elderly patients may experience a delayed awakening state, which can be caused by many factors.

Rarely do patients awaken from general anesthesia with a loss of motor or sensory function, although these functions should be assessed. Patients who undergo local or regional anesthesia should be evaluated for return of sensory and motor control as well. Monitoring the return of function with a dermatome chart will allow for recognition of full function.

Assessing pain, which is considered the "fifth vital sign," should be performed as soon as the patient is stabilized in the PACU. Pain location, intensity, duration, and quality should be evaluated. Treatment of pain should not be delayed due to concerns over vital signs. Using a multimodal approach to treatment will ensure that the patient receives a variety of measures to assist with pain control. Pain management should be reassessed frequently, and new or changed reports of pain should be evaluated and treated.

Wound and skin assessment should be performed, including assessment of the surgical site. Skin integrity should be evaluated at the surgical site as well as any areas that were prone to pressure while under anesthesia. Positioning of patients in the operating room can put increased stressors on skin, and pressure areas should be identified in the recovery period. Ensuring a proper anatomic position in the recovery area can reduce the risk of further complications.

Core body temperature readings should be attained. Hypothermia is common in the postoperative phase and can complicate healing and return to a normal state. Obtaining core temperatures using infrared tympanic monitors and temporal thermometry has been recommended as the preferred noninvasive route of temperature measurement in this setting. However, obtaining core temperature measures via endotracheal, pulmonary artery, nasopharynx, or tympanic membrane (via a thermocouple) may be more accurate. The site chosen should be used consistently throughout the preoperative, perioperative, and postoperative phases [6; 104]. It is important to recognize that accuracy will vary depending on the site, the device used, and the patient's condition. Patients should be assessed for chills and shivering as signs of hypothermia. Forced warm air devices may be used to assist in raising the core temperature of those patients who are hypothermic in the recovery area. If a temperature reading seems erratically low or high, a recheck is required.

Complaint of nausea and vomiting is frequent in the recovery phase. It is important to determine which medications, if any, were administered in the operative phase of care to manage postoperative nausea and vomiting (PONV). If a class of drugs is not working and the patient continues with complaints of nausea, the recommendation is to switch to another class. Vomiting is not common; however, should it occur, there are multiple risks to the patient.

The GI and genitourinary (GU) systems require assessment. The shape and size of the abdomen should be noted, and any alteration should be reevaluated every 15 to 30 minutes. Patients with abdominal drains and/or Foley catheters should have output measured regularly. These patients have an increased risk of DVT development and should be positioned to reduce this risk.

Medication administration should be considered. Intravenous sites should be assessed for patency, as catheters commonly remain in place until the time of discharge. Antibiotic therapy may be initiated in the PACU. If this is the case, the patient should be evaluated for any signs of developing an allergic response, including hives and swelling of the face and mouth. The timing of follow-up medications should be identified and charted to ensure a smooth continuum of care.

Patients often leave the operating room with many drains and tubes. These devices should be checked for proper functioning and the sites documented. Nasogastric, urinary, and chest drainage should be collected, measured, and noted on the intake/output record. Blood collection drains should be monitored; subsequent fluid intake is often calculated on these losses. Continual assessment should be performed to ensure that the tubes and drains are not occluded or kinked, preventing their normal functions.

Fluid and electrolyte status should be assessed when time permits. Blood loss, third spacing of fluids (i.e., when fluid is lost to the surrounding tissues), and the NPO status of the patient can all impact fluid balance in the recovery phase. Electrolyte measurement should be undertaken as ordered. Monitoring the cardiac conduction system via electrocardiograph (ECG) will allow for recognition of possible life-threatening dysrhythmia formation secondary to electrolyte imbalance.

The emotional state of the patient should be included in the postsurgical assessment. Surgical interventions cause anxiety for many, and upon awakening, patients may be concerned about the outcome of the surgery. Children will benefit from a parent's presence, which helps to ease the fear of the unknown. Spouses or significant others may be allowed to visit when the patient's condition warrants these visits.

Many PACUs use scoring systems for the evaluation of the patient's readiness for discharge. The most common scoring system is the Aldrete Scoring System. The Aldrete Scoring System consists of five clinically significant parameters that reflect the patient's physiologic recovery from anesthesia: muscle activity, respiration, circulation, consciousness, and color. Each category is assigned a score of 0–2, with a maximum possible total score of 10 [97]. These scoring systems allow the staff to follow the patient's recovery and calculate a score documenting their improvement. The scores that assess for consciousness, breathing, oxygenation, circulation, and movement are the most commonly used in determining readiness for discharge. If scores are obtained upon admission, then on a repeat basis, the patient will demonstrate improvement in these vital parameters. When complications arise, they may be evidenced in either a decreasing score or a lack of improvement in the score.

CARDIOVASCULAR SURGERY

Each patient population is at risk for specific postoperative complications. As the population ages and technology advances, the ability to correct and repair cardiac disturbances is becoming more common across the lifespan. Patients undergoing cardiovascular procedures require constant cardiac monitoring during the first few days postoperatively. These patients are at heightened risk for dysrhythmias and hypoxic events. Often, specialized indwelling catheters will remain in place for measurement of cardiac pressures and function. Alterations in cardiac function should be immediately reported to the surgeon and cardiologists in charge of the patient's recovery.

The stressors of surgery place a huge strain on the heart, and compensatory mechanisms are limited. Alteration in medication administration to support cardiac function is performed to support the injured myocardium. Heart surgery patients may also experience a significant amount of pain when an open procedure is performed. Less invasive procedures are being performed more frequently, but open-heart procedures are still numerous. The disruption of the integrity of the chest cavity is very painful, and good pain management is critical to ensure that the patient cooperates with the postoperative exercises that are required to speed recovery. Ventilatory effort should be assessed regularly to ensure that patients are able to clear secretions, preventing the development of pneumonia. Incentive spirometry should be initiated as soon as possible. In one study, patients who utilized nurse-guided incentive spirometry two days preoperatively and two days postoperatively had fewer cases of atelectasis and dyspnea after cardiac surgery than those who received non-spirometry therapies [98]. As for all patients, an assessment of all body systems should be undertaken to make certain that no other issues or complications go undetected.

ABDOMINAL SURGERY

Abdominal surgeries may be performed using a variety of approaches, including laparoscopy. Patients who undergo these procedures should be instructed to support their abdomen and surgical site when coughing or moving to reduce stress upon the incision site. The size and shape of the abdomen should be monitored at regular intervals, and any change should be immediately reported to the surgeon. Accurate intake and output measurements should be maintained, including the volume of fluid lost through drains. If possible, nausea and vomiting should be well controlled, as retching will put stress on the surgical site. Patients undergoing stoma formation should have the site regularly assessed for color and condition of the new stoma. These patients are at risk for fluid and electrolyte imbalances, especially hypovolemia, and assessment and replacement should be continued in the recovery period. Due to the length and extent of the procedures, abdominal surgery patients are commonly hypothermic upon return to the PACU. Patients undergoing abdominal procedures are at increased risk for DVT, paralytic ileus, infection, and wound dehiscence [7; 8]. In addition, laparoscopic abdominal procedures may result in shoulder pain due to gas inflation of the abdomen.

ORTHOPEDIC SURGERY

Fracture repairs, total hip and/or knee replacements, and amputations are a few of the commonly performed orthopedic procedures. Slightly more women than men have these procedures; it is postulated that the bone loss that occurs in postmenopausal women puts them at increased risk of injury requiring surgical repair [9]. Patients who have orthopedic procedures require accurate assessment of their neurovascular status, including color, pulses, temperature, capillary refill, sensation, and movement of the affected area [10; 11]. In the immediate postoperative period, these assessments should be completed at the same intervals as vital signs [95]. Body alignment should be maintained, as ordered. Supplemental traction devices, casts, or braces should be assessed for pressure areas. Edema is common, and elevation of the affected limb can reduce this risk. DVT risk is higher in this group of patients than any other patient population [10; 11]. Therefore, recommendations for DVT prophylaxis should be closely adhered to. Compartment syndrome may develop. The patient may be at risk for osteomyelitis, and hypovolemia is common in the postoperative phase. Patients undergoing amputation require close monitoring of their distal perfusion.

RESPIRATORY TRACT SURGERY

Surgery on the respiratory tract carries a high risk of postoperative hypoxia and respiratory compromise. The goals of postoperative care in these patients include optimization of respiratory function, liquefaction and mobilization of secretions, and re-expansion of the lungs. Patients will likely be admitted to the PACU with one or more chest tubes in place. It is vital that the integrity of these tubes be maintained to allow for drainage and reinflation of the lung. Thoracic procedures may be accompanied by a significant amount of blood loss intraoperatively; therefore, volume assessment and the infusion of fluids and blood products should be continued in the PACU. Many of these patients are admitted with an endotracheal tube in place and require mechanical ventilatory support. Patients should receive supplemental oxygen and humidification to prevent accumulation of secretions in the respiratory tract. Pain is a significant issue, and management of pain should be instituted with consideration of the effects of narcotics on the respiratory drive. One study found that patients who underwent a video-assisted thoracoscopic surgery and used incentive spirometry postoperatively had a lower incidence of pneumonia (5.5%) than those who did not engage in incentive spirometry (6.1%) [99]. As soon as tolerated, chest physiotherapy can be initiated to prevent and/or treat atelectasis. Postoperative pneumonia is common; prophylactic antibiotics are ordered to reduce this risk.

NEUROSURGERY

Neurosurgeries require extensive training and care during the operative and postoperative phases. For this reason, many centers do not perform these types of interventions. Rather, there are specialized care facilities at centers throughout the country to perform neurosurgeries. Neurosurgical patients often require ICU care due to the nature of the procedure. In the recovery period, these patients require astute, frequent assessment of their neurovascular status. The patient's status often improves as the patient is rewarmed and electrolyte imbalances are corrected. Rises in intracranial pressure (ICP) should be prevented, if possible. Proper positioning is important to ensure drainage from the cranial vault. In addition, the patient should be instructed to limit activities that increase ICP, including coughing and straining. Good pulmonary hygiene is important to prevent respiratory infection and limit rises in ICP. Complications following neurosurgical interventions include postoperative hypertension, shivering, seizures, and changes in cerebral blood flow, all of which can be harmful to successful patient outcomes. Metabolic disorders can develop postoperatively, including diabetes insipidus, which, if not treated, causes a significantly dehydrated state leading to poor cerebral perfusion. Preventing further neurologic deterioration is critical to the optimal care of the patient undergoing a neurosurgical procedure.

OBSTETRIC/GYNECOLOGIC SURGERY

The most common procedure performed in female patients is a cesarean delivery [4; 12]. Obstetric and gynecologic surgeries include not only deliveries but hysterectomies, fibroid removal, and dilatation and curettage, among others. The use of the laparoscopic approach when possible has increased tremendously in this patient population, and this has reduced the risk of certain complications in the postanesthesia period. Pain and psychological support may be a significant part of the postanesthesia care of these patients. Complications include disseminated intravascular coagulation (DIC), postpartum hemorrhage, and hypovolemia due to blood loss. Monitoring patients' cardiovascular status during the first few hours post-surgery is essential.

GENITOURINARY SURGERY

The most commonly performed GU procedures include correction of problems of voiding, repair of congenital defects, and prostate surgery. Included in this group of patients are those undergoing interventions to repair or correct problems of the renal system. Many of these surgical interventions are lengthy, and pressure area development is common not only due to the length of surgery but also the position of the patient while under anesthesia. Accurate intake and output are critical to ensure fluid homeostasis. Drainage systems can become blocked by clots, and the tubes should be monitored to ensure that they remain patent. Transurethral resection of the prostate (TURP) syndrome, whereby the patient develops a fluid overload state secondary to absorption of the irrigating fluid, can develop in male patients undergoing a transurethral removal of the prostate. This leads to a vascular overload, causing pulmonary and cerebral edema. Postoperative management of patients' fluid and electrolyte status is critical for a successful outcome.

OPHTHALMOLOGIC SURGERY

Patients who have undergone an ophthalmologic procedure require special assistance in the recovery period. These patients may return to the PACU with eye patches over one or both eyes, which limits their ability to orient themselves to time or place. Ophthalmologic patients generally have a significant amount of pain that must be managed. Controlling rises in intraocular pressure (IOP) should be considered; vomiting, coughing, performance of the Valsalva maneuver, and pain lead to IOP rise and subsequent wound dehiscence. Signs of increasing IOP include pain around the orbit, blurry vision, changes in visual fields, and nausea. Osmotic diuretics are used to help manage rises in IOP.

ORAL AND FACIAL SURGERIES

Oral, maxillofacial, neck, and ear, nose, and throat (ENT) procedures put patients at increased risk of airway loss after surgery. Swelling and edema formation can cause pressure on the trachea and the carotid arteries. Ice packs may be applied to reduce swelling, and humidification is used to decrease bronchial constriction. When the oral cavity is involved, it is not uncommon for salivary flow to increase; this requires the use of suction to ensure the airway does not become blocked and the use of volume replacement fluids to prevent hypovolemia. Transient bacteremia can develop, leading to temperatures of 39°C to 39.5°C. Antibiotics are often administered to prevent further system sepsis from developing. Other complications that may develop in the recovery phase of care include pneumothorax or air embolus, which may begin to develop in the operating suite.

The management of the postoperative patient includes not only a good assessment and history but also recognition and awareness of potential complications that can develop in the PACU. If the staff can "prepare for the worst," (including ready access to a tracheotomy set and supplies) then management of the patient will progress smoothly without unrecognized obstacles to safe care.

CASE STUDY

Patient A is a man 37 years of age who arrives in the PACU following surgical removal of his gallbladder. Surgical intervention using the laparoscopic approach is successful.

Patient A's airway and ability to maintain respiratory stability are evaluated immediately. His respiration is 16 breaths per minute, and his heart rate is 78 beats per minute. Oxygen is being administered at 2 liters via nasal cannula. A pulse oximeter is placed on his left forefinger, and his oxygen saturation is measured at 95%. The patient is arousable but easily drifts off to sleep.

A transfer of care report on the patient is received from the operating room staff. His operative course was unremarkable. Patient history obtained during the preoperative phase of care showed that he was a 2 pack per day smoker, and he denies taking any prescribed or over-the-counter medications. Patient A's weight is documented as 110 kg.

Further assessment of the patient demonstrates normal skin perfusion with good capillary refill in all extremities. He has a drain in his abdomen with a small amount of yellowish discharge. The wound site and sutures are clean and dry without bleeding or discharge. No Foley catheter is in place; when questioned, he denies the need to void. Completing a head-to-toe assessment shows no other alterations from Patient A's baseline.

Patient A wakes when the second set of vital signs is obtained. He reports that his pain is 6 on a 10-point scale. He states that he has pain in his shoulder and pressure in his abdomen. Morphine (5 mg) is ordered for the pain, and 4 mg is administered IV. His wife is in the waiting room, and she comes into the unit to visit and sits by his bed reading while the patient dozes off.

Repeat vital signs are obtained every 15 minutes for the first hour. At 45 minutes after admission, the patient's oxygen saturation is noted to be 90%. PACU staff suction secretions from the patient's throat, and he is instructed on how to use the incentive spirometer. His oxygen flow is increased to 4 liters/minute by nasal cannula. No change in the patient's oxygen saturation is noted over the next 15 minutes despite compliance with the respiratory exercises.

At one hour after admission, the patient's oxygen saturation remains at 89% to 90%, his respiratory rate is 16 breaths per minute, and he is more difficult to arouse. The nurse notifies the physician of the changes in Patient A's status. Oxygen delivery is changed again to a face mask at 4 liters/minute without improvement in the oxygen saturation level. All other parameters remain stable, demonstrating a readiness for discharge.

Despite the improvement in the patient's status, the oxygenation issue remains worrisome. The patient is admitted for an overnight hospital stay, and respiratory exercises are continued, eventually demonstrating an improvement in oxygen saturation to a high of 94%. The next morning, the patient is discharged home.

Case Study Discussion

The assessment of Patient A was thorough and well-organized. The ABCs were evaluated upon admission to ensure the stability of the patient. The history was ascertained, and vital signs were obtained on the recommended basis. However, despite this excellent care, the patient did not demonstrate adequate improvement in his status to be discharged on the same day.

The patient's history of smoking may be the cause of the respiratory insufficiency. Whether the patient was honest in his assessment of his smoking habit could be debated; many patients do not fully and honestly report their cigarette and/or drug and alcohol use. In addition, the patient may not have reported the feelings of nasal congestion and signs of a developing "cold" to the anesthesiologist prior to surgery. Had this been shared, the surgery may have been postponed. The patient may have been instructed to cut back on cigarette use and wait until the cold symptoms subsided prior to having surgery. When patients underreport or are dishonest during the preoperative phase of care, the staff caring for the patient in the postoperative phase is put at a disadvantage.

GLOBAL COMPLICATIONS

POSTOPERATIVE NAUSEA AND VOMITING

PONV is a global problem affecting patients across the surgical span. This condition is generally characterized by nausea and vomiting that occurs within the first 24 hours after surgery [13]. Early PONV has an onset within the first two to six hours after surgery, commonly in phase I PACU. Late PONV occurs within 6 to 24 hours, often when the patient has been discharged or transferred from the recovery unit. Delayed PONV occurs more than 24 hours after surgery. The term post-discharge nausea and vomiting has been used to describe the onset of nausea and vomiting after discharge from the healthcare facility. No patient is immune to the development of PONV; it is reported that one-third of patients undergoing a surgical procedure will experience PONV. In high-risk patients, the risk is estimated to be as high as 70% to 80% [13; 14]. It is critical for those managing postoperative patients to be aware of the triggers, methods for risk reduction, and management of this prevalent complication. PONV is the leading cause of unanticipated admission after planned ambulatory surgery [13]. The financial impact of prolonged care is estimated at millions of dollars per year.

Management of PONV begins in the preoperative phase with the recognition of at-risk patients. PONV is most common in female non-smokers with a history of PONV and/or motion sickness [14]. Risk factors can be divided into three categories: those that occur preoperatively, those that are initiated during surgery and while undergoing anesthesia, and those that occur postoperatively (***Table 1***). A Simplified Risk Factor Identification Tool can be used to judge the level of risk from low to very severe (***Table 2***). It is important to note that the risk of developing PONV increases with the number of risk factors (***Table 3***). Recognition of patients at risk for PONV should be relayed to anesthesia providers so they may institute prophylactic measures while the patient is still under the effects of anesthesia.

Reducing baseline risk factors can significantly decrease the incidence of PONV. Recommended strategies include [14; 110]:

- Use of regional anesthesia instead of general anesthesia
- Use of propofol for induction/maintenance of anesthesia
- Avoidance of nitrous oxide and volatile anesthetics
- Minimization of intraoperative/postoperative opioids

Additionally, recognition and treatment of PONV in the early phases will ensure that the effects of the complication are kept to a minimum. Patients who vomit run the risk of aspiration, wound dehiscence, and a delayed return to normal function. Cardiac disturbances (e.g., bradycardia) can develop secondary to the vagal maneuvers associated with vomiting.

Prevention and treatment of PONV includes both risk reduction measures as well as medication intervention. After the patient is received into the phase I or II recovery area, measures should be undertaken to limit the development of the condition. Depending on the procedure, some patients will remain NPO until peristalsis returns; however, it is important to ensure that patients are adequately hydrated. Fluid replacement measures ranging from 15 to 40 mL/kg may help to limit the development of PONV. Additionally, patients should be instructed to move slowly and be placed in the side-lying position until the gag reflex has returned. Adequate pain control should be monitored using a multimodal approach. Fluid and electrolyte status should be analyzed and prophylaxis measures instituted prior to the onset of symptoms. After symptoms develop, rescue treatments in the form of medication administration can be instituted.

RISK FACTORS FOR THE DEVELOPMENT OF POSTOPERATIVE NAUSEA AND VOMITING	
Patient Characteristic	**Risk Factor**
Preoperative Risks	
Age	School-age children
Sex	Female
Past medical history	History of previous PONV History of motion sickness
Preoperative assessment	Obesity History of delayed gastric emptying disorders
Premedications	Opioids
Other	Anxiety Nonsmokers
Intraoperative Risks	
Surgery type	Abdominal procedures Gynecologic procedures Orchidopexy ENT procedures Strabismus repairs Craniofacial surgery
Duration of surgery	Lengthy (longer than 60 minutes)
Anesthetic drugs	Inhalation agents Nitrous oxide High-dose neostigmine
Surgical events	Gastric distension Perioperative hypotension Patient positioning
Postoperative Risks	
Pain	Nonsteroidal anti-inflammatory drug use (NSAID) Regional medications Opioid use
Postoperative procedures	Early ambulation Early oral intake
Source: Compiled by Author	*Table 1*

PONV may be prevented with the use of antiemetics prior to symptom development. Studies have shown that the administration of antiemetics prior to the discontinuation of anesthesia is most beneficial [13]. Another recommendation for limiting the development of PONV is the use of total intravenous anesthesia [13; 110]. Patients with a history of PONV after undergoing general anesthesia with volatile gases may be candidates for total intravenous anesthesia use.

EVIDENCE-BASED PRACTICE RECOMMENDATION

According to the International Anesthesia Research Society, two interventions should be administered for PONV prophylaxis using in adults at risk for PONV. The combination with the highest level of evidence is ondansetron and dexamethasone.

(https://www.ashp.org/-/media/assets/policy-guidelines/docs/endorsed-documents/endorsed-documents-fourth-consensus-guidelines-postop-nausea-vomiting.pdf. Last accessed January 9, 2024.)

Level of Evidence: A1 (Multiple randomized controlled trials, and aggregated findings are supported by meta-analysis)

SIMPLIFIED RISK FACTOR IDENTIFICATION TOOLS	
Apfel et al.	
Risk Factors	**Points**
Female gender	1
Nonsmoker	1
History of PONV/motion sickness	1
Postoperative opioids	1
Total	0–4
Koivuranta et al.	
Risk Factors	**Points**
Female gender	1
Nonsmoker	1
History of PONV	1
History of motion sickness	1
Duration of surgery >60 minutes	1
Total	0–5

Source: Reprinted from J Perianesth Nurs, 21(4), American Society of PeriAnesthesia Nurses, ASPAN's evidence-based clinical practice guideline for the prevention and/or management of PONV/PDNV, 230-250, Copyright 2004, with permission from Elsevier.

Table 2

RELATIONSHIP OF NUMBER OF RISK FACTORS TO LEVEL OF RISK		
Number of Risk Factors	**Level of Risk**	**Increased Risk of PONV**
0–1	Low	10% to 20%
2	Moderate	40%
3	Severe	60%
4–5	Very severe	80%+

Source: Reprinted from J Perianesth Nurs, 21(4), American Society of PeriAnesthesia Nurses, ASPAN's evidence-based clinical practice guideline for the prevention and/or management of PONV/PDNV, 230-250, Copyright 2004, with permission from Elsevier.

Table 3

Medications used for prophylaxis of PONV include the serotonin receptor antagonists. Serotonin is a neurotransmitter that stimulates the vomiting cascade in the brain; blocking its uptake limits the incidence of PONV. Ondansetron is often considered the first-line drug, although its relative costs and incidence of headache after use have made other serotonin receptor antagonists increasingly popular. Ondansetron has greater antiemetic than antinausea effects [14; 15; 109]. Dolasetron may be considered, although its use is limited in patients with prolonged conduction defects, and the drug is no longer marketed in the United States [14; 16].

Granisetron has been shown to have some efficacy for PONV prophylaxis [14; 109]. Palonosetron is a second-generation receptor antagonist and has been found to be more effective at lower doses than granisetron and ondansetron in preventing PONV [14; 109]. Ondansetron and granisetron are most effective in the prophylaxis of PONV when given at the end of surgery [14; 109]. The administration of dexamethasone has been found to improve the efficacy of the serotonin receptor antagonists, especially when administered prior to initiation of surgery [14; 17; 109].

Other drugs used in the prevention and management of PONV include droperidol and scopolamine patches. Droperidol carries a U.S. Food and Drug Administration (FDA) black box warning, as lengthening of the QT interval has been demonstrated with doses greater than 2.5 mg. Thus, droperidol has limited benefit in certain patient populations. If droperidol is administered, ECG monitoring is recommended [16]. Scopolamine patches have had some success, often in patients who have described previous success with the patches during bouts of motion sickness. They have been found to be most effective when used as an adjunct to other antiemetic therapies [15; 105; 106].

Older antiemetics, including prochlorperazine and promethazine, are less effective and are often used as a last resort [15; 107]. Both drugs should be used with caution in children [16].

The same agents may be used as rescue medications; however, dosing may be different than for prophylaxis, and the reader is directed to other sources for dosing information [13; 17; 108]. While prophylaxis remains the best defense against PONV, these medications can be used to treat breakthrough episodes. If one type of drug is not effective in managing the patient, another drug class is recommended. Repeating the same drug may only delay successful treatment [110].

Complementary therapies can also be considered and used as appropriate. The most common therapy discussed in the literature is the use of the P6 acupoint stimulation [15; 18; 19]. This point, located on the inside of the wrist, is frequently used in acupressure and acupuncture regimens when stomach distress is noted by the patient. Other interventions that may be considered include relaxation therapies, music therapy, aromatherapy (e.g., lavender), and herbal therapy, including ginger root [20; 21; 22; 23].

Case Study

Patient B, a woman 31 years of age, is admitted to phase I PACU after undergoing an abdominal hysterectomy. During the preoperative assessment, the patient noted that she is a nonsmoker, has a history of motion sickness, and is quite anxious concerning the surgery and her future prospects, as she will be "sterile" upon recovery. The report from the operating room is that the patient received inhalation anesthesia and a neuromuscular blocking agent during the procedure. Prior to discontinuing the anesthesia, the patient was administered 4 mg of ondansetron for PONV prophylaxis. Also noted was a period of hypotension caused by a significant amount of blood loss requiring the intraoperative infusion of two units of whole blood.

Upon awakening, Patient B is quite agitated. She is moving from side to side and is not yet oriented to place and time. When questioned, Patient B states that her pain is 7 on a scale of 10. The PACU nurse administers 2 mg hydromorphone IV per order. The narcotic appears to begin to take effect, and when questioned, Patient B's pain is now reported as a score of 4. However, she is now complaining of nausea and asking for an emesis basin as she is afraid she will vomit. The nurse asks her to take slow deep breaths through her mouth and encourages her to relax.

When Patient B's complaints of nausea do not recede, the nurse contacts the physician who orders another dose of ondansetron, which is administered. Thirty minutes after medication administration, the patient's complaints of nausea have not subsided and the nurse again requests an order for an antiemetic. At this point, the physician orders a scopolamine patch be placed on the patient. Subsequent to patch placement, Patient B notes that her nausea is resolving.

Case Study Discussion

Preoperative management of Patient B's nausea was handled well. The staff had ascertained the pertinent information; had a risk factor identification scale been utilized, the patient would have been ranked at a very severe level of risk for PONV. The anesthesiologist recognized this risk and treated Patient B with an appropriate dose of antiemetic prior to the termination of surgery.

There were omissions in care that could have reduced the risk of PONV development in this patient. Prior to the first dose of ondansetron in the operating room, a dose of dexamethasone could have been administered to enhance the effectiveness of the serotonin antagonist.

During the PACU phase of care, the nurse caring for Patient B instituted measures to manage both the patient's pain and nausea. However, there were extenuating circumstances that were not considered and could have reduced the development of this complication. It was noted in the operative report that the patient had an episode of hypotension and blood loss; this volume depletion most likely increased the risk of PONV. In addition, the patient may have remained volume-depleted into the PACU, and no note of this was made.

The physician ordered the second PACU dose of ondansetron, which was administered without benefit. The recommendation for rescue management of PONV is to change drug classes if one is not adequate; thus, another drug should have been ordered. The scopolamine patch seemed to have a beneficial response; upon further questioning of the patient, it was discovered that whenever she had previous bouts of motion sickness the patient used patches to help her manage her symptoms. Had this information been ascertained in the preoperative phase, the patch could have been applied preoperatively or in the operating room. It is critical to gather as much information as possible to reduce these types of delays in patient management.

MALIGNANT HYPERTHERMIA

Malignant hyperthermia is a complication that normally begins in the operating room but requires continued care and vigilance for recurrence in the postoperative phase of care. Malignant hyperthermia is a disease of skeletal muscle and has genetic origins. The onset of complications begins when a triggering agent is administered to a susceptible patient. The skeletal muscles begin to contract in response to the trigger, and this hypermetabolic state leads to the marked temperature rise, which gives the disorder its name. If left untreated, the mortality rate is high. In cases that receive treatment, the risk of permanent disability exists [24; 25].

Malignant hyperthermia is most common in children and male patients. Many first cases are seen in children undergoing surgical corrective procedures. The most widely recognized triggers include the volatile gases (e.g., halothane, isoflurane, enflurane, desflurane) and succinylcholine [24]. After exposure, the patient may experience muscle rigidity, beginning with the masseter muscle and followed by global muscle rigidity, a significant rise in body temperature, and the development of systemic metabolic acidosis. Although these signs are identified as the "classic" signs of developing malignant hyperthermia, it is possible for the patient to have minimal muscle contraction and a delayed onset of elevated fever. However, all patients experience a rapid rise in exhaled carbon dioxide, which can be identified on end-tidal carbon dioxide monitors used in the operating suite. This is often the first sign of the condition. Upon recognition of the developing syndrome, the triggers are removed from the patient and immediate life-saving treatment is initiated.

Although a rise in body temperature is common with this complication, it can be controlled and limited. The other conditions that arise carry a much higher risk of morbidity and mortality. Early signs include elevated expired carbon dioxide and developing cardiac dysrhythmias, such as tachycardia and ventricular dysrhythmias, as a result of elevated potassium levels. The skin feels warm to the touch, yet the core temperature remains normal. As the disorder progresses, late signs include the development of a high core temperature, which can increase as rapidly as 1°C every five minutes. Temperatures have been reported as high as 46°C (114.8°F). The continuous muscle contraction causes a rise in the serum level of ionized calcium and a subsequent rise in the serum potassium level. Coagulopathy develops as fibrinogen levels fall. Respiratory acidosis develops in response to rising carbon dioxide levels, with the pH falling below 7. Muscle contraction causes a release of myoglobin, leading to rhabdomyolysis. If left untreated, the patient can progress to multiorgan dysfunction syndrome (MODS), which includes renal failure, cardiac failure, and death if not treated in an immediate fashion [100].

Management of malignant hyperthermia begins in the operating room and continues into the PACU. The surgical intervention has usually not begun at the time of onset; therefore, the recovery of the patient is based upon treating the disorder. Treatment is both specific and symptomatic. At the first signs of the impending development of malignant hyperthermia, anesthesia should be discontinued and the patient administered 100% oxygen through a clean anesthesia machine. Disease-specific dantrolene is administered to reverse the disease progression [24]. Supportive therapies include treating the developing cardiac and metabolic complications.

The development of dantrolene, a skeletal muscle relaxant, changed the treatment of malignant hyperthermia. Prior to its development, the mortality rate for malignant hyperthermia was as high as 70% to 80%; with immediate dantrolene use, the mortality rate for malignant hyperthermia can be as low as 2% [25; 26]. Dantrolene contains 3 g of mannitol per vial, which helps prevent the renal failure commonly seen with developing rhabdomyolysis. Dosing of dantrolene varies from 2.5 mg/kg (the common starting dose) up to 10 mg/kg, depending upon the severity of symptoms [16; 111]. Administration is time-consuming; the drug comes as a powder in the vial and must be reconstituted with sterile water without a bacteriostatic agent. Shaking and warming the vial helps to dissolve the powder. It is recommended that 36 vials of dantrolene be available at all times to treat a single case of malignant hyperthermia. Once reconstituted, the drug is orange-yellow in appearance and is rapidly infused. The effects occur within minutes and include relaxation of the muscle contractions and a fall in core temperature. If no response is seen, the drug is repeated at a higher dose.

While dantrolene may be a life-saving drug, it is only one of the many measures that should be instituted to prevent the lifelong sequelae that can develop secondary to malignant hyperthermia. As the core temperature begins to rise, neurologic effects may become apparent. The rising body temperature should be controlled with cooling measures. Iced normal saline solution is infused at a rate of 15 mL/kg [24; 111]. Internal cooling can be instituted using cold nasogastric, bladder, rectal, and/or peritoneal lavage. Cooling blankets can be applied to initiate surface cooling; this measure is much more beneficial in pediatric patients due to their high body surface area to body mass ratio.

Normalizing fluid and electrolyte balance is critical. The patient's calcium and potassium levels should be monitored. Hyperkalemia is treated with a glucose-insulin drip; serum acidosis is treated with intravenous sodium bicarbonate at 1–2 mg/kg. A urine output goal of greater than 2 mL/kg/hour is desired and achieved with furosemide [24; 111]. Preventing volume depletion is critical, and normal saline is administered to maintain adequate circulating volume. (Note: Lactated Ringer's solution is avoided as it can increase the risk of developing acidosis.)

Cardiovascular monitoring for developing ventricular dysrhythmias should be initiated early. Lidocaine, which was once thought to be a trigger for ventricular dysrhythmia, is used for ventricular ectopy. It is important to remember that calcium channel blockers are not recommended for cardiac dysrhythmias [24; 111].

Once stable, the patient should not be considered cured. At some point during the management of the patient, he or she will be transferred to the PACU for continued treatment. The risk of a repeat event is 25% and can occur up to 48 hours after the first event. To prevent recurrence, the patient should be transferred to the intensive care unit (ICU) and administered dantrolene 1 mg/kg every 4 to 6 hours for 36 to 48 hours [27; 111]. During this timeframe, the patient should be continually monitored for the development of delayed onset cardiac dysrhythmias.

In the preoperative arena, ascertaining a history and risk assessment for malignant hyperthermia should be performed. Any patient with a first-degree relative with a history of malignant hyperthermia is considered at risk. Patients should be asked about their previous surgical and anesthesia history as well as that of their blood relatives. Patients with bulky muscles and known muscular disorders or weaknesses (e.g., scoliosis, clubfoot) are also at increased risk. Preoperative testing using the caffeine halothane contracture test (CHCT) can be performed, although there are only five centers in the United States and Canada that perform the CHCT [24; 25]. Any patient at risk should have extensive counseling and evaluation done prior to instituting surgery with volatile gases. However, it is known that patients with malignant hyperthermia can have regional anesthesia with good success.

The initial management of the malignant hyperthermia patient begins in the operating room at symptom onset. Mixing the vials of dantrolene is a time-consuming process, and many hands are needed for a successful resuscitation. After the patient is moved to the PACU, IV fluid resuscitation should be continued, lab work monitored, and a vast array of therapies instituted and continued. As mentioned previously, dantrolene is repeated every four to six hours, and it is critical that the time for repeat drug administration not be overlooked.

Although some healthcare professionals may never see a case of malignant hyperthermia, there are certain pockets of patients known to reside in certain areas (i.e., Wisconsin, Nebraska, West Virginia, and Michigan) [24]. It is thought that these pockets of high-risk patients develop as known carriers of the disease grow up and have children of their own while staying in their home communities. In these high-risk areas, it is not uncommon for the operating room arena to see a number of cases during any given period.

Whether a facility has one or twenty cases of malignant hyperthermia, the stress of managing these patients is always high. Due to the varying signs of onset, it is not always known at the onset whether a patient is developing malignant hyperthermia. The Malignant Hyperthermia Association of the United States (MHAUS) provides and maintains an enormous amount of information for both patients and healthcare providers; much of this information may be accessed at their website, https://www.mhaus.org. In addition, the MHA provides the service of a 24-hour hotline for healthcare providers, which is available by calling 800-644-9737. This line is answered by medical professionals with extensive knowledge in malignant hyperthermia development and management and can provide up-to-the-minute help when managing an acute episode.

Case Study

Patient C is a high school senior. During the opening drive in the Friday night football game, Patient C is hit from behind. When he falls, he sustains open, comminuted fractures of his left tibia and fibula. Because he is unable to stand, an ambulance is brought onto the field to transport the young player to the hospital for evaluation.

Upon arrival at the emergency department, Patient C's leg is examined, x-rayed, and evaluated by the orthopedic surgeon on call. It is determined that prompt stabilization and cleansing of the wound would be optimal for the best possible outcome; thus, Patient C is prepared for surgery. His parents, who were at the game, arrive in the emergency department just moments after the ambulance and are available to give permission for the operative procedure. As Patient C has been medicated for pain, a history is obtained from the parents. There are no notable problems; Patient C is a healthy young man in excellent physical condition. He has not had previous operations and no previous exposure to anesthesia.

Patient C is transferred to the operating room. The anesthesiologist gives the patient a number of preoperative medications, including those to prevent PONV. The anesthesia of choice is enflurane (Ethrane), a volatile gas. The patient first receives succinylcholine prior to intubation, followed by the anesthetic gas. Within minutes, the anesthesiologist notes that Patient C's carbon dioxide levels are beginning to rise. Just as the surgeon is to begin, the patient sustains a cardiac arrest.

The anesthesiologist immediately stops the insufflation of the gas and begins to administer 100% oxygen. A code response is initiated by the remaining members of the operating team. The rescuer performing chest compressions notes that the patient's skin is warm. While resuscitative efforts continue, blood for laboratory evaluation is obtained. The arterial blood gas results demonstrate a pH of 6.9, partial pressure of oxygen (PaO_2) of 110 mm Hg, and a partial pressure of carbon dioxide ($PaCO_2$) of 55 mm Hg. At this point, the anesthesiologist's suspicions are confirmed; the patient is experiencing an episode of malignant hyperthermia.

As soon as the diagnosis is confirmed, the staff is ordered to administer dantrolene at a dose of 2 mg/kg. The operating room personnel contact the PACU to ask for assistance in drawing up and preparing the dantrolene. Only one nurse is available to leave the PACU, and she assists with mixing and administering the dantrolene as soon as it is prepared. Additionally, the patient requires repeat doses of sodium bicarbonate to combat the falling serum pH.

Within 15 minutes of administering the dantrolene, the patient begins to demonstrate a perfusing rhythm, although this is punctuated by frequent runs of premature ventricular contractions. Antiarrhythmics are administered to control cardiac complications.

Simultaneously, the patient is cooled with external cold packs applied to the groin and axilla areas. The leg wound is dressed to prevent further contamination during the resuscitative efforts. Repeat blood is obtained for laboratory analysis. The patient's potassium is elevated, and the patient is started on a glucose-insulin drip.

After the patient's cardiac condition is stabilized, the operating room staff request transfer of the patient to the PACU for further management. The patient is moved, and the PACU staff becomes responsible for managing the patient. The antiarrhythmics, the glucose-insulin drip, and the cooling measures are continued. During the first 30 minutes in the PACU, the patient's urine is noted to be a deep red color, indicative of developing rhabdomyolysis and potential renal failure. The patient is given 100 mg furosemide, and fluids are increased to 150 mL/hour. Within 20 minutes, the urine lightens in color, although it retains a reddish tinge.

Approximately three hours after the first cardiac arrest, the patient suffers a second arrest with the development of ventricular fibrillation. A second code response is called, and the patient is again resuscitated with dantrolene, antiarrhythmics, and sodium bicarbonate. Once again, the patient responds to treatment and regains a perfusing cardiac rhythm.

The patient is ordered to receive dantrolene every 4 hours for the following 48 hours to ensure that another episode of malignant hyperthermia does not develop. The patient is subsequently stabilized and transferred to the ICU, where he remains for 72 hours.

Case Study Discussion

Patient C is a perfect candidate for the development of malignant hyperthermia. He is a young male with well-developed musculature. He has had no previous exposure to anesthesia, so his history was not negative for anesthesia complications; it was incomplete. The onset of cardiac arrest was quite rapid in this patient. This devastating complication can be quick in onset, as demonstrated here, or may be delayed and occur later during the operative procedure. The first indication of the development of malignant hyperthermia in this patient was the rising carbon dioxide level. The skin temperature remained normal during the early phase of development; the first person to note the rise in body temperature was the rescuer performing chest compressions.

The patient was managed appropriately. The staff was required to perform a number of actions to save this patient's life. Administering medications, preparing those medications, cooling the patient, and monitoring blood laboratory values is only part of the picture. The additional PACU nurse pulled to the operating room to help with the resuscitation was instrumental in providing the additional hands and expertise needed in this case.

Upon arrival in the PACU, the patient continued to require extensive stabilization measures. The repeat dantrolene had been ordered but had not yet been administered when the patient sustained the second cardiac arrest. It is imperative that the administration of repeat doses of dantrolene be continued to prevent this type of occurrence. Fortunately, the patient was young and healthy and responded to the treatment.

The long-term outcome for this patient was excellent. The resuscitative efforts were exceptional, and the patient did not sustain any long-term neurologic deficits. It is important to point out that the patient did not have his fracture stabilized at this time. Subsequent surgery was delayed to ensure the stability of the patient. Once stable, the patient had the orthopedic repair performed with epidural anesthesia. Although the risk of developing malignant hyperthermia again while undergoing epidural anesthesia is small, dantrolene was used prophylactically to ensure patient stability throughout the procedure.

POSTOPERATIVE HYPOTHERMIA

Despite the best efforts to maintain normothermia in surgical patients, a large percentage of patients experience postoperative hypothermia [28]. Postoperative hypothermia is defined as a core body temperature of less than 36°C (96.8°F) [29]. Regardless of the core temperature, any time a patient exhibits signs of hypothermia (e.g., shivering, peripheral vasoconstriction, piloerection) measures to warm the patient should be instituted.

The causes of hypothermia may be external or internal. External causes include a low ambient operating suite temperature, the use of cold irrigants, and the length of exposure to these triggers. Internal causes include the use of general and regional anesthetics; pre-existing disease that increases the risk for hypothermia (e.g., endocrine disease, open wounds); decreased body mass, as seen with starvation and eating disorders; and medication administration, including vasodilators. Hypothermia is more common in young and old patients and in the female population.

There are many detrimental effects of hypothermia that can delay recovery. Adverse complications include a shift of the oxyhemoglobin curve to the left, leading to hypoxia development, altered drug metabolism, a decrease in the glomerular filtration rate, dangerous cardiac events (including dysrhythmia formation), and coagulopathies secondary to an altered platelet function. In addition, patients often complain of discomfort, and many will report that postoperative hypothermia was the worst part of surgery.

Managing hypothermic patients begins in the preoperative phase, when risk is analyzed. During this phase, the patient's temperature should be assessed and documented. Signs of hypothermia, including shivering and piloerection, should be noted. While awaiting transfer to the operating suite, the normothermic patient should receive preventative warming measures, including warm blankets, hats, and socks, which will limit exposure. The hypothermic patient should be warmed with active warming measures, including the use of a forced air convection system.

During the intraoperative phase of care, the patient may be exposed to cool ambient temperatures, which will further increase the risk of developing postoperative hypothermia. Patients at risk should be identified and warming measures implemented in the operating suite. Throughout the surgical intervention, the patient's temperature should be monitored by the attending anesthesia provider. While skin exposure is necessary at the operative site, passive warming measures, such as the use of warm blankets and other coverings, can be instituted on the remainder of the body surface. Should the body temperature drop precipitously, the ambient temperature can be raised and the patient can receive warm anesthetic gases.

Upon arrival in the PACU, the patient should have his or her body temperature assessed. Normothermic patients should receive passive comfort measures to ensure patient comfort. Hypothermia patients will require active warming measures. Other measures that can be instituted based on patient status include the warming of intravenous fluids, warming of inspired oxygen, and increasing the ambient temperature. Hypothermia patients should have their body temperature monitored every 15 minutes until normothermia is reached.

One of the consequences of hypothermia is the development of muscle contractions to maintain body temperature, also known as shivering. Postoperative shivering not only increases the patient's discomfort, it can significantly increase the body's oxygen and metabolic demands. Meperidine is recommended (off-label) to manage postoperative shivering and is administered once at 12.5–50 mg IV [16; 30, 112]. The antiemetic ondansetron also has been evaluated for use in the management of postoperative shivering. A meta-analysis to evaluate the agent found no difference in the incidence of postoperative shivering when compared with meperidine; compared with placebo, ondansetron significantly reduced postoperative shivering [31]. Supplemental oxygen should be administered to thwart the onset of hypoxemia. In addition to preventing other complications, achieving and maintaining normothermia can greatly enhance the patient experience.

EVIDENCE-BASED PRACTICE RECOMMENDATION

The American Society of Anesthesiologists recommends that meperidine should be used for the treatment of patient shivering during emergence and recovery when clinically indicated.

(https://pubs.asahq.org/anesthesiology/article/118/2/291/13600/Practice-Guidelines-for-Postanesthetic-CareAn. Last accessed January 9, 2024.)

Level of Evidence: Expert Opinion/Consensus Statement

POSTOPERATIVE PAIN

Although pain and discomfort are often expected following surgery, inadequate pain management is unacceptable. The consequences of inadequate pain management put increased stressors upon the body, with detrimental effects. Uncontrolled pain can lead to serious medical complications, including pneumonia and DVT formation. Surgical pain can impair recovery and has the potential to progress to chronic pain. Patients with chronic pain may become depressed or anxious and be unable to carry out the activities of daily living.

Surgical pain is caused by many factors. The type and location of the incision, the amount of retraction needed during the procedure, and the extent and duration of the procedure will all impact pain levels. Organ manipulation can lead to abdominal discomfort. The type of anesthesia used will impact postoperative pain; the analgesic components should be considered. Often the practitioner assumes that the patient's pain is at the incision site when it may be secondary to an invasive device, such as an endotracheal tube, an intravenous or Foley catheter, a surgical wound drain, or a nasogastric tube. Physiologic complications, such as lactic acidosis in surrounding muscles, can increase pain. Assumptions should never be made regarding pain; further assessment is always required.

Patients' perceptions of pain vary widely; patients' previous experiences with pain will impact their subsequent responses. Assessment of pain is not only a guideline. Pain is considered the fifth vital sign and should be evaluated, treated, and re-evaluated at regular intervals [32]. A pain history or pain assessment should be ascertained in the preoperative phase of care [33; 113]. This should include all of the following components:

- Pain intensity
- Alleviating and aggravating factors
- Present pain management
- Pain management history
- The effects of pain on the patient
- The patient's pain goal

Assessment of pain includes a number of measures. Physiologic parameters, including elevated heart and respiratory rates and perspiration, may be signs of increasing patient discomfort. However, these signs may be masked by medications. Nonverbal behaviors, such as restlessness, agitation, crying, or guarding, can be indicators of pain but may not be evident if the patient has received paralytic agents. Verbal assessment, using pain scales, should be performed early in the postoperative period. Educating patients in the preoperative phase on how to use these scales is imperative to successful evaluation in the postoperative period. Pain that is reported to be 9 on a 10-point scale should be believed and treated. Patients' pain scores are a reflection of their previous experiences, expectations, and pain history.

EVIDENCE-BASED PRACTICE RECOMMENDATION

The American Society of Anesthesiologists recommends that pain should be periodically assessed during emergence and recovery.

(https://pubs.asahq.org/anesthesiology/article/118/2/291/13600/Practice-Guidelines-for-Postanesthetic-CareAn. Last accessed January 9, 2024.)

Level of Evidence: Expert Opinion/Consensus Statement

Reassessment of pain should be performed whenever intervention is undertaken. Within 30 minutes of intravenous administration, the patient should be re-evaluated. Oral medications with a slower onset of action require reassessment at 45 to 60 minutes after administration. The time of onset for oral medication can vary with an individual's medical history and ability to metabolize the drug administered [101]. Each time the patient reports a new or changed pain, an assessment should be performed.

Barriers to pain management exist and prevent adequate pain control [32; 113]. The patient may return to the postoperative area with an endotracheal tube in place, unable to verbally communicate. Despite this obstacle, the patient should be assessed using nonverbal cues and printed material. The patient may fear what the pain means in terms of outcome; a painful site may be misinterpreted as a devastating outcome. Some patients fear drug dependence and/or addiction and may not adequately report their pain. It is important to note that many patients may not be aware of the difference between pain and discomfort. A patient who was placed in an unusual position in the operating suite may be uncomfortable because he or she has a stiff neck, as an example. This discomfort is different than the pain at the incision site and is often managed differently. Education of the patient is critical to ensure that the information and pain report are as accurate as possible [32].

Postoperative pain management includes four steps:

- Education of the patient
- Prevention
- Pharmacologic measures
- Nonpharmacologic measures

Education begins in the preoperative phase and continues through the postoperative phase and in discharge instructions. Prevention of pain is known as pre-emptive analgesia. This term is used to describe the proactive use of medications in the preoperative phase or at the beginning of surgery. An example of pre-emptive analgesia would be the administration of an anti-inflammatory agent to prevent postoperative swelling.

Multimodal analgesia is the term used to describe the process of pharmacologic treatment. This method includes the administration of a variety of drugs by a variety of different routes to improve pain relief and minimize side effects [33]. An example of multimodal analgesia is the administration of a nonsteroidal agent by the intravenous route and the administration of a narcotic by an epidural catheter. Another example of multimodal analgesia would be when an "in the wound" catheter is used to instill a local anesthetic at the surgical site and a narcotic is administered by the intravenous route. Many options and combinations are available and should be considered in all patients.

Administration of pain medications includes not only different methods (e.g., intravenous, epidural) but also different techniques (e.g., bolus, continuous infusions, nerve blocks). Each patient will respond differently to these methods and techniques, and healthcare professionals should be knowledgeable regarding the various options available to the patient. Patient-controlled devices are supported by many organizations and have met with great success over the years. The American Society of Anesthesiology now encourages and supports all of these various methods [30; 33; 113].

Pharmacologic management of pain is dependent upon a number of factors. The patient's prior exposure to the drug should be assessed. Patients may be categorized as either opioid naïve or opioid tolerant. The patient's age and liver and renal function will all impact the response to medications. The kinetics of the medications (i.e., onset, peak, duration) should be appraised and taken into account when developing a pain management plan. Comorbidities and the concomitant administration of other sedation drugs should be addressed as well.

Systemic narcotics are the cornerstone of the management of moderate-to-severe postoperative pain. This drug class has the advantages of rapid onset, ability to be given by a number of routes, and general reversibility with naloxone. Tolerance may develop more quickly with these medications, so close monitoring is critical to success. Side effects include sedation, confusion, respiratory depression, nausea and vomiting, pruritus, constipation, and urinary retention. Histamine release can occur with various narcotics and should be considered when administering these drugs to asthmatics. Morphine is the gold standard to which all other system narcotics are held. It is inexpensive and provides adequate pain relief for a vast array of patients. Other narcotics to consider include hydromorphone, oxycodone, nalbuphine HCl, hydrocodone, and codeine. Meperidine is still widely used for postoperative pain management, although its use is dwindling due to associated side effects and the fact that newer, better drugs are available.

Amid the current opioid epidemic in the United States, opioid-sparing analgesic regimens are increasingly being adopted for a broad range of complex surgical procedures. Regional analgesia, acetaminophen, NSAIDs, gabapentinoids, glucocorticoids, lidocaine, tramadol, and/or the *N*-methyl-d-aspartate class of glutamate receptor antagonists have been shown to be effective adjuncts to narcotic analgesia [34; 35; 36]. The use of nonsteroidal agents, most often the administration of ketorolac, has the advantage of providing pain relief upon movement. NSAIDs do not inhibit gut function, as narcotics can. There are limited side effects when used short term, and they treat or limit inflammation in addition to pain. It is important to monitor the number of days these drugs are used, as use longer than five days is met with increased side effects, including gastric bleeding and renal dysfunction. Other pharmacologic agents used in the postoperative phase include clonidine, antidepressants, adenosine, and anticonvulsants.

Nonpharmacologic methods of pain management include physical therapies, such as back rubs, massage, and acupressure, as well as cognitive and behavioral therapies, such as imagery, distraction, and meditation. These measures should be used as a supplement rather than a substitute for pharmacologic intervention. Education and assessment are again of utmost importance. Learning what may or may not work for a patient in the preoperative phase of care can lead to successful pain management in the postoperative period.

Postoperative pain issues are extensive, and it is not the intent of this course that this information is all encompassing. Nurses and other healthcare providers need continued education on the measures and methods of pain management that improve each year. Observational studies report that education and training programs for healthcare providers are associated with decreased pain levels, decreased nausea and vomiting, and improved patient satisfaction [33]. Certain physician and nursing organizations require pain education as part of the requirement for license renewal. The intention is that this education will improve the care that patients receive on a daily basis.

COMPLICATIONS OF SURGICAL POSITIONING

Patients are positioned in the operating suite to achieve maximum access to the surgical site with minimum effect on patient safety. While this positioning may optimize outcomes, the stressors of positioning can be harmful to the patient. Awareness of at-risk patients can alert caregivers in the operative and postoperative phases to support and manage the risks prior to complication development. The length of surgery is one of the major risk factors for complication development, although this cannot be controlled; no surgeon will rush through an operative procedure to reduce positioning risks.

The majority of surgical patients are placed in the dorsal recumbent position, including patients undergoing abdominal, mediastinal, and cardiac surgeries. While this position may seem to be harmless, it is not without risks. Intraoperatively, there may be pressure on the diaphragm, leading to respiratory difficulties, and abdominal organs can put pressure on the inferior vena cava. The risks increase in obese and pregnant patients, and these patients should be placed in the left lateral decubitus position to the extent possible during the procedure. Venous pooling occurs, leading to a postural hypotension that becomes evident in the postoperative phase when the patient tries to sit or stand. Pressure point compression, leading to ischemic tissue, occurs at the elbows, sacrum, shoulder, heels, and occiput at the back of the head. The hard, flat surface and alteration of the normal curvature of the lower spine may lead to complaints of backache. Improper positioning of the extremities can lead to compression of nerves and vessels, leading to a lack of muscle control in the PACU. Patients should be evaluated before, during, and after surgery to ensure that measures are undertaken to prevent these complications. One study noted a reduction in sacral wounds when sacral foam dressing was applied preoperatively [102].

Gynecologic and urologic surgeries often require that the patient be placed in the lithotomy position. As the legs are raised, the abdominal organs are pressed onto the diaphragm and the patient may develop a decreased functional residual capacity. When the legs are lowered, patients often experience an episode of hypotension.

The Fowler's position (also referred to as the sitting or park bench position) may be used for neurosurgical approaches to the posterior head and/or neck. During these procedures, the head is often secured and flexed forward. This flexion causes compression of the outflow of blood from the head, causing facial and airway edema. This complication can lead to airway and respiratory compromise in the postoperative phase of care. Intraoperatively, the patient may experience a drop in cardiac output followed by a compensatory episode of tachycardia and increased systemic resistance. During surgery, this compensation is generally adequate for circulatory support; complications arise when the patient is again placed in the head-elevated, supine position for transfer to the PACU. It is not uncommon for these patients to remain cardiovascularly unstable for a period of time during the initial phases of recovery. Another complication that may occur in the operating suite is the development of an air embolism. This is a life-threatening emergency that requires immediate attention and management.

Placing patients in the prone position is used in back, rectal, and spinal surgeries. During surgery, the patient experiences both chest and abdominal compression, which can lead to respiratory and circulatory problems. Positioning of the extremities is critical; overextension or flexion can lead to nerve and joint injuries. Protection of the head and face is critical, as eye abrasions and ear compression can occur. Positioning appliances, such as the Wilson frame, or rolled blankets placed under the chest are used to alleviate chest restriction. Finally, because the patient's head was rotated to allow the anesthesia provider maximum access to the patient's head and airway, the patient may awaken with significant neck pain.

The lateral position is most commonly utilized for access to the kidneys and lungs. Atelectasis of the dependent lung can occur with the pressure applied to this side during surgery. As with the patient in the prone position, eye abrasion and ear compression can occur on the side closest to the table. Rotator cuff compression can also occur in the dependent shoulder, leading to pain and limited movement in the postoperative phase.

Another complication that can occur during the operative phase is compression of the facial nerve as a result of being mask ventilated. If this compression occurs and the nerve is damaged, the patient may awaken with a drooping in the corner of their mouth, a drooping lower eyelid on the affected side, and speech difficulties. These signs all mimic the signs of stroke, and it can be very frightening for patients to awaken to these types of symptoms. Fortunately, the facial nerve has very good regenerative capabilities. These complications will resolve, although it may be weeks before a complete return to function is noted.

Management of positioning complications is critical during the initial phases of postoperative care. If proper techniques and preventative measures were undertaken in the operative phase, the development of these side effects is limited. However, when they do occur, measures should be taken to limit the effects on patients that can lead to delays in healing and discharge. Ensuring adequate circulating volume and circulatory status is imperative to assist the body in adjusting to the new postoperative conditions. Patients who remain hypotensive in the postoperative phase will not be able to compensate for the cardiovascular changes. Supporting dependent extremities with pillows or supports will ensure adequate venous return and reduce peripheral tissue congestion. If edema formation is present, ice packs may be used, assuring that their use is not contraindicated from a surgical standpoint. Compression devices (e.g., stockings, sequential compression devices) are often applied to the lower extremities to prevent DVT formation.

The pain and discomfort of these unusual positions can be managed with a variety of agents. It is an imperative detail that those caring for surgical patients perform a thorough assessment to allow for recognition of pain versus discomfort. Lying in an unusual position can be uncomfortable rather than painful, and measures to reduce this discomfort should be performed, including proper positioning. Medicating the patient with muscle relaxants can help ease the pain and discomfort of neck and muscle strain. Narcotic use may not be necessary to manage these side effects if good postoperative care is instituted early and continued throughout the recovery period.

COMPLICATIONS WITHIN BODY SYSTEMS

PULMONARY COMPLICATIONS

In the postoperative phase, respiratory problems are among the most common complications [37]. The reported incidence of postoperative pulmonary complications ranges from 5% to 80%, depending upon the patient population and the criteria used to define a complication [38]. Risk reduction measures can and should be instituted early and continued throughout the recovery phase of care. When patients experience severe compromise, management should be fast, efficient, and definitive to reduce the risk of respiratory arrest.

Hypoventilation (also known as respiratory insufficiency) leads to hypoxemia, which progresses to respiratory arrest if left untreated. Preoperative risk factors include the presence of an active respiratory infection or asthma. The anesthesia provider may postpone a surgical intervention if a patient presents with such a situation. Patients' age can also increase the risk of postoperative respiratory complications; elderly patients exhibit decreased respiratory effort and decreased cough reflex, which prevent them from successfully handling postanesthesia secretions. Young children have decreased respiratory reserves; thus, the development of hypoventilation leads to rapid deterioration in the child. Obesity can increase the risk of complication development. Pressure on the diaphragm can lead to a decreased functional reserve capacity, and fat retains anesthetic, leading to a prolonged recovery with delayed return of the respiratory drive. Smoking increases the risks of both operative and postoperative respiratory difficulties.

Postoperative hypoventilation is often secondary to cumulative drug effects and the use of narcotics with the potential for oversedation. While this risk may not be controllable, recognition of the risk is critical to safe care. Early extubation can lead to respiratory compromise, including aspiration. Swelling of the airway (i.e., postextubation croup) is a complication seen in the pediatric population (and will be addressed later in this course).

The first signs of developing hypoventilation and hypoxemia are usually falling oxygen saturations accompanied by a decrease in ventilatory rate and/or volume. The patient is somnolent; however, this may be secondary to the anesthetic agents remaining in the patient's system. Cyanosis is a late sign, indicating risk of respiratory arrest. Monitoring patients' respiratory status is imperative during this phase; a patient who is at risk of arrest should never be left unattended.

Recognizing the early signs of respiratory complications by assessing vital sign trends and oxygen saturations can reduce the risk of further compromise. Stimulating patients when they begin to arouse postoperatively by encouraging deep breathing and respiratory exercises will ensure that full lung expansion is achieved early. Supplemental oxygen may be of benefit; however, practitioners should be aware that this may mask the signs of falling oxygen saturations. Therefore, when oxygen is utilized, other assessment parameters should be performed. The cautious use of postoperative analgesics is recommended, but finding a balance between pain control and limiting respiratory side effects can be challenging. When respiratory insufficiency becomes a true complication, reversal of narcotics and/or benzodiazepines may be necessary. If reversal agents are utilized, alternatives to narcotics should be considered to ensure adequate pain management.

Aspiration

Aspiration in the postoperative period can carry a high mortality rate [39]. Patients can develop one of four aspiration syndromes. Most commonly, the airway is obstructed by particulate matter, which can lead to airway loss. Drowning is also a possibility if the volume of aspirated fluid is significant. Chemical pneumonitis carries a high mortality risk; damage to the airways and alveoli may be irreversible and result in subsequent respiratory failure and death. Finally, patients may develop infectious pneumonia, which can be managed successfully if treated early.

Preoperative risks for aspiration include the presence of an obstructed GI tract or abnormal GI motility. Patients who undergo emergent procedures require risk reduction measures to reduce the volume of the GI contents. Obese and pregnant patients are at risk secondary to the alteration in GI function and/or anatomy. The most significant postoperative risk is early extubation accompanied by an increased level of sedation.

Risk reduction requires appropriate management during preoperative care. Ensuring that the patient complied with preoperative instructions regarding NPO status is critical [40]. While guidelines allow clear liquids up to two hours prior to surgery, many physicians will instruct their patients to be without liquids or solids for longer periods of time [41]. Administration of antacids, histamine blockers, and medications to decrease gastric contents should not be routinely administered preoperatively but should be instituted in any patient undergoing emergency surgery [40].

Treatment of aspiration includes the use of rapid sequence intubation techniques to ensure a clear airway. Management of aspiration is dependent in part upon the type of aspiration syndrome. Regardless, suctioning of the airway and ventilatory support are instituted in all patients. Antibiotic therapy is initiated, and bronchoscopy may be performed in an effort to reduce the effects of chemical pneumonitis.

Outcomes from aspiration are dependent upon a number of factors, including age, patient's response to therapy, and extent of damage to the respiratory tree. While some patients may experience sudden death due to aspiration, others may survive the initial insult only to die days later secondary to overwhelming infection.

Noncardiogenic Pulmonary Edema

Noncardiogenic pulmonary edema (NCPE) is an uncommon respiratory complication that can cause sudden death in patients recovering from surgery. Signs and symptoms of this complication are typical of pulmonary edema, including a decrease in oxygen saturation, frothy sputum formation, bilateral infiltrates, and the use of accessory muscles to breathe. In cardiac-induced pulmonary edema, the pulmonary wedge pressure is elevated; in NCPE, it remains normal to low.

NCPE can be precipitated by three mechanisms. The first is caused by the rapid pushing of high-dose naloxone. This form can be prevented by the judicious awareness of medication administration and proper dosing. The remaining two mechanisms are laryngospasm or pulmonary failure secondary to a transfusion reaction, known as transfusion-related acute lung injury (TRALI).

The most common cause of NCPE is the development of an acute laryngospasm or upper airway obstruction. This blockage of the airway leads to a negative intrapleural pressure generated when the patient tries to breathe in against the obstructed airway. This negative intrapleural pressure causes an increased venous return to the right ventricle and an increased pulmonary blood flow. The increased fluid in the lungs leaks out into the capillary bed and floods the accompanying alveoli, leading to pulmonary edema. Interestingly, this complication is more commonly seen in younger, healthy males who are able to generate high negative intrathoracic pressures. These patients are able to breathe deep against the obstruction, creating this cascade of events. Elderly or debilitated patients without strong respiratory effort cannot create the pressure to generate these events.

Risk factors for NCPE include obesity, a short neck, and a history of sleep apnea. It is more commonly seen in ENT patients and patients with a history of a difficult intubation [42]. In the postoperative period, early extubation can lead to the development of NCPE as the patient is unable to manage the secretions, leading to airway blockage. Suctioning the patient prior to extubation can reduce the risk of this complication. All patients with a risk factor for NCPE should be monitored for at least 60 minutes postextubation.

Management of NCPE includes performing the jaw lift maneuver and applying positive pressure ventilation in an attempt to relieve the obstruction. Lidocaine has been used to relieve the laryngospasm. Succinylcholine should be administered with assisted ventilation to manage an uncontrolled obstruction. Reintubation may be necessary for a period of 24 hours. Steroids are administered to reduce the risk of repeat laryngospasm. Supplemental oxygen should be applied to all patients experiencing respiratory difficulty.

TRALI can also cause an NCPE [43]. This complication is caused by the sequestration of white blood cells in the pulmonary vasculature, leading to an increase in vascular pressure and permeability with the subsequent development of pulmonary edema. TRALI only occurs after recent blood transfusion, developing anywhere from one to six hours post-transfusion. This is not a complication of the wrong blood type being administered; it is a reaction to type-specific blood whereby the white blood cells are incompatible with the patient's body [44]. The sign of developing pulmonary edema may occur quite early during the operative phase or may not develop until hours later when the patient is in the PACU or even in the nursing unit.

Management of TRALI includes supportive ventilatory assistance. Some patients may require mechanical ventilatory support, while others will respond to oxygen therapy and the maintenance of hemodynamic status. Resolution of TRALI usually occurs within 96 hours of onset, although reported cases of continued problems have been seen up to seven days after onset. When the patient is ready for discharge, education concerning the complication is necessary. Any future interventions requiring blood transfusions should be performed with leuko-reduced red blood cells, or "washed" blood, which is blood that has undergone additional procedures to remove the offending white blood cells [44].

Case Study

Patient D is a male patient, 32 years of age, undergoing an uncomplicated bowel resection to repair damage and scarring of the bowel secondary to a traumatic automobile accident five years prior. The patient is a healthy, active male who states that he has smoked a pack of cigarettes a day off and on for the last 15 years. He had quit smoking after his auto accident but started again three years previously. His history is unremarkable for cardiovascular disease, and his anesthesia provider has reviewed his previous surgeries, performed at the time of the accident.

During surgery, the patient receives general inhalation anesthesia, intravenous narcotics, and neuromuscular blocking agents. The procedure runs approximately four hours in length. During the procedure, the patient has one short episode of hypotension that was managed with volume replacement.

Upon arrival in the PACU, the patient's vital signs are: blood pressure 118/62 mm Hg, pulse 78 beats per minute, respiratory rate 22 breaths per minute with shallow respirations, temperature 36.5°C, and oxygen saturation 91%. The patient had been extubated in the operating room just prior to transfer to the PACU. The nurse caring for the patient notes the signs and symptoms of respiratory distress, including the high respiratory rate, the shallow respirations, and the low oxygen saturation level. When the patient awakens complaining of pain, the nurse is hesitant to give too large of a dose of the narcotic that had been ordered.

After 30 minutes, the patient's respiratory rate is 18 breaths per minute, the oxygen saturation is 93%, and the patient is more alert. However, the patient continues to complain of ongoing pain, and the nurse leaves the patient's bedside to obtain the narcotics. Upon returning to the patient, the nurse finds the patient dozing. When the patient wakes, the nurse asks him to use the incentive spirometer; he had been instructed in its use in the preoperative phase of care. The patient complains of increasing abdominal pain and refuses to use the spirometer. At this point, the nurse chooses to administer 3 mg of hydromorphone as ordered for pain by the surgeon.

After receiving the hydromorphone, the patient again dozes off and appears to be comfortable. When obtaining the next set of vital signs, the nurse notices that the oxygen saturation has again dropped to 91%; however, as the patient's respiratory effort appears to be adequate, the nurse assumes this low saturation is a consequence of his smoking history. The patient has oxygen supplied by nasal prongs, and the nurse chooses not to intervene further. The patient is left sleeping while the nurse assists in the admission of another patient to the PACU.

Forty-five minutes after arrival in the PACU, Patient D experiences a respiratory arrest. The nurses immediately call a code and initiate resuscitative measures. The patient is administered naloxone, and positive pressure ventilation is initiated. However, bagging the patient is extremely difficult; the pop-off valve goes off with each ventilation, and the patient's chest is not rising as hoped.

Fortunately, the anesthesia provider responds and immediately asks for an endotracheal tube to reintubate the patient. When attempting to intubate the patient, the anesthesia provider finds it very difficult as a result of the patient developing laryngospasm. Succinylcholine is administered, and high positive-pressure oxygen is given via a jet vent. After another two attempts, the patient is successfully intubated. The patient is then placed on a mechanical ventilator with positive-end-expiratory pressure applied to help reduce the buildup of fluid in the lungs. He is started on a course of antibiotics and steroids and admitted to the ICU. After two days, the patient is extubated, moved to the surgical floor, and at day 6, is discharged from the hospital.

Case Study Discussion

Patient D is a typical postoperative patient. He was healthy and had an uncomplicated surgical event. He should have progressed through the recovery period without a problem; however, he sustained a respiratory arrest and his recovery was prolonged. Fortunately, he survived without long-term sequelae. The nurse caring for Patient D made assumptions about his condition based upon his preoperative history. The smoking history allowed her to be lulled into a sense of security knowing that smokers have altered oxygen saturations. His appearance of ease was comforting, and she became complacent in her vigilance.

When Patient D sustained the respiratory arrest, the initial cause was unknown. He had numerous risk factors; the arrest may have been caused by the dose of narcotics, in which case, naloxone would have been a treatment of choice. This was tried but without a successful response. He was hypoxemic upon arrival in the PACU, as evidenced by his low oxygen saturations. This hypoxemic state may have precipitated the respiratory arrest. In addition, he had received neuromuscular blocking agents in the operating room and the arrest may have been secondary to residual paralytic agent. However, upon intubation he was noted to have developed laryngospasm, which may indicate that he sustained an episode of NCPE. He was a candidate for NCPE due to his age, preoperative health status, and early extubation.

Whenever a patient sustains a life-threatening event such as a respiratory arrest, it is critical that care providers work to determine the cause. Identification of the cause can lead to the appropriate choice of a resuscitative effort. In this case, the nurse acted appropriately in administering the naloxone, although it was later determined that this was not the cause of the arrest. Despite the fact that NCPE was not considered until the patient was found to have a laryngospasm, the measures undertaken were appropriate. The only error was the complacency that the nurse exhibited towards the patient's status upon arrival in the PACU and the first 45 minutes of care. Early attention to the hypoxemic state may have prevented the development of the arrest, although this does not always make a difference in cases of NCPE.

Patient D should be educated prior to discharge regarding the development of this side effect. If further surgeries are needed, it is imperative that he be able to relate this information so that measures can be instituted to reduce the risk of respiratory compromise.

CARDIOVASCULAR COMPLICATIONS

An estimated 25% of patients experience life-altering or life-threatening outcomes when a complication develops in the cardiovascular system during noncardiac surgical procedures [45]. Postoperative hypotension and hypertension are not uncommon and generally carry a reduced risk if recognized early. However, the formation of life-threatening dysrhythmias increases the risk of death in the postoperative period. These dysrhythmias can develop immediately after surgery or during the late phases of recovery and should be monitored in any high-risk patient. Another common cardiovascular complication is the development of DVT and subsequent pulmonary embolism.

Hypotension

Hypotension in the early phases of recovery is often mistaken for hypovolemia. While hypovolemia is one of the most common causes of hypotension, it is not the only consideration when assessing a patient with low blood pressure. Preoperative holding of medications, food, and fluids can cause a period of postoperative hypotension; however, anesthesiologists commonly correct this volume deficit while the patient is under anesthesia. Therefore, when a patient presents with hypotension this cause should be considered and ruled in or out quickly.

Another cause of hypotension is the use of volatile anesthetics, which have a vasodilator effect. These anesthetics also depress the myocardial function; thus, the circulating volume is often low and presents as hypotension. The position of patients in the operating room can cause compression of major vessels and eventual third spacing of fluids. If this is the case, the patient will present with low blood pressure, but when the patient is placed in the supine position and circulation is re-established, the patient's blood pressure will return to baseline levels.

Medications can also depress cardiac function, causing hypotension. Morphine, meperidine, and other medications that produce a histamine release can cause hypotension. Mechanical ventilation, especially with end-tidal positive pressures, causes an alteration in the cardiac return and a subsequent decrease in cardiac output. High spinal or epidural sympathetic blockade used in regional anesthesia techniques can also produce a profound vasodilation and cause a patient to appear to be hypotensive. Finally, the preoperative use of antihypertensive agents can cause postoperative hypotension. These medications are often held prior to surgery, but if they are still present systemically, the patient may experience profound hypotension as a result of the dose being compounded with the anesthetics and vasodilators being used.

Risk reduction measures begin in the preoperative phase when the patient's volume status is assessed. Any volume depletion should be noted, and the anesthesiologist should be notified. Intraoperatively, it is important to ensure adequate volume to help prevent postoperative hypotension from developing. If volume loss occurs during surgery, either as blood loss or with third spacing, the patient should have volume replacements based on these estimated losses.

Postoperatively, patients should have continued assessments of their volume status. If necessary, additional fluids can be administered at this time. Drug reversal remains an option, although this is avoided unless as a last effort. Vascular support with dopamine or dobutamine is rarely needed in these patients. Most cases of postoperative hypotension will resolve as the patient's own compensatory responses return the blood pressure to baseline values.

Hypertension

Postoperative hypertension is of significant concern due to the associated consequences of the complication, including the risk of stroke. Approximately one in three Americans is hypertensive; therefore, it is expected that many patients undergoing surgery will be hypertensive during the baseline measurement of their vital signs [46]. If hypertensive medications are held during the preoperative phase of care, it is expected that the patient will be slightly hypertensive in the recovery phase. The biggest concern is if the patient's diastolic pressure exceeds 120 mm Hg. If this is accompanied by headache, blurred vision, or changes in level of conscious, immediate intervention should be undertaken.

Hypertension can be caused by a number of factors [47]. Patients in pain who are anxious and tense may have an elevated blood pressure. Bladder and/or gastric distension can also cause a rise in blood pressure. Shivering with hypothermia can cause the pressure to rise. Some medications, such as anticholinergics, can cause a period of hypertension. Hypoglycemia produces a reflex sympathetic response, raising systolic pressure. The use of irrigating fluids may cause a hypervolemic state if they are absorbed into the vascular system.

Risk reduction is based on the cause of the hypertension. If the patient is cold and shivering, warming measures should be instituted. If the patient is in pain, pain medications may be administered. Patients who are uncomfortable due to bladder distension can have a Foley catheter placed. Management is directed at the cause, so determining the etiology is key [47]. If the blood pressure remains elevated, antihypertensive agents may be considered. However, their use is often delayed, and initial treatment should be aimed at resolving the causal condition. If the blood pressure remains significantly above baseline, medication therapy may be considered.

There are a number of antihypertensive drugs available. Diuretics may be used in cases of hypervolemia. Beta blockers are often the first-line choice when antihypertensive therapy is considered. The advantage of these drugs is their relatively short length of action; if the patient's blood pressure falls precipitously, the effects will be short-lived. Peripheral vasodilators are also available; however, these drugs are usually one of the last choices due to the significant drop in pressure experienced with their use. One rule when choosing an antihypertensive agent is to use a drug in the same class that the patient has been using for long-term management. For example, if the patient's blood pressure has been continuously managed with diuretics, administer a diuretic such as furosemide.

Dysrhythmias

Dysrhythmias can develop at any point in the management of the patient but occur most commonly in the first four days after surgery. The presence of other complications (e.g., sepsis) should be considered in patients who develop postoperative dysrhythmia [47; 48].

It is not uncommon to see dysrhythmia development after thoracic and cardiovascular surgeries. In many cases, atrial flutter and atrial fibrillation are seen; these will often convert to normal sinus rhythm without aggressive treatment. In 20% to 30% of patients, no therapeutic intervention is required [47; 48]. Ventricular dysrhythmias are of greater concern, and the precipitating factors should be determined. The most common cause of ventricular dysrhythmias is hypoxia. All patients should be monitored with a pulse oximeter to allow for easy recognition of oxygen saturation values. When saturation percentages are in the low 90s or below, supplemental oxygen and respiratory exercises should be initiated. If improvement is not seen, additional therapies are needed to ensure adequate oxygenation.

Electrolyte imbalances are another common cause of postoperative dysrhythmias. Large fluid losses often result in hypokalemia, which can induce ventricular aberrations. Obtaining and monitoring laboratory values when appropriate will prevent these imbalances from becoming significant. If proactive, healthcare professionals can recognize these dangers and request orders for interventions prior to the problem becoming greater than necessary.

LEVELS OF THROMBOEMBOLISM RISK IN SURGICAL PATIENTS WITHOUT PROPHYLAXIS		
Level of Risk	**Approximate Deep Vein Thrombosis Risk Without Thromboprophylaxis**	**Successful Prevention Strategies**
Low risk (Minor surgery in mobile patients; medical patients who are fully mobile)	<10%	No specific prophylaxis; early and frequent mobilization
Moderate risk (Most general, open gynecologic, or urologic surgery patients; medical patients, bed rest or sick)	10% to 40%	LDUH (two or three times daily), LMWH at recommended doses, mechanical thromboprophylaxis
Moderate risk (Moderate venous thromboembolism risk plus high bleeding risk)	10% to 40%	Mechanical thromboprophylaxis[a]
High risk (Hip or knee arthroplasty, HFS; major trauma, SCI)	40% to 80%	LMWH at recommended doses, fondaparinux, apixaban, dabigatran, rivaroxaban, LDUH, oral vitamin K antagonist (INR 2–3), or an intermittent pneumatic compression device
High risk (Hip or knee arthroplasty, HFS; major trauma, SCI)	40% to 80%	Mechanical thromboprophylaxis[a]

HFS = hip fracture surgery; LDUH = low-dose unfractionated heparin; LMWH = low-molecular-weight heparin; INR = international normalized ratio; SCI = spinal cord injury.
[a]Includes intermittent pneumatic compression devices, venous foot pumps, and/or graduated compression stockings; consider switch to anticoagulant thromboprophylaxis when high bleeding risk decreases.

Source: [50] *Table 4*

Deep Vein Thrombosis

Vascular compression and venous stasis that occur during surgery are major factors in the formation of DVT. Many studies have demonstrated the extent of this problem, and guidelines for prophylaxis have been issued [49]. All caregivers in the PACU should be aware of these guidelines to ensure that all at-risk patients receive appropriate prophylaxis. The American College of Chest Physicians (ACCP) guidelines for the prevention of venous thromboembolism (VTE) outline the risks and recommendations for the management of DVT [50; 116].

The type of surgery is the primary factor in determining a patient's risk of DVT. Additional factors that affect the risk of DVT in general surgery patients include [50; 116]:

- Traditional risk factors (e.g., cancer, previous VTE, obesity, delayed mobilization)
- Increasing age
- Type of anesthesia
- Duration of surgery
- Postoperative infection

Patients who are mobile and are undergoing an uncomplicated, minor surgical procedure are considered to be at low risk. The highest risk patients are those undergoing major lower extremity orthopedic surgeries, including hip and knee replacements (***Table 4***). The ACCP recommends the routine use of thromboprophylaxis following major general surgical procedures. Both low-dose unfractionated heparin (LDUH) and low-molecular-weight heparin (LMWH) have been shown to reduce the risk of asymptomatic DVT and symptomatic VTE by at least 60% in general surgery compared with no thromboprophylaxis [51].

EVIDENCE-BASED PRACTICE RECOMMENDATION

In acutely ill medical patients, the American Society of Hematology suggests using unfractionated heparin, low-molecular-weight heparin, or fondaparinux rather than no parenteral anticoagulant.

(https://ashpublications.org/bloodadvances/article/2/22/3198/16115/American-Society-of-Hematology-2018-guidelines-for. Last accessed January 9, 2024.)

Level of Evidence: ⊕⊕◯◯ (Conditional recommendation, low certainty in the evidence of effects)

Signs of developing DVT include swelling, redness, tenderness, and a feeling of warmth over the developing clot. Homans' sign, pain upon dorsiflexion of the foot, is present. The extremity may become swollen; however, this is a late sign [116]. When signs appear, the clot has already formed and the risk is high for pulmonary emboli formation.

Risk reduction is based on a multimodal approach to management. The use of medication therapy and mechanical methods of prophylaxis are recommended for this patient group. Medications include fondaparinux, apixaban, dabigatran, rivaroxaban, LMWH, LDUH, or vitamin K antagonist. Mechanical methods include graduated compression stockings, intermittent pneumatic compression devices, and venous foot pumps. Combination therapy is also recommended for some moderate-risk patients [50].

Management of cardiovascular complications requires vigilance and astute assessment. These complications occur unexpectedly and cause rapid deterioration in the patient. Cardiac monitoring is a necessity for all at-risk patients to allow for early detection of compromise.

Case Study

Patient E, a man 74 years of age, is undergoing surgery for a blockage in his left femoral artery. The patient has a history of significant vascular compromise of his left leg secondary to the blockage. A stent is placed during surgery, and the patient is subsequently transferred to the PACU. Upon arrival in the PACU, his vital signs are: blood pressure 162/86 mm Hg, pulse 80 beats per minute, respiratory rate 16 breaths per minute, core temperature 34.5°C, and oxygen saturation 90%. The patient was extubated prior to arrival in the PACU. After the patient is stabilized and an assessment is completed, he is warmed using a warm air convection device. To combat his low oxygen saturations, his oxygen flow is increased to 6 liters per nasal cannula.

Fifteen minutes after arrival, the patient complains of severe pain in his left leg. His peripheral pulses are good, and his color is pink. However, as this was the surgical site, the nurse immediately contacts the surgeon. The surgeon speculates that the pain is secondary to new perfusion in this leg and the removal of sequestered by-products of circulation. He orders the patient to receive 3 mg hydromorphone for pain, which helps resolve the patient's complaints.

One hour after admission, the patient's vital signs return to preoperative values; his body temperature is now 36°C. At this point, he complains of pain in both lower extremities. Upon assessment, it is found that his peripheral pulses are weak in the right leg and the color of this extremity is dusky and cool to touch. His left leg remains warm, pink, and with good peripheral pulses. The patient's legs are elevated on a pillow to improve blood return to the heart, and he is again administered hydromorphone. After the second dose of hydromorphone, the patient drifts off to sleep. When he wakes, he continues to complain of pain in both extremities. The right leg remains cool, dusky, and with poor peripheral perfusion. The nurse again contacts the surgeon, who determines that the patient is possibly developing a DVT in the right calf. The patient has graduated compression stockings applied to the right leg to reduce the risk of further clot formation. As the patient had been heparinized in the operating room, no further anticoagulants are ordered.

The patient is discharged from the PACU to the surgical ward. At day 3, when he is ambulating in the hall, Patient E suffers a cardiac arrest and is not able to be resuscitated. He most likely sustained a pulmonary embolus secondary to the DVT in the right leg. The ambulation may have caused the clot to be knocked loose, allowing it to travel to the pulmonary vasculature.

Case Study Discussion

This patient was at high risk for DVT formation both due to the type and extent of surgery as well as his history of peripheral vascular disease. As he was anticoagulated in the operating room, no further interventions were instituted. However, the guidelines for management and prophylaxis of this type of patient recommend the institution of graduated compression stockings or intermittent pneumatic compression devices in addition to anticoagulation [50]. It can be speculated that this may have reduced his incidence of DVT formation; however, due to his extensive vascular history, he was at high risk prior to, during, and after surgery. It would be speculation to determine if this event may have been preventable.

The nurse caring for the patient performed her job according to policy. The only change that may have been recommended is the placement of the graduated compression stockings on the right leg prior to surgery or after the patient was stabilized in the PACU.

NEUROLOGIC COMPLICATIONS

It is common to anticipate when a patient will awaken following surgery based upon the drugs the patient received, when those drugs were last administered, and patient information, such as age, weight, and health status. When the patient does not conform to these anticipated parameters, a concern that the patient suffered some type of neurologic complication begins to develop. Delayed awakening is one of the most concerning complications in the postoperative period. On the other end of the spectrum, the patient may awaken abruptly and in a confused, disoriented state, leading to what is known as emergence excitement or emergence delirium. Either of these developments will disrupt the smooth transition from the state of anesthesia to the state of full awareness.

Other neurologic events that can occur in the postoperative period include prolonged paralysis or compartment syndrome. Both of these complications affect patients' ability to move their extremities as they were able to in the preoperative period. Patients often assume that some type of life-altering complication has developed and that they may never be able to move again; in other words, they believe that they are paralyzed for life. While this is far from the truth, the anxiety and fear that these complications can generate in the patient can be overwhelming. Measures to reverse neurologic complications should be instituted immediately; in the case of compartment syndrome, delayed management can cause life-long disability.

Delayed Awakening

Regaining consciousness and awareness following anesthesia is impacted by many factors. When a patient does not awaken within 60 to 90 minutes following anesthesia, this is referred to as delayed awakening. The medications administered to achieve anesthesia are common culprits of delayed awakening. When a patient has received inhaled gases, awakening is directly related to alveolar ventilation. With poor ventilation, the gases remain in the pulmonary tree, prolonging arousal. Premedications that have a longer length of action than the procedure can cause the patient to remain somnolent during this period. Midazolam, with its short length of action, is commonly used as a premedicant to prevent this occurrence.

The half-life of medications administered in the operating suite may be long. Clearance through the typical metabolic pathways may be prolonged due to pre-existing physiologic complications. For instance, lipid-soluble drugs become sequestered in the adipose tissue and their release is slow, leading to prolonged length of action. The more adipose tissue that is present, the greater the risk of delayed metabolism and, by extension, delayed awakening.

Medications may also have delayed onset and/or metabolism secondary to a slowing of circulation. Common in the elderly, this slow circulation results in delayed clearance by the kidneys, which leads to the drug remaining in the system longer and the drug effects continuing until the drug is cleared.

While the most common causes of delayed awakening include residual anesthetic or hypoventilation, other causes should be considered [52]. Both hypoxia and hypothermia can affect patient arousal. Electrolyte imbalances, hypoglycemia, or hyperglycemia can prolong awakening. These types of imbalances can produce metabolic problems that mimic delayed awakening. Although rare, drug overdose should be considered as a potential cause.

When a patient fails to awaken as expected, a treatment plan should include determination of cause, and reversal, if necessary. Reversal agents such as naloxone, flumazenil, and physostigmine may be used. These reversal agents may work for patients with residual medication; however, the awakening is often abrupt and uncomfortable, particularly when naloxone is used [16]. For patients who do not respond to these interventions, consideration of an intraoperative catastrophe should be considered. The patient may have suffered an episode of cerebral hypoxia or an intracerebral event, such as a clot or hemorrhage, leading to a stroke. These events will lead to life-long disability and/or death.

Emergence Excitement or Delirium

While many patients awaken as expected, some patients' arousals are neither smooth nor uneventful. Emergence excitement or delirium has been noted in 10% of the general surgical population [53; 117]. Emergence excitement is defined as a state of restlessness and disorientation during arousal. Patients may be confused and unable to process their thoughts in a normal pattern. Emergence delirium is an extreme form of excitement in which the patient is shouting, agitated, and thrashing about and may be at risk for harming himself/herself or others. Patients also generally do not respond appropriately to commands [53; 117].

Patients at risk for emergence excitement or delirium can be identified in the preoperative, intraoperative, and postoperative phases. Age and cognitive function are both predisposing factors to this complication. Emergence excitement and delirium are more common in the young and old patient populations [54; 55; 118]. Patients with an inability to process cognitive thoughts in an orderly fashion are also at increased risk. Preoperative fears and anxiety can increase the chance that the patient will not awaken in a smooth fashion [53; 117].

Intraoperative risk factors include the type of surgery, an episode of hypoperfusion, the use of certain medications, and the combination of multiple medications [55]. Patients undergoing hip and knee replacements have an increased incidence of an agitated or confused arousal. Abdominal wall surgical patients, including women undergoing abdominal hysterectomy, and women undergoing breast surgery have a greater chance of developing this complication as well [56; 119]. Children undergoing tonsillectomy and adenoidectomy are known to be at increased risk. The administration of certain medications, such as meperidine, ketamine, atropine, scopolamine, and droperidol, has been associated with emergence excitement [53; 117]. When multiple medications are used, the risk increases.

During the postoperative phase, there are certain possible causes that should be ruled out. The primary cause, until proven otherwise, is a state of postoperative hypoxia [53; 117]. This is easily identified by monitoring for low oxygen saturation levels. All patients with lower-than-expected saturations should have supplemental oxygen provided until their values return to the preoperative levels. Other causes that may be identified in the postoperative phase of care include hypocapnia, dehydration, hypothermia, or hypoglycemia [53]. Patients may be experiencing a full bladder or pain but have yet to develop enough awareness to communicate this. Other patients may be experiencing the effects of withdrawal from drugs and/or alcohol; these patients may not have reported substance use or dependence during the preoperative assessment. The incomplete reversal of medications may also be a precipitating factor [53].

The priority of those caring for a patient exhibiting signs of emergence excitement or delirium is to ensure that the patient and other staff members are safe from harm. Violent movements may cause the patient to hit his or her arms, legs, or head against the side rails, so pillows should be placed to pad these areas. While restraints may be considered, their use may only increase the agitation.

The second step is to determine the cause of the agitation. Each of the possible causes should be considered one by one until etiology is determined. First and foremost, hypoxia should be investigated and oxygen saturations assessed. While oxygen therapy may be beneficial, the application of an oxygen therapy device, such as a nasal cannula or a face mask, may agitate the patient further. In this case, blowing oxygen at the patient's face and mouth may be the only method of ensuring oxygen delivery. When a patient is screaming, the PACU may be disrupted, but it demonstrates that the patient is achieving maximum pulmonary ventilation, which is a good method for clearing residual anesthetic. The loudest patients will usually return to a normal state faster than those who are hypoventilating.

Nonpharmacologic interventions are preferred over medication administration. Reorientation of the patient may be of help. Removing indwelling tubes and catheters, when appropriate, may reduce the sense of fear in the patient. If a patient normally uses reading glasses or hearing aids, these should be obtained and given to the patient. For children, having a parent at the bedside can help diminish the sense of fear. However, prior to bringing parents into the unit to visit a child who is experiencing emergence behaviors, it is critical that parents are fully informed of the child's state and are comfortable with assisting in managing their child. Often, a parent who sees a child who is uncomfortable will become anxious, and this can have the negative effect of agitating the child further.

EVIDENCE-BASED PRACTICE RECOMMENDATION

According to the American Geriatrics Society, healthcare professionals should perform a medical evaluation, make medication and/or environmental adjustments, and order appropriate diagnostic tests and clinical consultations after an older adult has been diagnosed with postoperative delirium to identify and manage underlying contributors to delirium.

(https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5901697. Last accessed January 9, 2024.)

Strength of Recommendation/Level of Evidence: Strong/low

When patients are truly at risk of harming themselves, the use of pharmacologic intervention should be considered. Midazolam has been used; however, it may also be the precipitating factor. Elderly patients may develop emergence excitement in response to midazolam administered in the preoperative phase of care [16]. In this case, an additional dose of the drug will only potentiate the problem rather than resolve it. In cases of anticholinergic-induced delirium, physostigmine can be administered [16].

Most cases of emergence excitement or delirium last less than 15 minutes. While this may seem like an eternity when caring for the patient, the complication passes quickly and generally without consequence.

Prolonged Paralysis

Prolonged paralysis is commonly a complication caused by the residual effect of paralytic agents used during the operative phase of care. Neuromuscular blocking agents are used during surgery to prevent patient movement, produce adequate muscle relaxation, and facilitate intubation while preventing laryngospasm. In addition, these blocking agents have a potentiating effect on inhaled gases; therefore, the anesthesiologist may choose to use these agents in an effort to reduce the amount of gas required to achieve the desired depth of anesthesia. Normally, paralytic agents are given during the procedure depending on their need. By the time the surgical intervention is complete and the patient has been moved to the PACU, the effects of these medications have usually worn off. However, in cases of prolonged drug effect, the paralysis may last into this recovery phase.

EVIDENCE-BASED PRACTICE RECOMMENDATION

The Society of Critical Care Medicine and the American Society of Health-System Pharmacists recommend that optimal clinical practice requires administering analgesic and sedative drugs prior to and during neuromuscular blockade, with the goal of achieving deep sedation.

(https://journals.lww.com/ccmjournal/Fulltext/2016/11000/Clinical_Practice_Guidelines_for_Sustained.16.aspx. Last accessed January 9, 2024.)

Level of Evidence: Good practice statement (consensus statement)

Between 20% and 40% of patients arrive in the PACU with objective evidence of residual neuromuscular blocking agents. Multiple investigations have demonstrated that residual neuromuscular blocking agent is an important patient safety issue, and numerous clinical studies have documented that incomplete neuromuscular recovery is associated with a variety of adverse events (e.g., airway obstruction, hypoxemic episodes) in the early postoperative period [57]. Despite the evidence documenting the importance of perioperative neuromuscular monitoring, surveys indicate that subjective assessment using nerve stimulators is performed in less than 40% of patients, while objective monitoring is even rarer (17% of patients) [57]. Failure to monitor occurs not only in adult patients but also in pediatric patients who are even more vulnerable to the sequelae of incomplete reversal [57]. PACU nurses report that residual neuromuscular blocking agent is one of the most critical events that they may face requiring emergency intervention [58].

Recovery can be tested by evaluating the following parameters: ability to open eyes wide, sustained protrusion of the tongue, sustained hand grip for at least five seconds, sustained head lift for at least five seconds, and the ability to cough effectively [59]. Achievement of certain respiratory parameters, including a tidal volume of at least 5 mL/kg, a vital capacity of at least 15–20 mL/kg, and/or an inspiratory force of 20–25 cm, may also indicate recovery. However, in many settings, evaluation using these parameters has had limited success in preventing the occurrence of residual paralysis [57].

To guide appropriate perioperative management, assessment of residual paralysis with a peripheral nerve stimulator is mandatory [57]. As the effects of paralytic agents begin to wear off, muscle recovery is noted. The order of muscle recovery is as follows: diaphragm, intercostal muscles, large muscle groups (i.e., shoulders, abdominal muscles), medium muscle groups (i.e., extremities, tongue), and finally small muscle groups (i.e., eyes, mouth, face, fingers). The peripheral nerve stimulator is used to test the responses of the small muscles in the hand and fingers demonstrating the return of function of the last muscle group.

The peripheral nerve stimulator is usually applied to the ulnar nerve at the wrist or elbow. Other sites of electrode placement include the facial nerve, the peroneal nerve, or the posterior tibialis nerve. The electrodes are applied to the skin and attached to the peripheral nerve stimulator. Commonly, the train-of-four method of testing is used [57; 59]. Four rapid stimuli are applied through the electrode, stimulating the ulnar nerve, causing the small muscles of the hand and thumb to twitch. When the fourth twitch is not present, the amount of residual blockade at the motor end plates is estimated at 75%; when both the 3rd and 4th twitches are abolished, the blockade is estimated at 80%. If the second twitch is not seen, the block is estimated at 90%, and if no twitching is seen, there is 100% blockade. As the patient recovers, the amount of blockade will decrease and all twitches will be seen [59; 60]. Consensus guidelines for the use of muscle relaxants in critically ill children call for the assessment of the depth of the block at least once every 24 hours with train-of-four monitoring [57; 61; 120].

If the patient remains in a state of paralysis, agents are available to reverse the effects of the nondepolarizing blocking agents. Reversal agents include neostigmine and pyridostigmine [16; 59]. The newest reversal agent, sugammadex, was approved by the U.S. Food and Drug Administration (FDA) in 2015 [16]. Sugammadex is a modified gamma cyclodextrin (a selective relaxant binding agent) that reverses neuromuscular blockade induced by rocuronium or vecuronium in adults undergoing surgery. These reversal agents can be administered intravenously, and the effects occur within 5 to 15 minutes after administration (or in less than 3 minutes with sugammadex) [16]. When the patient begins to regain motor function, the peripheral nerve stimulator is no longer used. While return of function occurs within minutes, the patient remains weak and should be monitored throughout the recovery period for return of developing weakness or paralysis. If the patient was administered succinylcholine, a depolarizing blocking agent, the drug cannot be reversed and the return of motor function will be dependent upon clearance of the drug through normal metabolic channels [16; 59].

There are a large number of factors that potentiate the development of neuromuscular blockade. It is important to assess for these factors and develop a plan of care based on these interactions. Medications and conditions potentiating the development of neuromuscular blockade include:

- Antibiotics
- Sedatives
- Inhalation gases
- Hypothermia
- Many commonly prescribed cardiovascular medications

When these factors are present, paralysis may linger into the recovery phase, but with time and clearance of the drugs, the patient will regain function, often without the need for reversal agents.

Compartment Syndrome

Compartment syndrome is another neurovascular complication that can lead to lifelong disability if not recognized and treated early. Most commonly affecting the lower extremities, compartment syndrome develops when fluid and blood accumulate within the fascia surrounding the muscles. The fascia does not expand; thus, the increasing fluid accumulation causes an increase in the intracompartmental pressure. This increased pressure causes a decrease in circulation within the compartment and subsequent cellular death due to anoxia [62]. The most common cause of compartment syndrome after surgery is compression of tissue during surgical positioning. If the extremity is not positioned for drainage and circulatory flow, this pressure can increase, leading to compartment syndrome.

The most common sign of compartment syndrome is pain out of proportion to the injury [62; 63]. There may be evidence of swelling, tenseness, and redness around the affected area; however, these may be late signs, and recognition at this point may be too late to achieve a normal outcome. Loss of peripheral pulses has often been considered a sign of impending compartment syndrome, yet pulses may be present even in the acute stages of this complication. As an example, the lower leg has four compartments [63]. If one is developing compartment syndrome, the other three may be providing adequate circulation to the lower extremities, allowing pulses to remain intact despite the lack of circulation in the one affected compartment. Comparing extremity circumference from the normal to the affected side may also be used; however, due to the fact that the fascia is nondistensible, this difference is often minimal.

If unrecognized, the pain and paralysis will continue to the point of loss of function. After cellular demise begins, reversal is difficult; necrotic tissue develops, requiring surgical removal. Time of onset to the development of necrosis after ischemia is approximately six to eight hours [62]. Measuring intracompartmental pressure remains the standard for the diagnosis of compartment syndrome and can be performed using commercial or "self-made" systems. Often, evaluation by an orthopedic surgeon is all that is required. Once recognized, the surgeon performs a fasciotomy regardless of the compartmental pressure. The sooner the fasciotomy is performed, the earlier blood flow can return to the affected area and cellular repair can begin [62].

Recognition of compartment syndrome is critical to successful outcomes. It is important to be aware of the possibility of compartment syndrome development in any patient, especially those who were positioned for a lengthy surgery. Preceding trauma may also increase the risk of development; a thorough preoperative history will alert caregivers to this risk. Despite the lack of predisposing factors, any time a patient complains of pain that is considered out of proportion to the expected, compartment syndrome should be considered.

Case Study

Patient F, a woman 47 years of age, has sustained a comminuted fracture of her left tibia and fibula after falling on wet grass. Patient F is transferred to the emergency department, where the determination is made to take her to the operating room for internal fixation and subsequent casting.

Following surgery, Patient F is admitted to the PACU with a cast on her left leg. The leg is elevated on top of pillows to ensure adequate drainage. Upon awakening, the patient complains of pain of 9 on a 10-point scale. She is medicated with hydromorphone and falls back to sleep. Forty-five minutes later, she again complains of continued pain. At this point, she receives 3 mg of intravenous morphine. While reviewing the patient's chart and medication orders, the PACU nurse discovers that the patient has a history of frequent narcotic use and is labeled a "complainer" who is frequently seen in the emergency department or physician's office with vague complaints of pain and requests for refills of her narcotics.

After two hours in the PACU, the patient is transferred to the orthopedic floor for continued recovery. Other than her complaints of pain, her PACU stay is uneventful. When giving report to the nurses on the floor, the PACU nurse relays her findings regarding the patient's complaints of pain and repeat requests for pain medications.

During the remainder of the day and into the evening shift, the patient is monitored every four hours. She is medicated as ordered, but within one to two hours after receiving her medications she calls the nurse for additional analgesia. She continues to complain of pain, stating that she feels a burning sensation in her left leg. Her cast is checked and appears to be intact, without peripheral swelling of her leg, and peripheral pulses are present but weak.

At midnight, the patient calls the nurse with continued complaints of pain. The nurse notes that the cast is tight; the patient is no longer keeping it elevated as instructed. The orthopedist on call is contacted, and the decision is made over the telephone to bivalve the patient's cast to ensure adequate circulation. This is accomplished, and the patient appears more comfortable, although her reported pain score remains at 6.

The following morning the patient is seen by the orthopedic surgeon, who notes the bivalved cast and continued complaints of pain. The surgeon orders the cast to be replaced, which is accomplished. That evening the patient again complains of pain, this time giving a score report of 10. The physician is again contacted by telephone, and additional pain medications are ordered. Throughout the night, the patient continues to complain of pain despite frequent doses of narcotics.

The patient is scheduled for discharge in the morning. When seen by the surgeon prior to discharge, it is noted that the patient's foot is cool to touch and peripheral pulses remain weak. She has continued complaints of pain and does not want to be discharged at this time. At this point, the surgeon considers the possibility that the patient may be developing a case of compartment syndrome. The cast is removed, and the extremity is tense and cool, with poor color. The patient is immediately taken to the operating room, where a fasciotomy was performed. Upon opening the compartment, it is noted that there is extensive necrotic tissue that requires debridement. The remaining amount of muscle is minimal. The patient eventually recovers but with severe disability in her ambulatory capabilities.

Case Study Discussion

This patient sustained a long-term disability secondary to rapidly developing compartment syndrome. As discussed, rapid assessment and intervention is required to prevent this type of sequelae. The classic sign of compartment syndrome is pain that is out of proportion to the injury. This patient had continued complaints of pain; however, due to her history as someone who was always complaining of pain, her complaints were not taken seriously. All patient complaints should be addressed and believed; the lack of attention to these complaints led to a long-term disability in this patient.

Compartment syndrome is a common complication following fracture, and the possibility of this complication should have been recognized earlier. In fact, the first evening, when the first cast was bivalved, compartment syndrome should have been considered. It was more than 36 hours before the diagnosis of compartment syndrome was made, enough time for severe tissue necrosis to develop. Had the patient undergone a fasciotomy rather than bivalving the cast, the outcome may have been different.

This case demonstrates the need for prompt recognition of patient's complaints and consideration of all potential complications, regardless of the patient's previous history. The nurses and physicians in this case neglected the patient's pain complaints because of her prior history. The patient should have been given the benefit of the doubt, which may have allowed for earlier intervention.

This case subsequently went to litigation. The physicians involved in her care admitted to malpractice in neglecting to recognize and diagnose the development of the compartment syndrome earlier in her care when the potential for complications may have been decreased. The nurses admitted to malpractice as they chose to disregard the patient's complaints when further investigation should have been undertaken. It is a sad outcome, especially as it was a preventable complication.

VOLUME STATUS COMPLICATIONS

Patients sustaining volume status changes in the postoperative period are at risk for the development of recovery-delaying complications. Under- or dehydrated patients will have inadequate circulating volume to support basic body functions, leading to renal failure, immune system failure, and delayed wound healing. Overhydrated patients will experience edema formation, both at the surgical site and systemically. This edema can impact circulation to the involved tissues, delaying healing and preventing the removal of accumulated waste products.

Volume depletion in the recovery phase of care can be due to many causes. Preoperatively, patients are instructed to remain NPO after a certain time (commonly midnight). Many patients will go to bed earlier than midnight; their intake is actually stopped at bedtime. Older patients with cardiovascular disease may be on any number of diuretics, and these drugs can lead to a volume-contracted state. These patients then enter the operating suite with a depleted volume. Intraoperatively, the patient may lose volume either through hemorrhage or inadequate volume replacement. It is not uncommon, especially during abdominal procedures, that fluid is lost to the surrounding tissues, also known as third spacing of fluid. Patients with this complication will demonstrate the signs of volume depletion even though there has been no actual loss of volume, as the volume that remains in the circulatory system is inadequate to support vital functions. Postoperatively, patients may not receive adequate volume replacement to meet their needs.

Signs of volume depletion include a decrease in blood pressure and a decrease in urine output. When patients are initially admitted into the PACU, urinary output is not measured unless an indwelling catheter has been placed. When fully awake, patients may express the need to void, at which point urine output can be evaluated. With volume depletion, the urine is concentrated and appears dark yellow. If an inadequate volume state continues, the renal system becomes compromised, leading to the risk of renal failure.

Volume replacement is calculated on the measured losses (i.e., blood loss estimates) as well as the length of time the patient has remained NPO. It is important to remember that although instructed to be NPO after a certain time, many patients have been without fluid intake for a longer period of time. The formula for volume replacement for NPO time is 2 mL/kg for each hour the patient was NPO.

Replacement fluid can be given intravenously if warranted. Signs of impending renal failure should alert caregivers to the need for intravenous replacement. If the patient is awake, alert, and able to void, volume replacement can be done over the course of a few hours and may be accomplished by oral intake. Before advising the patient to increase oral intake, it is imperative that the patient be assessed and, if necessary, treated for PONV. One of the most common reasons that patients vomit in the postoperative period is early forced fluid intake. Preoperative or perioperative intravenous hydration therapy has been shown to be more effective at reducing PONV [64; 65].

Volume overload is equally as compromising to patients as is volume depletion. Preoperative causes of volume overload are rare; it is much more common for a patient to develop a volume depletion state than an overload state during this period. However, there are many intraoperative risks for volume overload. Patients are given several intravenous medications in the operating room, and it is necessary to flush the IV tubing to ensure adequate delivery of these medications. This repeat flushing of the IV line can significantly increase the volume infused. Patients who experience blood loss during the operative procedure may have blood replacement therapy initiated. When blood replacement is performed, it is common to infuse the entire bag of blood product. If a patient loses 400 mL of blood and receives a unit of packed red blood cells, the patient ends up in a volume excess state. It is rare that the patient would receive the exact amount of blood as the volume lost.

Another cause of volume overhydration is the absorption of irrigating fluid. This can occur whenever irrigating fluid is used, and patients can develop signs of hypertension and edema formation. It is not uncommon for patients undergoing TURP to absorb 1–1.5 liters during the procedure, also known as TURP syndrome [66]. Patients can develop life-threatening complications secondary to this volume overload. TURP syndrome occurs in only 2% of patients undergoing a TURP procedure. Caregivers may therefore be unfamiliar with the syndrome and may not recognize the signs and symptoms, which include [67]:

- Excessive urine output
- Signs of pulmonary congestion (e.g., a wet cough, rales, rhonchi)
- Headache
- Signs of congestive heart failure
- Hyponatremia
- Edema formation

Pulmonary edema can lead to life-threatening respiratory difficulties and the development of severe hypoxemia. Congestive heart failure can increase stressors on the cardiac system, leading to dysrhythmia formation. Hyponatremia can lead to volume shifts within the fluid cavities. Sequestration of fluid can reduce circulation to the tissues, causing hypoxemia and tissue destruction. Without adequate circulation to the wound, healing is compromised, prolonging recovery.

Management of volume overload depends upon the severity of symptoms. Patients with mild edema can have the edematous area elevated to enhance fluid redistribution. Assisting and encouraging the use of respiratory exercises will help resolve the developing hypoxemia. In severe cases, diuretic therapy may be ordered, but judicious use is recommended to prevent a volume depletion state.

Continued assessment in the operative and postoperative phases of care can reduce the risk of volume alterations. Awareness of intake and output is critical, and monitoring patients' responses should be performed for every patient.

Case Study

Patient G is a man, 83 years of age, who is undergoing colon resection for removal of cancerous nodes. The operative procedure proceeds without complication, and the patient is transferred to the PACU without incident.

During the first postoperative hour, the patient is noted to be hypotensive, with a systolic blood pressure of 80 mm Hg. A review of the patient's history indicates that his normal systolic pressure on admission was 160 mm Hg. The patient is noted to take furosemide, hydrochloride thiazide, metoprolol, and lisinopril for blood pressure control. With this information in mind, it is obvious that the patient's systolic pressure is significantly lower than anticipated.

Upon awakening, the patient is confused and disoriented. He needs continual reminders to help orient to person, place, and time. He is not compliant with postoperative instructions and tries to remove the dressing from his abdomen. He complains of pain when asked but is not able to rate the pain on a scale of 1 to 10. He requires wrist restraints to prevent him from disrupting the surgical site.

The patient is also noted to have a history of congestive heart failure following a myocardial infarction many years ago. While fluid resuscitation would be the first step in supporting the patient's blood pressure, the risk of developing further cardiac failure should be considered. Prior to instituting further management, the patient's history and medication use is reviewed.

The patient stated upon admission that he had been NPO after midnight, as instructed. He was told to take his medications in the morning with a small sip of water prior to arriving at the hospital, to which he complied. His wife told the nurses that he did not eat the food recommended on his bowel prep program the evening before surgery; he was anxious and wanted to ensure that his colon had been cleaned out sufficiently. His wife also noted that he had complied with the bowel prep cleansing as instructed.

The patient is administered additional intravenous fluids at a rate of 75 mL/hour. He is finally discharged from the PACU five hours after surgery and transferred to the surgical ward. On the surgical ward, his blood pressure remains low, with an average systolic pressure of 90–100 mm Hg. The patient is discharged on day 3 with a blood pressure of 102/86 mm Hg.

Case Study Discussion

This case presents the typical complication of under-resuscitation and subsequent volume depletion. The patient's response to this complication was the development of a prolonged hypotensive episode, complicated by confusion and disorientation upon awakening.

Further history should have been ascertained from the patient and the patient's wife prior to surgery. The staff was unaware that the patient had been NPO for such a length of time. When asked if he complied with the bowel cleansing as ordered, the patient replied yes; no further questions were asked to ensure how he complied, when he last ate, etc. This assumption increased the risk of compromise.

In addition, the patient took his normal blood pressure control medications prior to surgery. While holding of these medications is often done on the day of surgery, the nurses needed to recognize the potential risk this offered. Ensuring adequate resuscitation and volume status in the preoperative and operative phases of care should have been instituted.

Anesthetic agents are vasodilators. This combined with the administration of blood pressure reducing agents caused a significant drop in the patient's systolic pressure. The patient's systolic pressure remained low even at the time of discharge; it is critical to alert this patient to this development and ensure that the patient follow up with either the surgeon or the cardiologist. As the drugs cleared from the patient's body, the normal systolic pressure should have been achieved.

The confusion and disorientation that developed in the PACU was most likely a consequence of low perfusion pressure within the cranial cavity of this patient. There are several reasons for postoperative confusion in the elderly; those reasons should be identified and treated. In this case, had the patient received fluid resuscitation earlier in the course of care, this neurologic development may have been avoided.

Managing an elderly patient with a history of multiple disease processes, medication use, and anesthetic administration is challenging. Further in-depth evaluation and history taking is critical to ensure safe care delivery throughout the operative period.

GASTROINTESTINAL AND GENITOURINARY COMPLICATIONS

One of the major causes of GI and GU complications following surgery is the preoperative preparation that patients undertake prior to arriving at the hospital. The risk for both GI and GU complications is increased with the nutritional and fluid status of the patient prior to anesthesia. Patients are instructed not to eat before arrival and are kept NPO for many hours prior to the start of surgery. While compliance with these instructions reduces the risk of other complications, most importantly airway obstruction, it causes an increase in risk for GI and GU problems.

Postoperative Ileus

The absence of bowel motility after surgery is known as a postoperative ileus. There is no bowel obstruction causing this hypomotility; it is a physiologic response to surgical intervention on the abdominal tract. Postoperative ileus occurs most commonly following intraperitoneal surgery, but it may also be identified after retroperitoneal and extra-abdominal surgeries. The lack of motility leads to the accumulation of fluid and gas in the GI tract, causing bloating, pain, discomfort, and nausea with or without vomiting, and can extend the hospital stay of postoperative patients [68].

The most common symptoms of postoperative ileus are lack of bowel movement and absence of bowel sounds. Unlike an obstruction, in which bowel tones are present, this is an adynamic state in which there is no bowel motility and no movement of gastric contents. After surgery, the bowel regains function; the small bowel will regain function within hours. The stomach will resume function at one to two days postoperatively, and the colon will eventually regain motility at three to five days after surgery. This pattern of recovery is typically seen in patients without comorbid conditions. Complications such as sepsis, metabolic disorders, pneumonia, and trauma can significantly delay recovery times. In addition, medications commonly used in the recovery phase of care, including narcotics, anticoagulants, and antacids, can alter recovery.

When caring for a patient with an ileus, it is vital to recognize its development. The patient may be uncomfortable, often trying to move and change positions frequently to relieve the pressure in the abdomen. The patient may complain of nausea and may vomit, and the abdomen may be distended and tympanic. The size and shape of the patient's abdomen should be monitored regularly. While the ileus may resolve on its own within a couple of hours, increasing intravenous fluids may help to speed recovery. Judicious use of narcotics, which slow GI peristalsis, may be considered. When choosing medication for pain, the use of nonsteroidal agents may help to reduce the need for additional narcotics and to reduce the swelling of the bowel wall.

It is important that patients do not begin feedings until resolution of the ileus. Should the bowel remain immobile and food intake started, this food will remain in the GI tract and may increase the risk of mechanical obstruction. Beginning a diet with liquids and advancing to soft foods should be recommended for all patients upon resolution of the ileus.

Nasogastric tubes offer no benefit to the patient with an ileus in terms of recovery; however, they may provide discomfort relief if they help remove some of the accumulated gases. One study demonstrated that gum chewing helped speed up the return of peristalsis [68]. Other recommendations have encouraged early ambulation to reduce the risk of other complications, such as DVT and atelectasis. Although early ambulation has generally not been found to be harmful to the patient, it does not appear to prevent or ameliorate postoperative ileus [50; 51; 69; 70]. While most ileus formations resolve quickly and without intervention, many patients complain that this complication is a very uncomfortable aspect of their recovery.

Renal Insufficiency

Genitourinary complications in the postoperative phase include the development of renal insufficiency, which can lead to acute renal failure (i.e., acute kidney injury) if undetected and untreated. Some of the more common causes of renal insufficiency include: dehydration and/or hypovolemia preventing adequate renal blood flow; the use of intravenous dyes; and the use of certain medications. Furthermore, development is more common in certain patient populations, including patients undergoing coronary artery bypass [68].

Although the occurrence is rare (i.e., risk of 0.8%), several factors accurately predict the development of postoperative acute renal failure [68; 71; 72]:

- Advanced age
- Emergent surgery
- Liver disease
- High body mass index (BMI)
- High-risk surgery
- Peripheral vascular occlusive disease
- Chronic obstructive pulmonary disease requiring bronchodilator therapy

Recognition of increased risk can decrease the associated mortality; following cardiac surgery, the development of acute renal failure requiring dialysis is associated with a mortality rate as high as 40% to 70% [73; 74]. Infection and cardiorespiratory complications are the most common causes of death in patients with acute renal failure [72]. One sign of impending renal failure is a low urine output with rising serum creatinine levels. Hyperkalemia is a common complication of acute renal failure [72].

Management of renal insufficiency begins with fluid challenges [72]. Based on the age, weight, and medical condition of the patient, fluids are infused to challenge the kidneys to begin normal functioning. Furosemide may be used to correct volume overload if the patient is still responsive. All nephrotoxic agents should be avoided or used with extreme caution. All medications cleared by renal excretion should also be avoided or their doses adjusted [75].

Early recognition of renal compromise and postoperative ileus is imperative to maintaining homeostasis of the GI and GU systems following surgery. While an ileus is a common development, prompt resuscitation with fluid is important to prevent it from progressing to a more significant complication. Renal insufficiency in the early postoperative phase can be treated with fluid resuscitation with good success at preventing the more life-threatening complication of acute renal failure and the need for dialysis. Reviewing the patient's intake and output record is an important place to start the assessment of volume status, keeping in mind that the patient may have arrived at the facility in a state of dehydration and volume depletion. Ensuring adequate circulating volume is the one parameter that can prevent these two rare complications.

Case Study

Patient H, a man 34 years of age, is admitted to the PACU following abdominal surgery for colitis. In the operating room, the patient's disease was found to be extensive, and he now has an ileostomy for stool drainage. He had a large mid-line incision reaching from the pubis to the distal sternum.

Upon admission, his vital signs are: blood pressure 102/60 mm Hg, pulse 72 beats per minute, respiratory rate 16 breaths per minute, oxygen saturation 94%, and core temperature 35°C. He is somnolent but opens his eyes upon repeated commands. The formation of the stoma was discussed with the patient prior to surgery as a last choice option; however, he was unaware at that point in his care of the extent of his disease and the need for the ileostomy.

After 15 minutes, the repeat vital signs are unchanged except for the blood pressure, which is 90/58 mm Hg. His body temperature remains at 35°C. Measures to rewarm the patient are undertaken. He continues to sleep, although he is arousable. After 30 minutes, the patient's blood pressure drops to 84/48 mm Hg. It is also noted that urine output is only 5–10 mL of dark yellow urine in the Foley catheter tubing. The physician is notified, and she orders a fluid challenge of 100 mL.

After the fluid challenge, the patient's blood pressure rises to 92/60 mm Hg. Although this is below baseline, it does show improvement. However, urine output remains the same; there is no recognizable response to this fluid challenge. The ostomy drainage does increase and is measured at 100 mL of very light yellow liquid.

Two hours after admission, the patient remains in the PACU. His core body temperature remains low, and his blood pressure is below baseline. Little urine output has been noted, but ostomy output is at 250 mL since surgery. Bowel tones are heard as high-pitched squeaks. Additionally, the patient remains significantly sleepy and slow to respond to commands.

After three hours, the patient is transferred to the surgical inpatient unit. His blood pressure is 98/60 mm Hg, pulse 70 beats per minute, respiratory rate 16 breaths per minute, core body temperature 35°C, and oxygen saturation 96%. Urine output totals 30 mL since the end of surgery; ostomy drainage totals 350 mL. The patient is arousable but sleeping when not stimulated.

That same evening, approximately seven hours after surgery, the patient is awake and complaining of severe abdominal pain. His abdomen is distended; ostomy drainage now measures an additional 300 mL, and urine output is 150 mL. The surgeon is notified, and the patient is evaluated. At this point, the surgeon speculates that there may be leakage at the stoma site. The patient is prepped for the operating room for further evaluation.

While waiting for the surgical team to arrive, the patient begins passing a significant amount of gas into the ostomy bag. The amount of drainage remains high, but with the passing of the gas the distension begins to resolve and the patient notes that his pain has diminished. It is determined that the surgery will be delayed pending resolution of the abdominal distension.

The patient remains in the hospital for another four days. He receives instructions on how to manage his stoma and ostomy. His stoma drainage remains high for the first two days. He tries solid foods on day 3 but develops severe abdominal cramping and distension yet again. His diet is changed to soft foods, and over the course of the next week, he is eventually able to tolerate a normal diet.

Case Study Discussion

This patient was admitted following an extensive abdominal procedure. Upon arrival in the PACU, his core body temperature was low; however, this is common in patients undergoing an open abdominal procedure of extended length. The only error in care was the delay in beginning to warm the patient.

Rewarming measures, using forced air warming, should be the standard of practice for this type of patient.

The patient developed hypovolemia, as evidenced by his low blood pressure. This period of decreased circulating volume could have potentiated the risk of subsequent ileus formation. The fluid challenge of 100 mL was ordered without awareness of the ostomy output. This output should be included in the volume assessment of the patient prior to reporting his vital signs. Most likely, a large fluid challenge would have benefited the patient and could have helped to prevent the ileus formation.

When the patient complained of severe pain while in the nursing unit, it was appropriate to consider the risk of failure of the stoma sutures. This is not an uncommon complication in this type of surgery, especially with the distended abdomen. However, the patient required a more detailed evaluation prior to being prepped for surgery. Ileus formation was not considered because the patient had audible bowel tones. While most patients with postoperative ileus do not exhibit bowel tones, these tones are not uncommon for patients with a stoma and significant changes in their GI tract. One procedure that may be beneficial for these patients is the insertion of a tube into the stoma. However, with the concern of disruption of the sutures, this was not an appropriate course of action for Patient H and was not performed.

While the patient did exhibit postoperative complications, the development was not unexpected. The assessment of the patient could have been better; assessing the intake and output beginning before surgery may have alerted the staff to the hypovolemic state. If this had been recognized and treated earlier, the ileus formation may have been averted. However, it is not uncommon for this patient type to develop an ileus, so it is difficult to determine whether it was a controllable complication. The patient's ultimate outcome was not affected by these complications, but his recovery period could have been more comfortable and without risk had certain assessment parameters been monitored more closely.

COMPLICATIONS IN SPECIFIC PATIENT POPULATIONS

PEDIATRIC PATIENTS

Management of the pediatric patient in the postoperative period requires the same set of skills and interventions as for the adult patient; however, increased vigilance is necessary as children can decompensate rapidly. Awareness of the anatomic and physiologic differences between children and adults will impact care delivery. The measures undertaken to support a child should include not only hands-on care but emotional and psychological support as well.

Managing the airway of a child is critical to success. It is imperative to remember that the larynx is more cephalad and anterior than in the adult patient. This anatomic difference requires proper head positioning at all times. The child should be placed in the sniffing position, maintaining a jaw thrust position. Additionally, the airway diameter is narrow, and airway swelling can lead to rapid onset of airway obstruction. Ensuring good air movement through the trachea is an important assessment intervention.

Children are more susceptible to vagal and sympathetic stimuli. It is common to see large heart rate swings accompanied by blood pressure changes. Knowing the normal values for a child will allow for the accurate assessment of changes from baseline. Children also have small abdominal capacities, and air accumulation in the stomach is common, which puts pressure on the diaphragm. Children can swallow air while crying, and air can be insufflated during positive pressure ventilation. This pressure on the diaphragm can lead to a decrease in functional residual capacity in the child. In addition, renal function is not well developed in children; clearance of drugs can be delayed, and prolonged drug effects can occur. Weighing a child during the preoperative phase is important as all medications will be administered on a per-kilogram basis. Hypothermia is more common in children secondary to their large body surface area in relation to their body mass. The immune system is not as well developed, putting the child at increased risk of infection and delayed healing.

PEDIATRIC FLUID REPLACEMENT FORMULA
100 mL/kg for each of the first 10 kg 50 mL/kg for each of the second 10 kg 20 mL/kg for each kg over 20 kg
Example: 20-km child 1,000 mL for first 10 kg 500 mL for second 10 kg Total: 1,500 mL/24 hours Rate of administration: 62 mL/hr Fluid choice: D5 normal saline OR D5 0.25% normal saline
Source: Compiled by Author *Table 5*

Anesthetic considerations in children include the need for more inhaled gas to achieve the same depth of anesthesia as in the adult patient. However, children will emerge more rapidly due to their high minute volumes. In young children, the central nervous system is not well-developed and the blood-brain barrier is permeable. Young children may not respond to drugs in the anticipated manner, and the onset of drugs may be faster. Pain responses are not as well developed in young children; pain scales that are specifically designed for children should be available and used.

Postoperative management of the child includes performing a thorough, accurate assessment and repeating this assessment frequently. Children have high oxygen demands, and postoperative oxygen therapy is common. Maintaining proper head position with a small towel or pillow under the shoulder blades will ensure adequate airway protection. Elevating the head of the bed to decrease airway edema is always a wise choice, with consideration of operative needs. As children are more prone to postoperative hypothermia, it is important that warming measures be instituted early. Warming intravenous fluids may assist with rewarming; however, the volume of fluid infused may be inadequate to make much of a difference in the patient's body temperature. Using forced air devices is the best method for rewarming. Another measure that has shown some success is the use of overhead heaters [76]. Due to the large body surface area of children, these devices may be of benefit in this population while their use is limited in adults.

Prevention of volume depletion is important in the management of pediatric patients. Fluid replacement is based on the child's weight (***Table 5***). Children have increased fluid loss through normal mechanisms and are therefore prone to volume depletion. Supporting the ventilatory effort of the child is necessary to prevent the development of hypoxemia. During the assessment, healthcare professionals should consider using devices such as incentive spirometers; children often consider these devices to be like a game and are therefore more cooperative in performing the exercises.

Assessing pain and providing pain relief is important in this patient population. The American Society of Anesthesiology recommends aggressive and proactive pain management in the pediatric population to overcome the historic undertreatment of pain in children [33]. A child's underdeveloped nervous system may respond to pain medications differently than an adult's; it is common to administer pain medications at one-half the normal dosage during the first postoperative hour. The use of the multimodal approach to pain management should be instituted. Providing alternatives to pain medications can be useful. Allowing a parent to hold a child or providing a child with a pacifier or bottle may be helpful in providing comfort to the child. Of course, all these measures should be undertaken with the constraints of the surgery in mind.

As previously noted, common postoperative complications in children include hypothermia, nausea and vomiting, malignant hyperthermia, and emergence delirium. The interventions for these complications have been discussed in this course. Unique to children is the development of postextubation croup. Subglottic edema develops secondary to prolonged intubation, trauma during intubation, or as a result of coughing against the endotracheal tube. This type of croup is more common in young children between 1 and 3 years of age [77]. The symptoms usually occur within 30 minutes of extubation and peak at six to eight hours post-extubation. The child exhibits the signs of croup, including the barking cough, stridor, and chest retractions. With treatment, these signs will subside within 24 hours. Management includes administration of cool, humidified oxygen and nebulized epinephrine. The role of corticosteroids remains controversial [78; 121].

Management of children in the PACU includes addressing both their physical needs and their psychosocial needs. A child's response to awakening in the PACU is commonly one of fear: fear of the unknown, fear of the care providers, and fear of the lack of control. Involving parents in the care of the child is often recommended and encouraged. Parents can provide a bridge between the caregivers and the child. Parents are able to interpret the needs of their child and to assess for normal versus abnormal behaviors. Involving one or both parents in the care of a child is becoming a standard of practice in many pediatric PACUs.

Attention to detail is critical in the management of a child recovering from anesthesia and surgery. Protecting the child from harm and ensuring a safe recovery should be the foremost concern. With these considerations in mind, children recover quickly without the long-term sequelae that are more common in older patients.

Case Study

Patient I is a girl, 5 years of age, undergoing a surgical intervention to correct a congenital cleft lip and palate. She is small for her age and has had multiple difficulties with food intake. During the first year of life, it was nearly impossible for her to suck either at the nipple or on a bottle due to the shape and size of the defect. Despite multiple attempts and alternative methods of feeding, her growth has been slowed due to malnourishment. As she became able to ingest solid foods, she had difficulty with swallowing and had multiple bouts of sinus infections due to food particles being forced into the open sinuses.

In the preoperative phase of care, Patient I is noted to be quite anxious, crying in her mother's arms and shying away from the caregivers. She does not want an IV line started and throws a tantrum when this is attempted. Despite her young age, she is well aware of the multitude of interventions that occur in a hospital setting and she is determined to maintain some control over these developments. Her mother comforts her and does not appear to have much control over Patient I's behavior.

The corrective repair progresses without complication, although the surgery is long, more than six hours in length. When Patient I is transferred to the PACU, she is intubated and asleep. The surgeons do not want her to awaken abruptly and risk dislodgement of the endotracheal tube and/or damage to the surgical site. Her vital signs are stable compared to those obtained during the preoperative phase of care. She has an IV line in her right forearm, a Foley catheter, and cardiac monitoring electrodes on her chest, along with the endotracheal tube.

After Patient I is stabilized in the PACU, her mother is allowed in to see her and sit at the bedside. The mother is instructed to watch the patient and notify the nurses if she starts to awaken and reach for the tubes. The mother is overwhelmed by the change in her daughter's appearance, something she has dreamed about for the last five years.

After 30 minutes in the PACU, Patient I begins to move in bed. Her eyes remain closed but she appears to be awakening and somewhat agitated. The orders are to administer narcotics to the patient for pain; however, the patient is unable to use any type of pain scale due to the decrease in cognition. The mother is holding the child's hand when the child pulls her hand away and starts to reach for her mouth. The nurse sees this happening and is able to grasp the child's wrist and prevent her from reaching the tube and surgical site. Wrist restraints are applied to ensure that the patient is not able to repeat this potentially life-threatening action.

At 60 minutes, the patient begins to open her eyes and starts to move from side to side. She is pulling against the restraints and trying to sit up so she can reach the endotracheal tube to remove it. The nurse instructs the patient that she must lie still and that the tube must remain in place. The nurse attempts to use an illustrated pain scale, but the patient refuses to cooperate, continuing to pull at the restraints.

During this combative period, the patient's blood pressure and pulse rate continue to rise and blood is noted on the dressing around her mouth. It is imperative that something be done to reduce the risk of damage; the nurse decides to medicate the patient with the narcotic ordered to help control the agitation and allow the child to relax and perhaps fall asleep. This objective is achieved, and the patient falls asleep and appears relaxed. Her vital signs again return to preoperative values.

Ninety minutes after surgery, the surgeon enters the PACU to examine the patient. While touching the patient's dressing, the patient's eyes open; she grasps the hand of the surgeon and tries to grasp the endotracheal tube. She is shaking her head violently from side to side, and the dressing on her face begins to loosen. The physician yells for assistance, and the nurse holds the head of the child still so the tube and dressing can be re-stabilized and secured. The look in the eyes of the child is one of pure terror. By now the only way the patient is able to lash out is to kick her legs, and she is thrashing about in the bed. Her mother is trying to calm her, but the child does not appear to recognize her mother or at least does not respond to the mother's efforts.

The surgeon orders a dose of midazolam in an effort to calm the child and ensure the safety of the tube and surgical site. After administration, the child does calm down and is no longer struggling; however, she does not appear to fall asleep. She continues to have a very scared look in her eyes, and she does not appear to be fully aware of what is going on around her. Within 20 minutes, the child is dozing quietly and appears to be much more comfortable.

Two hours after surgery, the patient again awakens and is calm and cooperative. She is responding to her mother and is receiving comfort from her mother's presence. She is again instructed as to the need for the restraints and is not pulling against them. She tries to talk and begins coughing against the endotracheal tube. The surgeon has ordered that the patient remain intubated for at least the first 48 hours post-surgery to ensure adequate time for the wound healing to begin. This is going to be a challenge with this patient as she is trying continually to either remove or talk around the tube.

The patient is stable at three hours and is transferred to the ICU, as she remains intubated. Report is given to the staff. While the patient is being moved to the ICU bed and her hands are free, she grabs the endotracheal tube and pulls. Fortunately, she is prevented from removing the tube, although the tube is checked to ensure proper placement. At 48 hours, she is extubated and transferred to the pediatric floor. Within four days she is discharged home without further complication.

Case Study Discussion

This child presents a number of challenges to the PACU staff. Airway management is always the first step in stabilizing a patient who has arrived from the operating suite, and this patient did have a secure airway at the time of transfer. The concern developed when the patient began to awaken and tried to remove the tube. Had she been successful at pulling the tube, this could have been a life-threatening complication. Attempting to mask ventilate the child would be challenging with the surgical repair site preventing the achievement of a good seal with the mask. Re-intubation would have to be performed with extreme caution to prevent damage to the surgical repair.

The child was initially stable, and the recovery appeared to be without incident. However, after the child started to awaken she demonstrated many of the signs of emergence delirium, which is more common in children than adults. She was thrashing about, pulling on her restraints, and uncooperative with instructions. Her mother did not appear to be able to calm her, indicating the possibility that she was disoriented and confused.

While the nurse was aware of the need to protect the child, she chose to administer the narcotics as ordered rather than receive an order for a different medication. It may have been that the narcotic was the right choice; the patient could have been in pain, although this was not assessed due to her behavior. On the other hand, the narcotic could have caused the second bout of combativeness noted upon the surgeon's arrival. When the patient was able to grasp the endotracheal tube, it was determined that the mother had released the restraint while holding her daughter's hand. This could have been another life-threatening complication; the nurse needed to not only ensure that the mother understood the need for the restraints but also check for proper placement of the restraints when her vital signs were obtained. Midazolam was the drug that was able to allow the child to fall asleep and awaken in a more controlled state. Although midazolam may be a cause of emergence delirium and confusion in children, it is also one of the first drugs considered in its management. For this patient, it was the right drug, although the right time may have been during the first episode of combativeness. Not all children must be medicated; however, with the risks of tube dislodgement and surgical site disruption being quite high in this child, the administration of midazolam in the earlier phase of care may have been a better choice.

This case demonstrates the multitude of issues in dealing with pediatric patients. Although patients are educated prior to the surgical intervention, this education is not fully understood and the child may not follow instructions as directed. The mother was an excellent source of comfort to her child but also put her child at huge risk by untying the restraints. Parents should have continual reminders of their place in the care of their child.

The risk of postextubation croup was not addressed but could have presented a significant challenge to this patient either in the ICU or once on the pediatric unit. The risk of this form of croup increases when the patient has remained intubated for a length of time and/or when the child fights against the tube, both risk factors in this case. Fortunately, this did not occur and the patient was eventually discharged without further incident.

Children present challenges regularly in the PACU. Their risk of compromise is greater, and the complications are different. Astute care will allow for safe recovery during this period.

GERIATRIC PATIENTS

Individuals older than 85 years of age make up one of the fastest growing segments of the population in the United States [79; 122]. This increase in longevity makes it inevitable that geriatric patients will undergo an increased number of surgical interventions. More than 40% of procedures performed in the United States are performed on patients older than 65 years of age [3]. Additionally, this age group has longer hospital stays and utilizes more healthcare resources than any other age group [3]. The existence of comorbid diseases increases with age; these chronic conditions can delay recovery. Thus, managing care for geriatric patients is a large part of the postoperative picture. Awareness of the changes that occur with aging and their significance to care will ensure safe care delivery.

Preoperative assessment is a critical part of care delivery in the geriatric population. An extensive, thorough history should be ascertained, including the presence of comorbid diseases that increase the risk of postoperative complications. A list of prescribed and over-the-counter medications and a history of the last doses of these drugs should be obtained. Prediction of risk and mortality is difficult, but measures can be undertaken to help determine if patients are at risk for either intraoperative or postoperative complications. If time allows, ambulatory ECG monitoring for 24 hours may be employed. Signs of silent ischemia should be noted and can direct the course of care during the intraoperative period.

Additional assessment should be directed at recognizing patients who are malnourished. Due to financial restraints, many elderly patients will not be able to spend money on well-balanced meals, leading to malnourishment. The loss of body proteins can affect the metabolism, onset, and clearance of highly protein-bound drugs. On the other end of the scale, obese geriatric patients are at risk of prolonged drug action when administered drugs that are highly lipid-soluble. The pharmacokinetics of drugs used for these patients should be assessed based on the history and physical state prior to their administration.

As humans age, the cardiovascular system deteriorates. The myocardium is less sensitive to catecholamine release, and cardiac output drops by half [80]. The vascular system stiffens, and responses to blood pressure changes are not as beneficial, causing compensatory responses to be blunted. This weakening of the cardiovascular system impacts elderly patients' responses to medications; the lower cardiac output leads to a slower onset of drug action and a longer length of drug action secondary to slower metabolism.

As the respiratory system ages, there is a decrease in total lung surface area, an increase in the ventilation-to-perfusion ratio, and a decrease in the cough reflex. Patients may develop an inadequate removal of carbon dioxide and an increased work of breathing. The loss of the cough reflex can lead to an accumulation of secretions and an increased risk of postoperative pneumonia or respiratory infection. Respiratory complications encompass the largest group of problems in the postoperative elderly patient [81;123;124]. Astute care is required to prevent respiratory failure in this patient population.

Neurologically, there is a loss of neurons with age, leading to alterations in function. Responses to medications can be altered, and neurologic assessment may be more difficult. Preoperative neurologic function should be evaluated as a baseline for comparison in the recovery phase of care. Fluid and electrolyte imbalances become more common as the body ages, and patients often take an increasing number of prescribed and over-the-counter medications. With diminished neurologic awareness there is an accompanying loss of protective mechanisms, putting the patient at increased risk of injury and falls.

Measures to manage and limit postoperative complications in geriatric patients are the same as those in adult patients. However, priority in management should be directed at supporting the cardiovascular and respiratory systems. Maintenance of ventilation and the optimization of gas exchange are critical in preventing postoperative hypoxemia. Ensuring cardiovascular stability with judicious assessment of volume and fluid and electrolyte status is imperative to prevent cardiac events.

Medication administration in elderly patients can present a challenge. Cardiovascular changes cause the slow onset of drugs, and renal deterioration leads to a prolonged clearance of drugs. In addition, comorbid diseases may require medication administration, leading to cumulative drug effects. When administering medications to the elderly patient, the recommended method is "Start Low, Go Slow" [30; 33; 82]. This method will allow time for adequate onset and assessment of the effects on the patient. As an example, orders for postoperative narcotics are generally decreased during the initial phases of recovery [30].

Managing pain in the geriatric patient can also be difficult. The presence of comorbid diseases can impact pain responses. Older patients have different attitudes to pain than younger patients; their pain is often neglected and/or underreported [33; 83]. Changes in cognition require the use of pain scales that can take these alterations into account. Utilizing the titration method to manage pain can limit the oversedation that is common with many of the commonly used pain medications. Providing comfort measures will have the benefit of making the patient more comfortable. The awkward positions required in the operating room may greatly increase discomfort in elderly patients with stiff joints and arthritis. Ensuring comfort with pillows, back support, and light massage will be greatly appreciated.

Elderly patients are more vulnerable to hypothermia during the recovery phase [81;123]. The loss of subcutaneous tissue enhances the loss of body temperature. Shivering will significantly increase the metabolic rate of geriatric patients; this patient population does not have the reserve available to meet these increased demands. Providing warm blankets, utilizing forced air heating, and warming both oxygen and intravenous fluids can reduce this risk. It is important to note that external warming devices should be used with caution; the thin skin of elderly patients increases their risk of burns and tissue destruction.

One of the most commonly encountered complications in the management of the elderly patient following surgery and anesthesia is the development of emergence confusion/disorientation or a delay in awakening. Emergence delirium, which has been discussed in this course, is only one facet of this complication. The elderly patient may indeed be demonstrating emergence delirium secondary to hypoxemia and drug administration. However, it may also be possible that the patient suffered a neurologic event, such as a stroke, while under sedation. This type of complication may not be recognized while the patient is under deep anesthesia. When the patient is expected to awaken and does not, or awakens with a neurologic deficit, this type of devastating event should be considered.

Delayed awakening can also be caused by cumulative drug effects. The half-life of most drugs is significantly lengthened in elderly patients, and repeat dosing may lead to the accumulation of the drug within the central nervous system. Allowing time for the patient to awaken naturally and slowly will be much more successful than the utilization of reversal agents, if available. Reversal agents can cause an abrupt change in the physiologic responses to medications and are very uncomfortable for patients. If the patient does not awaken within one to two hours, repeat assessment and consultation with a neurologist may be considered.

Another possible cause of delayed awakening is hypothermia. Hypothermia causes multiple complications, and these complications, including a shift in the oxyhemoglobin curve and a decrease in the glomerular filtration rate, can cause the patient to remain somnolent for a long period of time during recovery. Warming the patient and encouraging good respiratory effort once awake can speed the arousal and orientation of this patient population.

Care of geriatric postoperative patients will often continue long into the post-recovery phase. Ensuring that the patient will receive continued care, whether at home or in a nursing care facility, is critical before discharge. Also, it is imperative that each patient's wishes are identified in an advanced directive. This advanced directive should be reviewed with the patient prior to the administration of any sedating or mind-altering medications. A responsible adult should be identified who can act as a spokesperson and advocate for the patient [84].

With the improvement and advances in technology, more and more procedures are available to the elderly patient. Twenty years ago, this patient group may not have been considered good candidates for many of the surgical interventions that are being performed today. It is critical that the stressors of anesthesia and surgery are identified and compensated for to assist elderly patients with the best success at returning to a functional lifestyle at the time of discharge.

Case Study

Patient J is a man, 87 years of age, undergoing surgical repair of a fractured hip. He was living at home independently when he slipped and fell in the bathroom, fracturing his right femoral neck. He was on the floor for an indeterminate amount of time prior to being found by a neighbor who checked on him when he had not been seen for a number of hours. Emergency service personnel were called. They found the patient on the bathroom floor in a confused state. He was unable to accurately note the date or time, and he had no recollection of how he ended up on the floor. During the head-to-toe assessment, it was noted that Patient J had sustained a small scalp laceration over his right temporal region, which was clotted by the time the ambulance personnel arrived. His leg was in a displaced position, and a fractured hip was suspected. He was also noted to have a healed scar on his sternum, indicative of a previous open-heart procedure.

Upon arrival in the emergency department, the patient is evaluated by orthopedic, cardiology, and neurology specialists. His history is reviewed and reveals a previous open-heart procedure eight years prior to admission, a long history of smoking prior to the cardiac procedure, and a history of lifelong obesity. The patient's skin condition is poor; he has multiple bruises in varying stages of healing. He has multiple folds of fatty skin, and between these folds, the skin is quite dirty and foul smelling, indicating a poor hygienic state. He has a list of medications in his wallet, which identifies the following drugs: digoxin, simvastatin, furosemide, potassium chloride, amlodipine, and lisinopril. Due to his current state of confusion, the accuracy of this list and the last time the patient took his prescribed medications are unable to be determined.

Patient J's greatest immediate need is stabilization of the fractured femur. The neurologist deems that it is appropriate to perform the surgery under general anesthesia and that postoperative neurologic assessment should be initiated. The cardiologist agrees that the patient is stable from a cardiac standpoint and that he will most likely be able to tolerate the effects of anesthesia. The orthopedic surgeon performs the fractured hip repair.

Upon transfer to the PACU, the patient is still asleep; he was extubated in the operating room, has a cardiac monitor on and a Foley catheter in place, and his hip is positioned for optimum healing. His vital signs are: blood pressure 162/100 mm Hg, pulse 80 beats per minute, respiratory rate 22 breaths per minute, oxygen saturation 89% on 4 liters nasal prongs, and core temperature 34.5°C.

No urine is noted in the Foley catheter. The greatest initial concern is the lower oxygen saturation; the nasal prongs are replaced by a face mask at a flow rate of 6 liters per minute. Within 15 minutes of switching the oxygen delivery device, the oxygen saturation increases to 91%.

Thirty minutes after arrival in the PACU, the patient remains asleep. His vital signs are stable; however, his body temperature remains at 35°C despite forced air warming. He is not moving nor does he appear to be in any discomfort. His skin condition does not appear to have improved. His lower extremities are cool to touch, and peripheral perfusion is poor.

At approximately 40 minutes after arrival in the PACU, the patient sustains a cardiac arrest. Resuscitation efforts continue for approximately 20 minutes without success, and the physician in charge pronounces the patient dead.

Case Study Discussion

This patient is representative of the typical postoperative geriatric patient. He has multiple health issues and takes many medications. His physical status is compromised by his nutritional status, in this case, obesity. He was living independently prior to this event; he did not have family close by, and his history was only ascertained by the information that his neighbor and the first care responders were able to locate. Even with that, the accuracy of this information was questioned. Prior to the fall, the patient had been happily living his life, which was subsequently lost after the surgery.

After the patient was pronounced dead, it was speculated that he had developed a clot that occluded his pulmonary vasculature. If this was indeed the case, the outcome would not have changed despite the resuscitation efforts. However, due to his advanced age and condition, a postmortem exam was not performed and the cause of death was never confirmed.

The patient's condition was compromised by numerous factors. He had a positive cardiac and smoking history and may have sustained a neurologic event at the time of the fall, or a neurologic event may have precipitated the fall. His obesity presented a number of issues. His skin condition was quite poor, and his apparent lack of hygiene would increase his risk of postoperative infection. While he was considered to be independent, his current health state was definitely not optimal.

Had this patient survived, in all likelihood, he would not have been able to return to an independent living environment. He would have required care in a rehabilitation facility to learn to ambulate post-surgery. Whether he would be strong enough to recover to a fully independent state was questionable.

This case demonstrates the many issues and challenges in managing the elderly patient. The lack of concrete information in the preoperative stage can impact the decisions that are made in the operating suite. Patient J's poor health status put him at increased risk for complication development. Even if the patient had survived, his long-term outcome would have been significantly different than the lifestyle he had prior to the injury. Preparing the patient and family for these less-than-optimum outcomes should be considered part of the preoperative care measures.

MORBIDLY OBESE PATIENTS

As morbid obesity (also referred to as severe obesity or class 3 obesity) becomes an increasingly common condition in our society, the need and desire for bariatric surgery has exploded [85; 93]. Morbidly obese patients (defined as persons with a BMI of 40 or greater) are requesting surgical intervention to put an end to the risk they are exposed to when overweight [86]. Morbid obesity increases the risk of hypertension, diabetes, hyperlipidemia, coronary heart disease, and stroke [87; 125]. These conditions increase the risk of complication development when undergoing surgery, including bariatric surgery.

There are two major types of bariatric surgery: those that restrict the limit of intake and those that restrict absorption. Restrictive procedures, including gastric banding and sleeve gastrectomy, reduces the amount of food the stomach can hold. Malabsorptive procedures, including biliopancreatic diversion with duodenal switch (BPD/DS), divert the gastric contents so the food bypasses the small intestine where food and nutrient absorption occur, preventing absorption. The criterion standard of bariatric surgery, Roux-en-Y gastric bypass, combines both malabsorption and restrictive techniques [94]. These types of procedures are associated with a weight loss of 40% to 80% of excess weight in patients, with maintenance of approximately 50% or greater at five-year follow-up [87; 94]. The other advantage of bariatric surgery is reduction or removal of life-threatening complications of obesity. In one study, 77% of bariatric surgery patients with preoperative diabetes no longer required medication after weight loss [87]. The most effective surgery for patients with diabetes is BPD/DS [94]. Ten of 11 randomized controlled trials from around the world that compared surgery with medical treatment of type 2 diabetes found surgery to be superior at achieving remission of diabetes or glycemic improvement. Surgery was also superior at improving weight loss and reducing medication burden [88].

Management of morbidly obese patients requires assessment and intervention not only on the physiologic level but also on the medical and psychological level. These patients have numerous health issues that should be addressed, and the emotional and psychological impact of the disease is significant. Many of these patients come to the surgeon's office hoping that the surgery will solve their problems and are not willing or able to address the multitude of issues associated with their condition and the surgery. Often, their hope is that minimal effort is required for weight loss.

Postoperative management is challenging. Studies have demonstrated that when a surgeon and facility manage these patients more frequently, the risk of complications decreases [87; 125]. Familiarity with the postoperative complications allows for better patient management. Mortality rates range from 0.1% to 2% [87; 125]. The risk of death is higher in men, patients with advanced age, cases of severe obesity (i.e., BMI ≥50), and patients with comorbid conditions [87; 125].

There are several complications common to bariatric surgery. Nausea and vomiting occur in up to 50% of postoperative patients [87]. Dumping syndrome, which includes diarrhea, occurs in up to 70% of patients [89]. A multitude of fluid and electrolyte imbalances occur as absorption is altered. Additionally, there are a number of surgical complications that may develop, including anastomotic leaks, strictures, bowel obstruction, adhesions, hernias, and cholelithiasis [90].

EVIDENCE-BASED PRACTICE RECOMMENDATION

According to the American Association of Clinical Endocrinologists, the Obesity Society, and American Society for Metabolic and Bariatric Surgery, respiratory distress or failure to wean from ventilatory support should prompt a diagnostic work-up for pulmonary embolus.

(https://linkinghub.elsevier.com/retrieve/pii/S1530891X20428022. Last accessed January 9, 2024.)

Level of Evidence: Grade B; BEL 2 (Strong recommendation based on intermediate evidence)

Due to the multitude of health issues that obese patients experience preoperatively, there is an increased risk of additional complications in the postoperative period. These patients have an increased risk of DVT, pulmonary embolism, and depression. Despite the risks, the benefits generally outweigh the complications. Reversal of the life-threatening complications of obesity is achieved, and longevity can be extended.

Management of bariatric surgery patients in the postoperative period is the same as for any other patient undergoing abdominal surgery. However, the patient's history of comorbidities should be considered and these complications managed. It is important to assess for respiratory insufficiency when the patient returns to the PACU. If the patient is in the supine position during the surgical procedure, the weight of the abdomen will displace the diaphragm upward, limiting the respiratory excursion effort. This results in decreased ventilation. If this is the case, the patient will demonstrate hypoxemia and hypercapnia during the recovery period. The head of the bed should be elevated to help reduce this pressure on the diaphragm and maximize lung expansion [89].

Abdominal pain or left shoulder pain or tenderness can be a sign of an anastomotic leak. Other signs include tachycardia, fever, elevated white blood cell count, and oxygen desaturation. These changes should be reported to the surgeon immediately; if not treated, these leaks carry a high mortality rate. Treatment can vary from a re-operative procedure to placement of an abdominal drain.

The physical care of this patient also presents a challenge. The patient may not fit onto a standard PACU stretcher and, therefore, should be managed on a stretcher that has been built to support the additional weight. Obese patients also often have skin care issues. They may not have been able to reach and access skin folds, so organisms can accumulate in these areas. Decubiti formation is also possible. These patients have a difficult time moving and rotating from side to side; thus, they tend to remain in one place, with poor circulation to the dependent area.

Managing postoperative diabetes is critical. Swings in blood sugar levels can occur following weight-loss surgery, as the patient's metabolic system has been altered. Check blood sugar regularly and administer insulin, as needed, to prevent blood sugar surges. Following sequential laboratory values can alert healthcare professionals to the development of electrolyte imbalances, including shifts in potassium, chloride, and calcium levels.

Case Study

Patient K is a woman, 42 years of age, who weighs 432 pounds. She has a BMI of 62 and is scheduled to undergo a restrictive bariatric procedure. Her history is positive for hypertension, diabetes controlled with two to three insulin injections daily, gastroesophageal reflux disease, and obstructive sleep apnea. She is nervous prior to surgery, yet anxiously awaiting the new life that she sees in her future.

The operative course of care is unremarkable. The patient has a gastric band placed, creating a small pouch. She is transferred to the PACU having been extubated. Her vital signs upon admission are: blood pressure 182/112 mm Hg, pulse 82 beats per minute, respiratory rate 24 breaths per minute, core temperature 35°C, and oxygen saturation 91%. She remains very somnolent but opens her eyes with loud verbal stimulus.

Upon admission, the concern for this patient is the low oxygen saturation. She maintained a saturation of 94% during the procedure but the postoperative saturation remains 90% to 91%. Oxygen is being delivered by nasal cannula at 4 liters/minute. The nurse caring for the patient is unsuccessful at awakening her for more than a few seconds. The oxygen delivery system is changed to a face mask with a liter flow of 6 liters/minute. Little improvement in the patient's status is seen with this change.

It would be optimal to awaken the patient to have her participate in respiratory exercises; however, she remains quite sleepy while in the unit. Elevating the head of the bed may help her oxygenation but does little to increase her oxygen saturation values. Arterial blood gas analysis is obtained; the results are pH of 7.34, PaO_2 of 74, and $PaCO_2$ of 47. With these results it is obvious that the patient is hypoventilating, most likely secondary to pressure on the diaphragm limiting her respiratory excursion effort.

The patient remains somnolent for the next four hours. Her oxygen saturation values remain around 91% despite the efforts of the staff. After four hours in the PACU, she is transferred to the inpatient unit for an overnight stay. She remains hypoxic until the following afternoon.

Case Study Discussion

The patient in this case study demonstrated one of the more common complications following bariatric surgery: hypoventilation. The upward displacement of Patient K's diaphragm prevented full expansion of her lungs, causing carbon dioxide levels to rise while oxygenation values remained low. Although the levels were low, they were not to the point of being life-threatening.

One measure that may be used to improve oxygenation in patients following surgery is respiratory exercises to help expand the lungs and encourage the patient to expel secretions. To accomplish this goal, the patient should be cooperative and have an appropriate cognitive level to follow the commands. As this patient remained somnolent for a lengthy period, efforts at obtaining her cooperation were unsuccessful. It is not uncommon for obese patients to experience a delay in awakening following anesthesia. The drugs are absorbed into the fatty tissue, and release occurs over an extended period. One measure that may have been successful in arousing the patient more quickly is a fluid challenge. This extra fluid can often help circulate the remaining anesthetic and speed the metabolism of the medication, allowing the patient to awaken more quickly. While this may not always be the answer to delayed awakening, it is often successful in obese patients.

Fortunately, this patient did not experience any of the other postoperative complications that are common following bariatric surgery. After her respiratory status improved, she was able to meet the criteria for discharge and was sent home the next day.

In follow-up with this patient, she lost more than 100 pounds in the first year following surgery. She started an exercise regimen and is determined to continue with her weight loss. While 100 pounds is quite a bit of weight to lose, her weight is now 330 pounds; therefore, she remains at risk for the complications of obesity. Her diabetes has not resolved, yet she remains hopeful that with continued weight loss, she will one day be free of insulin injections. Morbidly obese patients have a long and often arduous path ahead of them and should not expect miracles to happen overnight.

CONCLUSION

Postoperative complications have a negative effect upon surgical outcomes. Patients can experience delayed healing and delayed release from the hospital and can risk life-threatening or life-changing sequelae. The cost of postoperative complications is estimated at millions of dollars per year [91]. If these complications can be controlled, the benefits to patients and the healthcare system can be significantly improved.

Management of postoperative complications encompasses all phases of patient care. Beginning in the preoperative area, those caring for the surgical patient should obtain an accurate, thorough history. A preoperative assessment should be performed, as discharge planning of the patient is often based upon the data documented during this assessment. Intraoperatively, risk reduction measures can be instituted to limit the development or progression of postoperative complications. Healthcare professionals working in the PACU have the task of ensuring the safe recovery of the patient while minimizing complication development. Risk-reduction measures should be initiated during all patient interactions and should include thorough assessment and preventive measures.

It is important to develop the skills to recognize patients at risk and help develop policies to reduce complication development. If this is accomplished, patient outcomes will improve.

GLOSSARY OF TERMS

AORN: the Association of periOperative Registered Nurses, a professional nursing organization.

ASA: the American Society of Anesthesiologists, a professional medical organization.

ASPAN: the American Society of PeriAnesthesia Nurses, a professional nursing organization.

Body mass index (BMI): the weight in kilograms divided by the square of the height in meters.

Deep vein thrombosis (DVT): a clot that develops in the deep vasculature, commonly in the lower legs.

Hypothermia: a core body temperature of less than 36°C (96.8°F).

Inhaled anesthesia: anesthesia achieved by providing volatile gases.

Malignant hyperthermia: a rare but life-threatening disorder of the musculature causing a rapid rise in body temperature during the initial phases of anesthesia.

Morbid obesity: a BMI of 40 or more. Also known as severe obesity or class 3 Obesity.

Multimodal analgesia: the administration of a variety of drugs to improve pain relief and minimize side effects; may be given by different routes.

Noncardiogenic pulmonary edema (NCPE): a disorder causing severe respiratory distress and failure.

Perioperative period: includes the preoperative, intraoperative, and postoperative phases of care.

Postdischarge nausea and vomiting (PDNV): nausea and/or vomiting that occurs after discharge from the healthcare facility.

Postoperative nausea and vomiting (PONV): nausea and/or vomiting that develops within the first 24 hours following anesthesia.

Total intravenous anesthesia: anesthesia that is obtained only using IV agents; no inhaled gases are used.

Transfusion-related acute lung injury (TRALI): a respiratory disorder occurring within four to six hours following administration of blood products.

Implicit Bias in Health Care

The role of implicit biases on healthcare outcomes has become a concern, as there is some evidence that implicit biases contribute to health disparities, professionals' attitudes toward and interactions with patients, quality of care, diagnoses, and treatment decisions. This may produce differences in help-seeking, diagnoses, and ultimately treatments and interventions. Implicit biases may also unwittingly produce professional behaviors, attitudes, and interactions that reduce patients' trust and comfort with their provider, leading to earlier termination of visits and/or reduced adherence and follow-up. Disadvantaged groups are marginalized in the healthcare system and vulnerable on multiple levels; health professionals' implicit biases can further exacerbate these existing disadvantages.

Interventions or strategies designed to reduce implicit bias may be categorized as change-based or control-based. Change-based interventions focus on reducing or changing cognitive associations underlying implicit biases. These interventions might include challenging stereotypes. Conversely, control-based interventions involve reducing the effects of the implicit bias on the individual's behaviors. These strategies include increasing awareness of biased thoughts and responses. The two types of interventions are not mutually exclusive and may be used synergistically.

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