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A review of Enhancing Operating Room Safety: Protocols, Practices, and Preventative Measures

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Abstract

Preventable medical errors significantly contribute to morbidity, mortality, and financial burden, with an estimated 44,000 to 98,000 deaths and $79 billion in costs annually in the United States. Ensuring patient safety in the operating room is crucial, particularly in plastic surgery procedures. Effective communication among surgical team members, utilizing crew resource management principles, and adhering to standardized protocols can substantially reduce errors. Proper patient positioning, considering individual risk factors and procedure-specific requirements, is essential to prevent complications such as peripheral neuropathies and pressure ulcers. Surgical hand antisepsis using alcohol-based hand rubs and patient skin preparation with alcohol-based agents combined with chlorhexidine are recommended to minimize infection risks. Consistent use of deep venous thromboembolism prophylaxis, maintaining normothermia, and prompt recognition and management of malignant hyperthermia are critical. Preventing operating room fires requires addressing the interplay between ignition sources, fuel sources, and oxidizers, while electrosurgical safety involves using modern dispersive electrode pads and avoiding flammable substances. Laser safety measures include eye protection, plume evacuation, and moist towels around the laser field. Standardized counting protocols and radiographic imaging when necessary can prevent retained surgical items. Pneumatic tourniquet use requires careful patient selection, proper cuff placement, and minimizing inflation pressures. Structured patient handoffs using models like SBAR (Situation, Background, Assessment, Recommendation) can reduce errors during transport. Implementing evidence-based safety practices and fostering a culture of communication and collaboration are essential for enhancing patient safety in the operating room.

Keywords: Operating Room, patient safety

Introduction

Preventable medical errors are a significant contributor to morbidity, mortality, and financial burden on society. The widely referenced report, To Err is Human: Building a Safer Health System by the Institute of Medicine, estimates that medical errors are responsible for between 44,000 and 98,000 deaths annually, with an associated cost of approximately $79 billion each year(Institute of Medicine (US) Committee on Quality of Health Care in America, 2000). This article, along with the preceding one, centers on the importance of ensuring patient safety within the operating room. While the current article delves into intraoperative and postoperative patient safety with a particular focus on plastic surgery procedures, it also offers a comprehensive review of other elements of operating room safety.

The goal of this article is to present concise insights into safety practices within the operating room. For those seeking detailed guidance on patient safety within office-based surgical environments, reference is made to the Journal article by Horton et al. and the work of the American Society of Plastic Surgeons Task Force on Patient Safety in Office-Based Surgery Facilities.

The impact of communication

A substantial number of preventable medical errors arise from failures in communication. In 2006, The Joint Commission reported that communication failures were responsible for 70 percent of all sentinel events in healthcare, which are defined as unexpected incidents involving death or serious physical or psychological injury.

Several studies have highlighted the prevalence of communication breakdowns in the operating room. For example, Lingard et al. conducted an observational study of 48 surgical cases, identifying 421 communication events, of which one-third were deemed failures(Lingard et al., 2004). Similarly, an analysis of closed malpractice claims by Greenberg et al. reviewed 60 cases involving 81 communication failures. Of these, 92 percent were verbal, most of which occurred between a single transmitter and receiver. Ambiguity surrounding delegation of responsibility was the most identified factor contributing to communication breakdowns. Additionally, the American College of Surgeons Closed Claims Study revealed that communication failures were a major factor in 90 of 460 claims. These errors included incidents such as wrong-site surgeries, retained foreign objects, medication misuse, and missed diagnoses. Interestingly, in 25 percent of these cases, the standard of care had been met, but communication failures resulted in anger, mistrust, and litigation(Griffen, 2007).

Crew resource management and sentinel events

The Institute of Medicine report not only outlined mechanisms to reduce medical errors but also recommended adopting crew resource management, a safety and error management approach from the aviation industry. This concept arose from findings that 50 to 80 percent of aviation incidents and accidents were primarily attributable to human error rather than mechanical failure(France et al., 2005).

Initially developed for airline cockpits, crew resource management has since been adopted by various industries. The Federal Aviation Administration defines it as the effective use of all available human, informational, and equipment resources to ensure the safe and efficient performance of operations. Crew resource management involves an active process in which team members identify significant operational threats, communicate them to a designated leader, and collaboratively develop, communicate, and implement plans to mitigate risks.

In aviation, this approach has been shown to improve performance, safety, communication, and morale while reducing accidents caused by crew errors. Its application in healthcare has also demonstrated safety improvements. For instance, Methodist University Hospital in Memphis, Tennessee, implemented crew resource management focusing on sponge counts as an outcome measure. After six months, the institution recorded a 50 percent reduction in counting errors. Similarly, Vanderbilt University Medical Center employed this strategy to train nearly 500 personnel across trauma, surgery, emergency medicine, and administrative departments, with 95 percent of participants believing it would reduce errors in their practice. Another study applying crew resource management to emergency department staff reported a 58 percent reduction in observable errors(Shapiro et al., 2004).

Crew resource management implementation: employing effective operating room communication

There is growing momentum to integrate crew resource management into healthcare as a safety enhancement strategy. Surgeons should be aware of critical aspects of its implementation. Many institutions have introduced briefing and debriefing protocols as part of this effort. For instance, the Veterans Hospital Administration launched a medical team training program in operating rooms across various facilities, leading to improved compliance rates for antibiotic and deep venous thrombosis prophylaxis(Paull et al., 2010). Similarly, the San Francisco Veterans Administration Medical Center reported reduced case delays and improved staff perceptions of communication and patient safety following medical team training. Studies underscore the importance of establishing a safe environment for effective briefing and debriefing, where all participants feel comfortable expressing their opinions regardless of rank(McGreevy & Otten, 2007). Papaspyros et al. implemented briefing and debriefing sessions with cardiac surgery teams, providing opportunities for all team members to contribute. Participants reported enhanced professionalism and communication(Papaspyros et al., 2010). These sessions represent a practical method for introducing crew resource management.

Surgical-site identification: safeguarding against wrong-site surgery

While effective communication is foundational to improving patient safety, preoperative practices also play a critical role. Wrong-site surgery is among the top five sentinel events reported by The Joint Commission. Its sentinel event database records 150 cases of wrong-site, wrong-person, or wrong-procedure surgeries. The root cause in all these cases was poor communication.

A retrospective review of multiple databases offers even more concerning statistics regarding wrong-patient adverse events. Seiden and Barach estimated that annually, there are between 1,300 and 2,700 cases of wrong-site, wrong-person surgeries or near misses in the United States. These findings prompted The Joint Commission to develop a universal protocol to prevent such errors. The protocol recommends a preoperative verification process in which all team members confirm the correct site, patient, and procedure. Surgeons should mark the incision site while the patient is awake and involved, paying particular attention to left/right distinctions and multiple levels when applicable. Finally, a "time-out" involving active communication among all team members should occur to confirm the correct site, patient, and procedure.

The World Health Organization has furthered these efforts through its Safe Surgery Saves Lives Challenge, which includes a universal surgical safety checklist. A prospective study by Haynes et al. analyzed data from eight hospitals across eight countries participating in the WHO challenge. They observed statistically significant reductions in mortality rates (from 1.5 to 0.8 percent) and complication rates (from 11 to 7 percent) following the checklist's implementation. Despite these extensive initiatives, evidence suggests that wrong-site surgery incidents are increasing. From January 1 to the third quarter of 2011, it remained one of the most frequently investigated sentinel events by The Joint Commission, with 115 cases recorded. This highlights the ongoing need for further education among operating room personnel.

Patient positioning

The risks associated with improper patient positioning, such as peripheral neuropathies, brachial plexopathies, myopathies, compartment syndromes, and pressure ulcers, are well-recognized. Nevertheless, careful consideration of specific patient characteristics and the nuances of common surgical positions can help mitigate these complications. This is especially critical in plastic surgery, where unusual positioning may be necessary for adequate exposure.

Certain patient factors inherently increase surgical risk regardless of position. These include advanced age, extreme height or weight, comorbidities (e.g., diabetes, pulmonary or cardiovascular conditions), poor nutritional status, prolonged hospitalization, and preexisting movement limitations. These characteristics also heighten susceptibility to positioning-related complications(Armstrong & Bortz, 2011). In supine or Trendelenburg positions, for instance, significant chest bulk combined with deep anesthesia may induce Pickwickian physiology, compromising respiratory function. Conversely, cachexia can lead to bony prominences, increasing the risk of compressive neuropathies or pressure ulcers.

Preoperatively, a thorough assessment of factors such as body habitus, preoperative skin condition, comorbidities, existing neuropathies, movement limitations, and prior procedures is crucial for selecting the safest position(Armstrong & Bortz, 2011). Despite these precautions, surgically acquired pressure ulcers remain prevalent, with an incidence ranging from 4.5 to 26 percent. A survey by Aronovitch reported an 8.5 percent incidence in surgeries lasting at least three hours(Aronovitch, 2017). Preventable intraoperative factors include hypotension or local hypoperfusion, pressures exceeding 32 mmHg (the average capillary perfusion pressure), excessive layers between the patient and pressure-reducing surfaces, extended operative times without repositioning, moist skin from solutions or irrigation, and shear or friction during transfers.

Specific positions

Supine

The supine position is used in approximately 80 percent of surgical procedures. While the hemodynamic effects of this position in awake patients involve increased venous return with a compensatory decrease in cardiac contractility to prevent hypertension, these mechanisms are disrupted under anesthesia. General anesthetics' sympatholytic effects may necessitate additional fluids, sympathomimetics, or vasopressors. Respiratory consequences include reduced total lung capacity and functional residual capacity, along with ventilation/perfusion mismatches, which are exacerbated by diaphragmatic paralysis during general anesthesia. These issues can intensify hypoventilation in patients with chronic obstructive pulmonary disease.

Improper positioning can lead to postoperative neuropathies, such as ulnar and brachial plexopathies, which accounted for 28 and 20 percent, respectively, of closed malpractice claims in 1999. These complications can be avoided by limiting arm abduction to 60–90 degrees to prevent brachial plexus traction, maintaining supination when arms are abducted to avoid ulnar nerve pressure at the medial epicondyle, and keeping arms neutral when tucked at the patient's side. Proper padding of the armboard and ensuring surgeons do not lean on extremities are also critical preventive measures (Millsaps, 2006).

Prone

The prone position is the second most common in plastic surgery. Complications include vertebral artery occlusion causing stroke, brachial plexopathy, and shoulder impingement-related pain(Shermak et al., 2006). Most complications arise from excessive head and neck pressure. Although blindness is a rare complication, it is multifactorial and can result from ischemic optic neuropathy rather than just increased intraocular pressure. Proper positioning is a modifiable risk factor that should always be addressed. A well-padded headrest, careful eye protection, and easy airway access are essential. The neck should be in a neutral position without extension or rotation to prevent carotid or vertebrobasilar artery dissection. Bilateral chest rolls should distribute weight to the clavicles and iliac crests, minimizing abdominal and thoracic compression, which can affect cardiopulmonary function(Grant et al., 2010). Support for legs with pillows from ankles to knees, as well as padding for breasts and male genitalia, is necessary. Turning an anesthetized patient from supine to prone is particularly high-risk and requires great care.

Lithotomy

The lithotomy position poses risk similar to the supine position, such as upper extremity neuropathy, hemodynamic changes, and respiratory complications, but also introduces risks specific to the lower extremities. These include venous stasis and peripheral nerve injuries. Hips should be minimally externally rotated with limited thigh flexion. Padding of lithotomy poles prevents compression of the common peroneal nerve. Maneuvers involving the legs should be performed synchronously to prevent lumbar spine torsion(Millsaps, 2006).

Lateral Decubitus

The lateral decubitus position necessitates the use of an axillary roll to protect the dependent axilla, as well as pillows to separate arms and legs. The lower leg should be flexed at the hip and knee, while the upper leg remains extended. Proper placement of the axillary roll reduces the risk of compressive brachial plexopathy. Traction on the suprascapular nerve may result in postoperative pain and should be avoided. The ear must not be folded against the support surface. There is also a risk of retinal artery thrombosis in the dependent eye if it is compressed by the headrest or pillow (Robinson, 2017).

Surgical scrub and skin preparations

Surgical preparations and barriers are guided by two primary objectives: minimizing risks to the patient, such as surgical-site infections, chemical injuries, and thermal burns, and reducing hazards for surgeons and operating room staff, including exposure to infectious agents or chemicals. Despite these goals, many traditional surgical practices lack robust evidence to confirm their effectiveness.

The purpose of hand antisepsis is to eliminate transient microorganisms and reduce resident flora, based on the assumption that lowering bacterial counts decreases the risk of infections. Modern investigations aim to identify the simplest yet effective methods, though the diversity of techniques and small-scale studies complicate broad conclusions. Recent findings indicate that alcohol-based hand rubs (e.g., Avagard; 3M, St. Paul, Minn.) may be more effective than traditional scrubbing. While scrubbing removes transient bacteria, it can also disrupt the stratum corneum, exposing resident flora. Repeated scrubbing exacerbates excoriation and may promote colonization with transient bacteria(Hsieh et al., 2006).

For cleansing the patient, antiseptics should act rapidly, have broad-spectrum antibacterial properties, and exhibit residual activity. Commonly used agents include alcohols, iodophors, and chlorhexidine gluconate. A recommended combination pairs alcohol, which provides immediate bactericidal action, with chlorhexidine for sustained activity after the alcohol evaporates. In a study by Darouiche et al., patients undergoing clean-contaminated surgery showed significantly lower rates of surgical-site infections when chlorhexidine–alcohol was used compared to povidone–iodine(Darouiche et al., 2010). Rings should not be worn in the operating room as they increase bacterial colonization on the underlying skin. These organisms may persist despite thorough hand hygiene, as evidenced by reports of cardiothoracic wound infections linked to a surgeon's rings, even after proper surgical scrubbing and glove use. Similarly, artificial nails are associated with higher bacterial counts, though no conclusive data exist regarding nail polish(Jepson et al., 2006).

As with hand antisepsis, skin preparation for patients aims to remove contaminants and transient organisms to reduce infection risks. Common antiseptics include iodophors, alcohols, and chlorhexidine. Despite frequent use, data supporting the ideal preparation technique are lacking. Evidence suggests that a simple soap-and-water shower, followed by a saline rinse, may adequately lower infection risks in clean surgeries. Traditional iodine-based scrubbing and painting may not be necessary, as scrubbing can excoriate the skin, exposing commensals. Moreover, iodine requires drying to achieve full efficacy and is often removed before its action is complete. Alcohol-based preparations rapidly reduce bacterial colonies and are effective without additional scrubbing(Ellenhorn et al., 2005).

Until definitive guidelines are established, alcohol-based preparations combined with iodophore (e.g., DuraPrep; 3M) or chlorhexidine (e.g., Chloraprep; CareFusion, San Diego, Calif.) are recommended, in alignment with Centers for Disease Control (CDC) and Association of periOperative Registered Nurses (AORN) recommendations(Tanner & Parkinson, 2012). These guidelines include the following:

1. Avoid shaving surgical site hair; if necessary, use clippers or depilatory agents immediately before surgery and away from the surgical field.
2. Clean the skin with a shower or surgical wash before applying antiseptics.
3. Prepare the surgical site and surrounding skin using an appropriate antiseptic agent.
4. Prevent pooling of antiseptic agents under the patient, especially near cuffs, tourniquets, or electrodes, and ensure alcohol-based solutions dry thoroughly to reduce the risk of surgical fires.
5. Annually review institutional policies on skin preparation techniques.

The evidence regarding surgical gloves is ambiguous. A Cochrane review by Tanner and Parkinson found that double-gloving with indicator undergloves reduces perforations of the inner glove and improves detection of outer glove breaches(Tanner & Parkinson, 2012). However, it remains unclear whether improved detection decreases blood-borne pathogen transmission or surgical-site infections.

Other protective barriers, including surgical attire, masks, gowns, and drapes, serve to limit contamination between the patient and operating room staff. Operating room-specific clothing and shoes aim to reduce infections, though evidence of their effectiveness is lacking. Many institutions allow staff to launder scrubs at home, with the CDC deeming the risk of blood-borne pathogen transmission via soiled linen negligible. The role of surgical masks in preventing surgical-site infections is also unclear, though masks do provide protection for the surgeon against contamination. Gown and drape characteristics have not been reliably correlated with infection rates, leaving recommendations inconclusive(Belkin, 2016).

Deep venous thromboembolism prophylaxis

Extensive research establishes that deep venous thromboembolism (DVT) and pulmonary embolism are significant and frequent complications of surgical procedures. In general surgery, the estimated incidence of DVT ranges from 16 to 30 percent. In orthopedic surgeries, this risk is even higher, with DVT occurring in approximately 45 to 70 percent of patients undergoing hip surgery and 53 to 84 percent of patients undergoing knee surgery in the absence of prophylaxis. Despite this well-documented risk, a recent survey revealed inconsistencies among plastic surgeons regarding the consistent use of DVT prophylaxis(Broughton et al., 2007). Depending on the procedure, including facelifts, liposuction, and combined surgeries, prophylaxis was used consistently by only 45.7 percent, 43.7 percent, and 60.8 percent of plastic surgeons, respectively. Similarly, a survey among head and neck surgeons found that 57 percent did not routinely use DVT prophylaxis. Given the potentially fatal consequences of DVT, a systematic approach to evaluating patients for risk factors and implementing preventative strategies is essential. Plastic surgeons are strongly advised to follow the protocol outlined in Plastic and Reconstructive Surgery by Davison et al. and reviewed by Horton et al. This comprehensive system involves a detailed risk assessment and implementing prevention measures based on the identified risk level(Davison et al., 2004).

Patient temperature and maintaining normothermia

Numerous studies demonstrate that maintaining normothermia improves surgical outcomes and reduces complications associated with perioperative hypothermia. In a prospective multicenter study, Kurz et al. showed that maintaining normothermia in patients undergoing elective colectomy significantly decreased wound infections, expedited return to enteral feeding, and reduced hospital stays(Scott & Buckland, 2006). A systematic review of hypothermia and surgical outcomes consistently identified postoperative complications related to inadequate thermal management, including cardiac events, wound infections, pressure ulcers, and increased need for blood transfusion. Recommendations published by the American Society of PeriAnesthesia Nurse should be followed to mitigate these risks(Hooper et al., 2010). These guidelines emphasize identifying patients at risk for hypothermia, employing active warming techniques when necessary, and maintaining an appropriate ambient room temperature. Surgeons should actively monitor and ensure the operating room temperature supports normothermia throughout the procedure.

Malignant hyperthermia

Malignant hyperthermia (MH) is a rare, autosomal-dominant, life-threatening condition characterized by a hypermetabolic response of skeletal muscle. In the operating room, MH is typically triggered during or after exposure to inhalational anesthetics. It involves excessive heat production, calcium release, glycogenolysis, and increased muscle contractility(Hommertzheim & Steinke, 2006). Historically, MH carried a mortality rate as high as 70 percent, but heightened awareness has reduced this to approximately 10 percent. Mortality is often due to complications such as acidosis, hyperkalemia, organ failure from hyperthermia, disseminated intravascular coagulation, and renal failure from myoglobinuria. Hyperthermia itself is a relatively late-onset symptom and is observed in only 30 percent of cases.

Surgeons must identify high-risk individuals, including those with a family history of adverse reactions to anesthesia, prior heat stroke, hypokalemic periodic paralysis, or exercise-induced rhabdomyolysis, as these factors are associated with MH susceptibility. Diagnosis of MH is challenging, with the caffeine-halothane contraction test being the only definitive diagnostic tool. This test, available at a limited number of specialized centers, is 98 percent sensitive but has a high false-positive rate of up to 22 percent. Genetic testing for MH susceptibility is now available and is recommended for individuals with a positive caffeine-halothane contraction test, relatives of confirmed MH patients, or those with clinical episodes strongly indicative of MH.

Effective management of MH involves prompt recognition of symptoms and timely intervention. Patients with known or suspected MH can safely undergo procedures with regional anesthesia, such as spinal, epidural, or nerve blocks.

Preventing operating room fires and electrosurgical safety

Fire is a recognized risk in the operating room, as acknowledged by both the Joint Commission and the Association of PeriOperative Registered Nurses. The Joint Commission has recently issued a sentinel event alert regarding operating room fire prevention, and the Association has published a related guidance statement. While no centralized database exists for operating room fires, it is estimated that at least 100 cases occur annually, resulting in one to two fatalities each year.

To mitigate this risk, the Association of PeriOperative Registered Nurses has introduced the "fire triangle" concept, emphasizing the interplay between an ignition source, fuel source, and oxidizers. Effective fire prevention strategies must simultaneously address all corners of this triangle. Following the Association's fire prevention guidelines is strongly recommended. In particular, the use of open-delivery oxygen (e.g., nasal cannula) should be restricted to concentrations below 30 percent. Cuffed endotracheal tubes are preferred in procedures involving the mouth and oropharynx to reduce oxygen accumulation in the nasopharynx, though this may not be feasible in pediatric cases. Surgeons must remain aware that 100 percent oxygen administered via open systems, such as nasal cannulas, can collect under surgical drapes, creating an oxygen-enriched environment that poses a significant fire hazard. Communication with anesthesia personnel to reduce oxygen concentrations when using electrocautery near open oxygen sources is essential.

Since its introduction by William T. Bovie and Harvey Cushing in the 1920s, electrocautery has revolutionized surgery. Despite advances in power generators, electrode design, and surgical techniques, the potential for error and associated risks remain significant. A national survey of otolaryngologists reported 324 complications related to electrosurgical instruments in the preceding year, including 219 direct burns, 48 burns transmitted through metallic retractors, 13 grounding pad burns, 11 fires, and 32 incidents of pacemaker interference. Additional reports highlight flash fires caused by eye lubricants, skin burns from DuraPrep, and endotracheal tube fires linked to electrocautery.

To mitigate these risks, the Association of PeriOperative Registered Nurses published detailed electrocautery safety guidelines in 2005. These recommendations include using devices with audible activation tones, employing modern dispersive electrode pads, and ensuring isolated units. Historically, burns at the site of electrocautery pads have been the most frequent complication. These burns typically result from dispersion failure due to dry gel on the pad, improper pad size, moisture under the pad, or placement over tattoos, metal prostheses, or bony prominences. To prevent such injuries, single-use dispersive electrodes of appropriate size should be applied to clean, dry skin over a well-perfused large muscle near the surgical site. Additionally, the active electrode must be stored in a clean, dry, insulated safety holster when not in use, and nonmetal clamps should be used to secure the device to drapery. Electrocautery must never be used in the presence of flammable substances, and pooling of alcohol-based preparations under drapes, in hair, or on fabric should be strictly avoided.

Laser safety

Laser safety is crucial in plastic surgery due to the frequent use of laser technology. Protective measures must be taken to safeguard the patient, surgeon, and all operating room personnel. Rohrich et al. conducted an experimental investigation into the flammability of CO_2 lasers on commonly used objects in the surgical field during resurfacing procedures, such as endotracheal tubes, towels, sponges, eye protectors, and ophthalmic ointments. While no flames or burns occurred on moistened items, dry materials frequently ignited. Based on these findings, recommendations include avoiding supplemental oxygen, using protective eyewear for patients (metal corneal shields) and staff (protective glasses with shields), employing a plume evacuator, and placing moist towels around the laser field.

Although specific experimental data are lacking for other laser types used in plastic surgery, adherence to these recommendations is strongly advised. Additional safety guidelines from the Association of PeriOperative Registered Nurses include mandatory training for personnel, delineation of hazard zones with appropriate signage, and the use of protective eyewear, matte or anodized surgical instruments, and local exhaust ventilation. High-filtration surgical masks should also be worn during procedures.

Surgical smoke and laser plume

The health implications of surgical smoke remain contentious. Surgical smoke is generated through electrocautery, laser tissue ablation, ultrasonic dissection, and harmonic tissue dissection. This smoke contains over 600 organic compounds, including benzene, hydrogen cyanide, formaldehyde, and viruses. Studies suggest that particulate matter from surgical smoke may cause pathological damage when deposited in mammalian lungs.

Currently, there are no regulations mandating surgical smoke control. However, the Association of PeriOperative Registered Nurses recommends a combination of general room and local exhaust ventilation(Castelluccio & Association of Operating Room Nurses, 2012). Local exhaust ventilation may involve room suction systems or portable smoke evacuators. The National Institute for Occupational Safety and Health advises that local exhaust ventilation systems should capture smoke at a velocity of 100 to 150 feet per minute at the nozzle inlet and use high-efficiency particulate air filters to trap contaminants. While wall suction can be used, it is less effective than dedicated smoke evacuation systems. Ventilation devices should be positioned no more than two inches from the source of smoke production.

Instrument counts and retained surgical items

A recent study estimated that hospitals performing between 8,000 and 18,000 procedures annually experience at least one incident of a retained surgical item (RSI) each year. The likelihood of an RSI increases in emergency surgeries, cases with unexpected procedural changes, or in patients with higher body mass index (BMI). The American College of Surgeons' recommendations for preventing RSIs align closely with guidelines from the Association of PeriOperative Registered Nurses. These guidelines emphasize enhancing communication among surgical staff and adhering to consistent and standardized counting protocols.

These measures include counting all sharps and sponges before and after each procedure, documenting sponge counts in the intraoperative record, thoroughly inspecting wounds prior to closure, and utilizing radiographic imaging when necessary. If a count is incorrect, the surgical wound must be reopened and thoroughly examined. The full depth and length of the wound should be explored, and if the item remains unfound, a radiograph must be obtained and interpreted by a radiologist before the patient leaves the operating room.

Institutional policies, such as those at the University of Wisconsin-Madison, stipulate mandatory radiographs in cases where over 50 laparotomy sponges are used, patients have a BMI exceeding 60 or weigh over 400 pounds, procedures involve unanticipated changes, emergency surgeries occur, or operating times exceed 10 hours.

Tourniquet safety for extremity surgery

Pneumatic tourniquets are frequently employed in both upper- and lower-extremity surgeries, but improper use can lead to serious complications. Documented adverse outcomes include deep vein thromboembolism, pulmonary embolism, hypotension, rhabdomyolysis, and nerve injuries. Tourniquets consist of several components—an inflatable cuff, pressure source, pressure regulator, connective tubing, and pressure displayeach presenting opportunities for error. Effective tourniquet use requires coordination among the surgeon, anesthesiologist, and circulating nurse, with the latter two being notified before exsanguination, inflation, and deflation.

Pneumatic tourniquets may be contraindicated in patients with compromised circulation, previous extremity revascularization, dialysis access in the limb, or known venous thromboembolism. Placement recommendations include positioning upper-arm, thigh, and calf tourniquets at the point of maximal circumference proximal to the surgical site, placing forearm tourniquets at mid-forearm, and situating ankle tourniquets over the lower third of the leg with the distal edge of the cuff above the malleoli.

Research emphasizes the importance of minimizing cuff inflation pressure to prevent arterial inflow while reducing the risk of nerve and muscle damage and postoperative pain. Ideally, each patient's limb occlusion pressure should be individually calculated. Limb occlusion pressure is determined after anesthesia induction and blood pressure stabilization by increasing the cuff pressure until the peripheral pulse (radial artery for the arm, posterior tibial artery for the leg) is absent for several heartbeats. A safety margin is then added to this pressure. Commercially available tourniquets can measure limb occlusion pressure and apply an appropriate safety margin.

Despite these advancements, many surgeons still rely on anecdotal pressure values—such as 250 mmHgbased on their experience in achieving bloodless fields. For cases where limb occlusion pressure is not calculated, the Association of PeriOperative Registered Nurses recommends inflation pressures of 50 to 75 mmHg above the patient's systolic blood pressure for upper extremities and 100 to 150 mmHg above the systolic pressure for lower extremities in adults. For pediatric patients undergoing upper-extremity surgery, the recommended inflation pressure is 100 mmHg above systolic blood pressure.

Prior to inflation, exsanguination should be performed by elevating the limb and applying an elastic bandage, such as an Esmark bandage, unless contraindicated (e.g., malignancy, foreign body, infection). In such cases, passive exsanguination through limb elevation for several minutes is advised. Although tourniquet times should be individualized, standard practice suggests upper-extremity occlusion should not exceed two hours. If additional time is required, the tourniquet should be deflated for five minutes for every 30 minutes of inflation.

Patient transport and handoff

The Institute of Medicine's report, *Crossing the Quality Chasm: A New Health System for the 21st Century*, identifies patient handoff as a critical transition point in clinical care that is highly susceptible to errors. In 2006, The Joint Commission established standardized patient handoff procedures as a National Patient Safety Goal. Specifically, within the operating room context, the Joint Commission mandates standardized handoffs between the circulating nurse and anesthesiologist in the operating room and the receiving nurse in the postanesthesia care unit. While institutions may define the specific mechanisms for these handoffs.

At our institution, the SBAR (Situation, Background, Assessment, Recommendation) model, originally developed for military use, has been implemented for handoffs. This model provides a structured framework for communication. Additionally, an operating room checklist is utilized to ensure consistent and accurate handoffs among healthcare team members. While it is premature to assess the long-term impact of these measures, such initiatives are critical for reducing medical errors during patient handoffs.

Conclusion

Operating room safety is a multidimensional concern requiring meticulous attention to patient, procedural, and environmental factors. This article highlights the significance of systematic risk assessments, such as those for deep venous thromboembolism and malignant hyperthermia and underscores the necessity of proper patient positioning to avoid postoperative complications. Additionally, it explores the importance of hand antisepsis, surgical-site preparation, and fire prevention protocols, emphasizing adherence to evidence-based guidelines.

In the operating room, communication failures and inadequate handoff procedures remain major contributors to preventable medical errors. Incorporating strategies such as crew resource management and standardized handoff protocols can substantially reduce these risks. Similarly, advances in electrosurgical safety and laser use demonstrate the evolving focus on minimizing hazards to both patients and healthcare personnel.

Surgical teams must remain vigilant about preventing retained surgical items and managing intraoperative challenges, including hypothermia and smoke inhalation. These efforts, coupled with institution-wide adherence to established best practices, are essential for optimizing patient outcomes, reducing morbidity and mortality, and fostering a culture of safety in surgery. Ultimately, the ongoing commitment to these principles reflects a proactive approach to mitigating risks and improving the quality of care in the operating room.

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