Patient Safety in the Operating Room: I. Preoperative

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Background: Beyond the controlled trauma of surgery, the operating room can be a hazardous place for patients and health care workers alike. Modern plastic surgery requires a thorough knowledge of various perioperative risks and methods to minimize these risks. As the importance of teamwork becomes more evident, clear communication skills preoperatively, intraoperatively, and postoperatively become equally critical. To facilitate an improvement in perioperative patient safety, this article will review aspects of communication, including crew resource management, root cause analysis, and surgical-site verification. In addition, the authors will discuss patient positioning, antiseptic hand and patient preparations, and barriers, such as surgical scrubs, gowns, gloves, and drapes.

Methods: The authors reviewed the literature regarding operating room safety, both primary research and secondary reviews, via multiple PubMed queries and literature searches. Topics most relevant to inpatient plastic surgery were included in the final analysis and summarized, as a full review of each topic is beyond the scope of this article.

Results: Many possible interventions were identified, with the goal of reducing perioperative complications, such as wrong site surgery, neuropathies, myopathies, compartment syndromes, pressure ulcers, surgical-site infections, and blood-borne disease transmissions among plastic surgeons and their patients.

Conclusions: There are ample opportunities for the reduction of preventable adverse events in plastic surgery. This article aims to provide its reader with the tools to research adverse events and a basic education in avoiding specific preoperative events. A second article addressing intraoperative and postoperative patient safety follows. (Plast. Reconstr. Surg. 130: 1038, 2012.)

The landmark report To Err Is Human: Building a Safer Health System by the Institute of Medicine estimated that approximately 44,000 to 98,000 Americans die annually secondary to preventable medical errors costing approximately $79 billion.1 Preventable medical errors also cause great morbidity to patients. This article and the one following it are designed to review various aspects that relate to patient safety in the inpatient operating room to identify modifiable factors that can be improved to decrease preventable medical errors.

The Impact of Communication

Many preventable medical errors are the result of communication failure. The Joint Commission reported in 2006 that 70 percent of all sentinel events in health care, which are unexpected occurrences involving death or serious physical or psychological injury, stem from communication failures (Fig. 1).2-4

Multiple articles have demonstrated communication breakdowns in the operating room. In a study by Lingard et al., 48 surgical cases were observed during which 421 communication events were identified.5 One-third of these were considered communication “failures.” In reviewing closed malpractice claim files, Greenberg et al.

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analyzed 60 cases involving 81 communication breakdowns. Ninety-two percent of the communication breakdowns were verbal, the majority of which involved a single transmitter and receiver. Ambiguity about delegation of responsibility was the factor most commonly associated with communication breakdown. In the recently published American College of Surgeons Closed Claims Study, 90 of 460 claims were largely because of communication failures. Errors resulting in claims include wrong site surgery, retained foreign bodies, inappropriate use of medication, and missed diagnoses. Interestingly, in 25 percent of the cases the standard of care was met, but failed communication “led to anger, mistrust, and litigation.”

CREW RESOURCE MANAGEMENT AND SENTINEL EVENTS

The Institute of Medicine’s report, in addition to identifying multiple mechanisms to avoid medical errors, included recommendations to adopt an aviation approach to safety and error management known as crew resource management. The concept of crew resource management grew from the recognition that between 50 and 80 percent of all aviation incidents and accidents are mostly caused by human, rather than mechanical, errors.

Though crew resource management was initially created for airline cockpits, it was subsequently adopted by many other industries. The Federal Aviation Administration defines crew resource management as follows:

The utilization of all available human, informational, and equipment resources toward the effective performance of a safe and efficient flight. Crew resource management is an active process by crew members to identify significant threats to an operation, communicate them to a person in charge, and to develop, communicate, and carry out a plan to avoid or mitigate each threat.

Since being widely introduced into the airline industry, crew resource management has been shown to improve performance, safety, communication, and morale and to decrease accidents related to crew error.

The concepts of crew resource management have also been applied to medicine and been shown to improve safety. For example, Methodist University Hospital in Memphis, Tennessee, enlisted crew resource management and targeted sponge counts as a measurement of outcome. They demonstrated that after the employment of crew resource management, there was a 50 percent reduction in counting errors 6 months following training. Vanderbilt University Medical Center used crew resource management as a training tool and then evaluated the attitudes and reactions to this management of nearly 500 personnel from trauma, surgery, emergency medicine, and administration; 95 percent believed that crew resource management training would reduce errors in their practice. Another study that employed this training for emergency department
staff showed a 58 percent reduction in observable errors.\textsuperscript{10}

**CREW RESOURCE MANAGEMENT IMPLEMENTATION: EMPLOYING EFFECTIVE OPERATING ROOM COMMUNICATION**

There is an increasing push for crew resource management implementation in health care as a means of improving safety, and surgeons should be aware of several key aspects (Table 1).\textsuperscript{4} To incorporate crew resource management, many institutions are developing briefing/debriefing protocols. The Veterans Hospital Administration launched a medical team training program in operating rooms at various institutions. Some outcomes evaluated were antibiotic and deep venous thrombosis prophylaxis compliance rates. Improvements were found after training.\textsuperscript{11} The San Francisco Veterans Administration Medical Center found improvements in areas such as decreased delays in cases and improved staff perceptions of communication and patient safety after participating in medical team training.\textsuperscript{12} Studies have shown that for briefing/debriefing to be effective, a safe environment must be established in which everyone feels comfortable expressing opinions, no matter rank.\textsuperscript{13} In a study by Papaspyros et al., implementation of briefing/debriefing sessions were conducted with staff cardiac surgery teams. All team members were given chances to talk. Team members felt the briefing/debriefing process promoted professionalism and improved communication.\textsuperscript{14} Briefing/debriefing sessions can be a practical way to implement crew resource management.

**SURGICAL-SITE IDENTIFICATION: SAFEGUARDING AGAINST WRONG SITE SURGERY**

Although effective communication is an essential starting point to improving patient safety, many aspects of preoperative care can also be targeted to improve patient safety. Wrong site surgery is one of the top five most reported sentinel events identified by The Joint Commission.\textsuperscript{15} The Joint Commission’s sentinel event database has recorded 150 cases of wrong site, wrong person, and wrong procedure surgery.\textsuperscript{16} The common root cause of all these events was poor communication.

A recent retrospective review of multiple databases reveals far more staggering numbers related to wrong patient adverse events. Seiden and Barach estimated that there are between 1300 and 2700 cases of wrong site and wrong person surgery or near misses per year in the United States.\textsuperscript{17} This ultimately led The Joint Commission to develop a universal protocol to prevent these events (Fig. 2).\textsuperscript{18} Current recommendations are: Before any surgical procedure, there must be a preoperative verification process to ensure all team members verify the correct site, correct person, and the correct operation. Marking the incision site should be performed by the surgeon with the patient awake and involved. Particular attention should be paid in cases involving left/right dis-

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tinction and with multiple levels. Finally a “time out,” which is active communication among all members of the team, should be performed as a final effort to verify correct site, person, and operation.

Recently, the World Health Organization implemented the “Safe Surgery Saves Lives Challenge” that includes a universal surgical safety checklist (Fig. 3). A prospective study by Haynes et al. gathered data from eight hospitals in eight countries worldwide that participated in the World Health Organization challenge. They found a statistically significant decrease in the death rate from 1.5 to 0.8 percent and the complication rate from 11 to 7 percent after implementation of the surgical safety checklist. Despite these significant nationwide efforts, there is still convincing evidence that wrong site surgery is actually on the rise. From January 1st to the third quarter of 2011, it was one of the most frequent Joint Commission sentinel events, with 115 cases investigated. This demonstrates the need for further education of all operating room personnel.

PATIENT POSITIONING

Although the risks of improper patient positioning seem obvious, including peripheral neuropathies, brachial plexopathies, myopathies, compartment syndromes, and pressure ulcers, attention to specific patient characteristics and idiosyncrasies of common positions can help prevent these complications. This is especially true in plastic surgery, for which unusual positioning may be required for adequate exposure.

Several patient factors increase surgical risk regardless of position, including advanced age; extremes of height and weight; comorbidities, such as diabetes, pulmonary disease, or cardiovascular compromise; poor nutritional status; prolonged hospitalization; and preexisting limitations of movement. These same characteristics also predispose a patient to positioning complications. In the supine or Trendelenberg positions, significant chest bulk combined with deep anesthesia may induce Pickwickian physiology and compromise respiratory function. Cachexia may produce bony prominences, predis-

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posing a patient to compressive neuropathies or pressure ulcer formation. Preoperatively, several factors should be noted and assessed in an effort to select the safest position for the patient including: (1) body habitus; (2) preoperative skin condition; (3) comorbid illnesses; (4) existing peripheral neuropathies; (5) limitations in movement; and (6) prior procedures, positions, and complications. Surprisingly, the incidence of surgically acquired pressure ulceration ranges from 4.5 to 26 percent. A large survey by Aronovitch showed an 8.5 percent incidence in cases lasting at least 3 hours.23 There are several intraoperative factors that may be minimized to prevent pressure ulcers, including: (1) hypotension or local hypoperfusion; (2) local pressure in excess of 32 mmHg (this value reflects the average capillary perfusion pressure in healthy tissue and may be as low as 12 mmHg in the presence of peripheral vascular disease); (3) layers, such as a warming blanket or gowns, between the patient and the pressure-reducing surface; (4) operative time greater than 90 to 120 minutes without repositioning the patient; (5) moist skin from preparative solutions or irrigation; and (6) shear and friction on the operating table or during transfer.22

**SPECIFIC POSITIONS**

**Supine**

Eighty percent of surgical procedures take place in the supine position.24 The hemodynamic effects in a patient who is awake lying supine include increased venous return with a compensatory decrease in cardiac contractility to limit the resulting increased cardiac output and hypertension. In anesthetized patients, these mechanisms are perturbed. The sympatholytic effects of many general anesthetics may necessitate the administration of additional fluids, sympathomimetics, or other vasopressors. The respiratory effects of lying supine include a decrease in total lung capacity and functional residual capacity, and a ventilation/perfusion mismatch. These effects are exacerbated by the diaphragmatic paralysis of general anesthesia and may worsen the hypoventilation of a patient with chronic obstructive pulmonary disease. Lastly, the two most common postoperative neuropathies, ulnar and brachial plexopathy, occurring respectively in 28 and 20 percent of closed claims in 1999, result from improper positioning and padding.24 This may be avoided by abducting the arms no more than 60 to 90 degrees to avoid traction on the brachial plexus, maintaining supination when the arms are abducted to avoid pressure on the ulnar nerve as it passes posterior to the medial epicondyle, maintaining a neutral position when the arms are tucked at the patient’s side, properly padding the arm board, and not allowing the surgeon to lean on the extremities (Fig. 4).25

**Prone**

Prone positioning is the second most common position in plastic surgery. Complications related to prone positioning include vertebral artery occlusion causing stroke, brachioplexopathy, and shoulder impingement causing pain.26 Most complications reported in prone surgery are related to excessive pressure on the head and neck.27,28 A rare complication associated with prone positioning is blindness; however, the etiology is multifactorial and not just secondary to increased intraocular pressure.29 More commonly, it is secondary to ischemic optic neuropathy, which too has many etiologies.30 However, because proper positioning is an easy modifiable risk factor, it should be implemented with every case. A well-padded headrest should always be used. Particular attention should be paid to eye protection and access to the patient’s airway. The neck should be stabilized in a neutral, nonextended position, with neck rotation and accelerated movements avoided to prevent dissection of the carotid and/or vertebrobasilar arterial systems. Bilateral chest rolls should support the patient’s weight on the clavicles and iliac crests to lessen compressive forces on the abdomen and thorax, which may negatively affect cardiopulmonary status.29 The legs should be supported on pillows from ankle to knee. The breasts and male genitalia should be padded. The turn from supine to prone of an anesthetized patient is the most risky aspect of this position, and care should be employed (Fig. 4).25

**Lithotomy**

This position poses the same risks of upper-extremity neuropathy, hemodynamic, and respiratory consequences as the supine position. In addition, there are significant consequences of lower-extremity venous stasis and hazards to lower-extremity peripheral nerves. The hips should be maintained with minimal external rotation and thigh flexion, the lithotomy poles should be padded to avoid compression of the common peroneal nerve, and all maneuvers should occur simultaneously with both left and right legs to avoid lumbar spine torsion (Fig. 4).25
Fig. 4. Safety considerations of four common surgical positions. Reprinted with permission from Millsaps CC. Pay attention to patient positioning! *RN.* 2006;69:59–63.
Lateral Decubitus

An axillary roll for the dependent axilla is needed, as are pillows between the arms and legs. The lower leg should be flexed at the hip and knee, and the upper leg should be extended. There is a risk of compressive neuropathy of the brachial plexus in this position, which may be reduced with a properly placed axillary roll. There is also a risk of traction on the suprascapular nerve, resulting in postoperative pain. The ear should not be folded against its support. Lastly, there is a potential for thrombosis of the retinal artery of the dependent eye if it is compressed by the headrest or pillow (Fig. 4).

SURGICAL SCRUB AND SKIN PREPARATIONS

With regard to surgical preparations and barriers, two separate and complementary goals should be considered. The first is to minimize risks to the patient, such as surgical-site infection, caustic exposure, and thermal injury. The second is to minimize the hazards facing the surgeon and operating room staff, such as exposure to pathogens or chemicals. Much of our common surgical practice has shown little evidence that it helps to achieve these goals.

The aim of hand antisepsis is to eliminate transient bacteria and reduce commensulates, with the assumption that lower bacterial counts will reduce infections. Modern research has tried to identify the simplest effective method, but the wide variety of techniques and underpowered studies make generalization difficult. Nevertheless, recent data have supported that rubbing with an alcohol-based solution (e.g., Avagard; 3M, St. Paul, Minn.) is likely more effective than scrubbing. Although scrubbing eliminates transient bacteria, it uncovers commensulates from the stratum corneum. Furthermore, repeated scrubs can cause excoriation and increased colonization with otherwise transient bacteria.

The antiseptic chosen to cleanse the patient should act quickly, have a broad antibacterial spectrum, and have some residual activity. Common agents include various alcohols, iodinated preparations, and chlorhexidine gluconate. An excellent combination of agents is alcohol, which works immediately, combined with chlorhexidine, which provides residual activity once the alcohol has evaporated. A study by Darouiche et al. compared surgical-site infection in patients undergoing clean contaminated surgery whose skin was cleaned with chlorhexidine–alcohol or providine–iodine scrub and paint. They found the overall rate of surgical-site infection was significantly lower in the chlorhexidine–alcohol group.

Rings should not be worn in the operating room by the surgeon, as they have been shown to increase bacterial counts in the underlying skin. The organisms may not be easily removed with general hand hygiene, and there is at least one case report of cardiothoracic wound infections being traced to the rings of a staff surgeon, despite a full surgical scrub and gloves. Similarly, false nails can increase colony counts. No clear data exist for nail polish.

As was the case with hand scrubs, preparation of the patient’s skin is meant to remove soil and transient organisms, reducing infections. The most common antiseptics are iodophors, alcohols, and chlorhexidine. Similarly to hand scrubs, the research regarding the ideal preparation does not exist. A simple shower with soap and water, with a preoperative saline rinse, may be sufficient to reduce the incidence of wound infection in clean cases. The traditional iodine soap scrub followed by paint may be unnecessary, particularly when viewed in the context of data demonstrating that scrubbing may excoriate the skin, exposing commensulates. Furthermore, iodine must dry to have full effect, and it is often wiped off before starting the case. Alcohol-based scrubs are immediately effective at reducing colony counts. The benefit of incise drapes, such as OpSite (Smith & Nephew, London, United Kingdom) or Ioban (3M) has not been demonstrated, but the concept deserves study.

Until clear data are available regarding skin preparation solutions, we recommend using alcohol-based preparations combined with either iodophore (DuraPrep; 3M) or chlorhexidine (Chloraprep; CareFusion, San Diego, Calif.) and following the recommendations of the Centers for Disease Control and the Association of periOperative Registered Nurses. These recommendations include the following:

1. Avoid shaving hair at surgical sites. If necessary, use a depilatory agent or clippers immediately before the procedure, away from the operative field.
2. Clean skin with a shower or surgical wash before using an antiseptic preparation.
3. Prepare the surrounding skin and surgical sites using an antiseptic.
4. Avoid pooling of the antiseptic beneath patients, around cuffs or tourniquets or electrodes, and before using electrocautery; in
addition, allow alcohol-based preparations to dry thoroughly to prevent operating room fires.
5. Annually, review policy regarding skin preparations.

The data regarding the proper use of surgical gloves are ambiguous. A recent Cochrane review by Tanner and Parkinson, however, suggests that double gloving with indicator undergloves reduces the incidence of perforation of the innermost glove and increases detection of outer glove perforations. Whether increased detection will lead to fewer blood-borne transmissions or surgical-site infections remains to be seen.

Other barriers between the patient and operating room staff include surgical clothing, masks, gowns, and drapes. Clothes and shoes dedicated to the operating room are meant to reduce rates of infection; however, there is no clear evidence that they are successful. Many institutions now allow staff to launder their scrubs at home, and the Centers for Disease Control consider the risk of blood-borne pathogen exposure on soiled linen to be negligible. The benefits of surgical masks in reducing rates of surgical-site infections are similarly dubious.43,44 Masks do, however, help prevent contamination to the surgeon.45 Also, there has been no reliable relationship found between gown and drape characteristics and surgical-site infection rates; therefore, recommendations remain indistinct.45

CONCLUSIONS

The topic of patient safety in the perioperative period is vast. Given the scope of the problem, an exhaustive review of all aspects of patient safety related to inpatient plastic surgery could not be contained in a single issue of Plastic and Reconstructive Surgery; however, this article should stimulate all plastic surgeons to be vigilant in assessing their practice to improve patient safety.

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