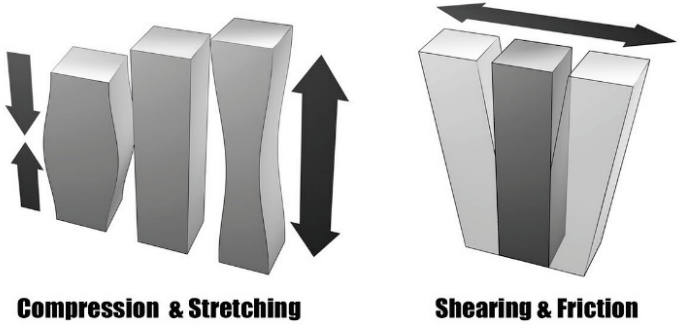
INTRODUCTION

Positioning the patient correctly can protect the patient from preventable injury incurred as a direct result of undergoing a surgical procedure. Patients under the influence of general anesthesia, as well as local anesthesia in certain cases, are unable to feel pain generated from remaining in one position for a prolonged period of time and do not have the ability to adjust their position.[1] Correct positioning also provides adequate access to the surgical site and allows the anesthesia professional to adequately ventilate and provide for patient needs that arise as a result of surgery.[2] While perioperative positioning is a team effort with different players including the surgeon and anesthesia professional providing input on patient position,[2] perioperative RNs serve as the patient's advocate during the procedure and play a critical role in minimizing the risk of injury to the patient. Examples of nursing advocacy activities include ensuring all steps are taken to correctly position and reposition the patient, making positioning decisions based on evidence-rated guidelines, selecting proper positioning accessories, and collaborating with anesthesia professionals and primary surgeon to ensure patient safety. Steps for correct positioning can include:

- preoperative assessment of the patient's risk of injury according to extrinsic and intrinsic factors;
- the selection and safe use of positioning support equipment and devices;
- implementation of interventions that protect the patient's circulatory, respiratory, musculoskeletal and neurological structures; and[3,4]
- correct documentation of patient positioning activities and related patient condition such as skin color to identify early signs of skin breakdown.[5]

Surgical positioning injuries are caused by a number of different forces, which include stretching or compression of tissues, friction and shear forces (see Figure 1), or prolonged pressure that can result in skin breakdown.[1] Compression can reduce a patient's blood flow and disrupt cellular integrity that can cause tissue edema, ischemia, and necrosis. Stretching can also lead to ischemic changes caused by reduced blood flow.[6]

Figure 1 – Forces Related to Position Injuries



Direct and prolonged pressure can lead to permanent injury, such as corneal abrasions, nerve injury, pressure ulcer, and compartment syndrome. Certain positions can pose a number of risks for a single patient. For example, a patient in the prone position could experience ocular pressure and respiratory compromise caused by compression of their abdomen, breasts, genitalia, knees, or toes. Such pressure can result in nerve and soft tissue injuries (eg, skin abrasion or tearing) and affect the patient from head to feet, including face, ears, chest, hips, the thigh distal to the inguinal ligament, and the tips of the toes.[2] Positioning injuries can cause the patient to experience injury to a number of anatomical structures, including the patient's skin and soft tissues, joints, ligaments and bones, eyes, nerves, and blood and lymph vessels.[7] The severity of a positioning injury can range from minor inconvenience, to long-term functional restriction, secondary morbidity, and death.[7,8]

Certain anatomical areas are at increased risk of injury for a range of different of positioning approaches. For example, the most common site for a pressure injury, according to one study,[9] was the sacrum (70%), followed by the heels (12%) and then the chin, sternum, and trochanters (6%). Sacral and heel pressure injuries were associated with the supine position, and pressure injuries on the chin, sternum, and trochanters were associated with the prone position. High-risk patients such as those who are elderly, pediatric, obese, and those who have co-morbidities pose unique risks (ie intrinsic factors) for positioning injury that preoperative assessment can identify. Specific surgical factors (ie extrinsic factors) such as type and duration of surgery also pose challenges that need to be addressed. For example, many positioning injuries are associated with prolonged procedures.[10] The physiological understanding of positioning injury dangers and protective benefits of using a standardized positioning safety system provides important tools for reducing the risk of these injuries and ensuring optimal surgical outcomes that are not negatively affected by preventable injury.

Perioperative RNs understand the critical role of applying correct and standardized positioning approaches based on national guidelines, such as AORN's 2017 Guideline for Positioning the Patient[10] to correctly approach all aspects of patient positioning, including policy development and education,[1] to support standardized practices, communication and collaboration for a patient's positioning experience and associated risks throughout the continuum of care.

This standardized approach also involves positioning systems, which are equally important for the perioperative nurse to understand and apply correctly. The ideal positioning system will be easy to use, provide optimal protection for the patient, and offer efficient application for perioperative personnel. Another factor influencing the need for this standardized and evidence-based approach is that positioning injury can result in financial harm to the health care facility due to financial penalties related to health care-acquired conditions (HAC) by the Centers for Medicare and Medicaid Services (CMS).[11] For example, a pressure ulcer that occurs as a result of patient positioning can be deemed a HAC if the pressure ulcer is a Stage 3 (ie, full-thickness loss of skin where adipose tissue is visible in the ulcer and granulation tissue and rolled wound edges are often present; slough or eschar may be visible) or a Stage 4 (ie, full-thickness skin and tissue loss with exposed or palpable fascia, muscle, tendon, ligament, cartilage, or bone; slough or eschar may be visible; rolled edges, undermining, or tunneling may be

present.)[12] Pressure injuries that develop during a hospital admission may harm the patient, and also may result in additional costs or reimbursement challenges for the health care facility.[11]

When surgical team members use safety precautions for positioning, including correct padding of pressure points, repositioning, and keeping the patient in the position for the shortest amount of time required,[10] the patient is at reduced risk of developing pressure or other positioning injuries.[1] As technologies advance, surgical procedures and the necessary protective requirements for these procedures also develop. For example, minimally invasive and robotic surgical procedures can pose unique challenges to position the patient safely and also provide adequate access to the surgical site. These challenges make it critically important for the perioperative RN to follow national guidelines and recommendations and document positioning activities and assessments throughout a surgical patient's continuum of care.[2] Alongside the evolution of new surgical procedures, positioning technologies and strategies also continue to evolve. As new positioning products and accessories have become available, gone are the days when nurses had little at their disposal and had to be creative with towels and adhesive tape to position patients. When standardized products are used correctly for their intended use, patients are at decreased risk for positioning and pressure injury and nurses have the tools at their disposal to develop a positioning plan and ensure safe, efficient positioning for every patient's unique needs.

TOP CHALLENGES FOR SAFE PATIENT POSITIONING

Certain positioning scenarios are documented in the literature as presenting common challenges for the perioperative team. Other positioning scenarios are documented on variance reports and kept in hospital risk management files and not necessarily reported or published making it difficult to quantify or rank the top challenges. Based on discussions with clinicians in the field or at trade show meetings, the top positioning challenges depends on several factors. First is the inherent risk in any procedure for certain anatomical high-risk areas for injury such as bony prominences of the iliac crest and heels, and soft tissue anatomical areas such as female breasts, abdomen and male genitalia. These basic risks can become worse or expand in number when a patient is at higher risk for injury due to a number of factors, such as high body mass index (BMI), compromised skin integrity, and co-morbidities such as diabetes or hypertension that can influence important anatomical functions, such as blood flow. Specific positioning approaches can also pose a higher risk for patient injury, such as prone, Trendelenburg, and lateral positions that can put the patient at risk for injury, particularly with longer surgery duration. The following includes more detailed discussion on the top positioning challenges and associated patient injuries all nurses should be prepared to address.

Providing Correct Ocular Pressure Protection with Prone Positioning

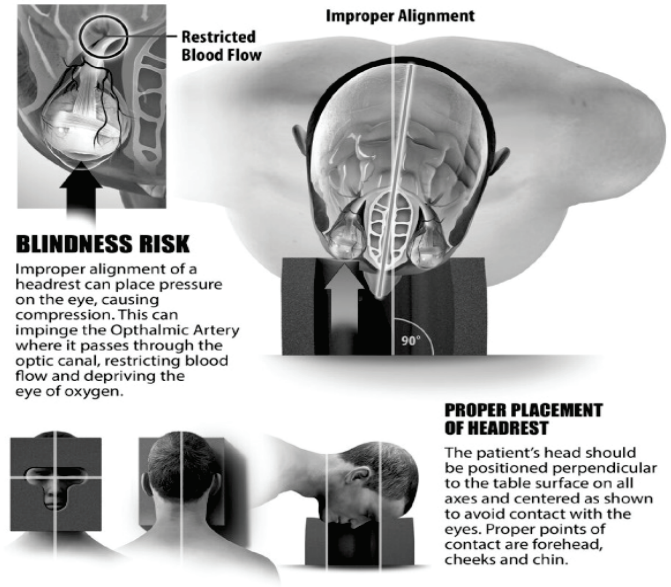
The prone position is used for procedures that require access to the rectum, sacrum, spine and other dorsal areas of the body.[1] When the patient is placed in the prone position, this position can put abnormal pressure during the procedure on the patient's eyes, nose, and ears.[2] Ocular pressure can lead to serious and permanent injury. Direct pressure on the eyes can cause central retinal artery occlusion that can lead to temporary or permanent blindness.[10] Spinal surgeries, which often require the prone

position, can result in ocular pressure and subsequent injury as a result of hypotension, embolism, hemorrhagic shock, direct trauma, and prolonged compression of the eyes. Postoperative visual loss can be classified into four categories, including:

- ischemic optic neuropathy,
- central retinal artery occlusion,
- cortical blindness, and
- posterior reversible encephalopathy syndrome.[13]

Ischemic optic neuropathy is the most common cause of perioperative visual loss after a spinal procedure such as spinal fusion operation, according to a report by the Postoperative Visual Loss Study Group of the American Society of Anesthesiologists.[14] Central retinal artery occlusion, which occurs when blood supply to the retina is reduced, is also a high risk associated with the prone position and is associated with head position and external compression of the eye, which is accompanied by ptosis and ophthalmoplegia.[13] Corneal abrasions or other ocular injuries can occur in anesthetized patients as a result of increased intraocular pressure, edema, or direct trauma to the unprotected eye or a failure of the eye to fully close; general anesthesia reduces tear production and can lead to corneal drying which can increase the risk for corneal abrasion.[15] Figure 2 illustrates the importance of proper alignment and proper points of pressure when positioning the patient's head in the prone position.

Figure 2 – Proper Head Positioning Decreases the Risk of Ocular Injury Associated with Prone Positioning



Correct positioning to reduce the risk for ocular pressure in prone positioning should include a head positioning device that protects the patient's ears, forehead, eyes, and chin and provides clear path for the endotracheal tube. Although evidence related to the safest and most effective face positioner is inconclusive,[10] researchers tend to agree that using a device that is designed to prevent mechanical ocular compression when the patient is in the prone position can be useful in the effort to prevent tissue injury and postoperative vision loss.[19,20] In addition to implementing correct positioning practices and equipment prior to surgery, the patient should be monitored throughout the surgery to assess for changes in ocular pressure to prevent direct pressure.[21]

Tucking Patient Arms to Secure but Not Compress Upper Extremities in the Supine Position

When positioned in the supine position, the patient's arms need to be secured and this can be done in several different ways as decided by the needs of the surgical team and the physical limitations of the patient. These arm positioning strategies can include (see Figure 3):

- tucked at the sides with a draw sheet,
- secured at the sides with arm guards,
- flexed and secured across the body, or
- extended on arm boards .[22,4]

Peripheral nerves in the upper extremities or the brachial plexus can become compressed as a result of arm tucking.[23] Compartment syndrome is also possible with arm tucking that creates compression. For example, in one case involving a 63-year-old woman placed in a supine position for a left nephrectomy and removal of tumor thrombus from the inferior vena cava, the patient's arms were tucked at her sides. The day after surgery the patient complained of pain and tenderness and presented with swelling in the hand. She was diagnosed with compartment syndrome and had an emergent fasciotomy of the left hand. Three months later the patient was pain-free and had full range of motion and sensation to her fingers. It was concluded that this compartment syndrome had been caused by overzealous arm tucking that led to a tourniquet effect and functional venous obstruction.[24]

Figure 3 – Specialized Arm Protector

Arm tucking that is too loose can also be a concern. If the patient's arms are not tucked tightly enough, there is a risk for them to become unsecured during the procedure.[25] To prevent compression injuries to the ulnar nerve when the patient is in the supine position, the perioperative nurse should place the patient's palms up to decreases pressure on the ulnar nerve[26,27] and padded arm boards should be used that are level with the mattress to decrease the risk for upper extremity neuropathy.[27,28]

Specialized arm protectors are available as part of an advanced positioning system that can be used for tucking the patient's arms on the OR bed or on an arm board. A one-piece arm protector can protect the ulnar nerve and fingers throughout a surgical procedure.

Securing Patients in Extreme Positions or with Extreme BMI

Perioperative patients may be at risk of falling when positioned or repositioned on the OR table or specialty bed; placed into or removed from positioning devices (eg, stirrups); or the position of the OR table is changed (eg, supine to Trendelenburg).

Injuries from falls can cause the patient pain, soft tissue injury, swelling, ecchymosis, lacerations, fractures, head injury, functional impairment, disability, or death. Long term consequences of a fall may contribute to increased length of hospital stay, a need for rehabilitation, and increased health care costs.[29] Extreme surgical positioning, such as steep trendelenburg can increase a patient's risk for falling. For example**,** a 60-year-old man suffered severe head injury after somersaulting feet-over-head off the operating table while positioned in steep Trendelenburg position in preparation for a robotic prostatectomy. The patient had been anesthetized and intubated but was not strapped or otherwise restrained to the table before being placed into steep Trendelenburg. The fall resulted in severe intracerebral bleeding that led to the patient's death two days after surgery.[30]

Extreme patient BMI can also pose an increased risk for falls in the OR. In one reported case of an obese patient undergoing spinal fusion surgery in the prone position on a spinal table, a slight axial rotational adjustment was made to the patient's position, which caused the table to rapidly tilt vertically and the patient fell to the floor. The patient immediately developed a large subgaleal hematoma. Investigation concluded that the fall was caused by a failure to correctly activate the table locking mechanism.[31]

In addition to Identifying potential hazards unique to the patient and establishing safe practices to reduce the risk of patient and personnel injury during positioning and repositioning the surgical patient,[10] positioning devices designed to reduce the risk for falls with extreme positioning can be applied. Such a device can contain shape-conforming properties and can be secured directly to the OR bed with hook and loop straps at each of the four corners.[32] This positioning device can also include a two-layer lift sheet positioned in between the patient's scapulae and sacrum with a body strap included in the design for positioning across the patient's chest to allow chest expansion but also secure the patient when being rotated into the Trendelenburg position (Figure 4).

Figure 4 – Examples of Positioning Devices Designed to Reduce the Risk for Falls with Extreme Positioning

Preventing Pressure Injuries in Cardiac Surgery

Pressure injury is a concern for all surgical patients, however, patients undergoing cardiac surgical procedures have been identified as being at higher risk for surgery-related pressure ulcer injury, which can include surgical alopecia. Research suggests cardiac surgery patients have rates of healthcare-acquired pressure injuries reported to be as high as 29%.[33] Several extrinsic surgical factors have been suggested for this increased risk of pressure ulcer among cardiac surgery patients, including:

- length of procedure;
- periods of hypotension, paralysis, and heavy sedation due to anesthesia;[34]
- intraoperative manipulation of body temperature;
- metabolic changes to the tissues caused by prolonged immobility;
- inability to reposition;
- extracorporeal circulation,
- anesthesia impact circulation to the skin; and
- postoperative use of cardiac assistive devices that require immobilization.[35,36]

The anatomical areas at highest risk for pressure injury in this patient population include the sacrum and coccygeal area,[33] as well as the occiput. Patients undergoing cardiac procedures may also be more likely to rate positive for intrinsic pressure ulcer risk factors, such as older age, poor nutritional condition, aberrant body mass index, and low levels of albumin or hematocrit.[37] In the OR, repositioning the patient at least every two hours and using pressure redistributing surfaces (eg, rectangular padding that is breathable, skin-friendly, and can be inserted around high-risk areas) is recommended. Monitoring in the postoperative period can also support early recognition of pressure injury in this patient population. Perioperative RNs should recognize superficial reddening of the skin as the first clinical sign of pressure injury development after surgery.[38]

Elevating Patient Heels Correctly to Prevent Heel and Associated Sacral Pressure Injury

Heel skin temperature can increase after placing the patients' heels on the bed surface for as little as 15 minutes and this increase in temperature has been documented to contribute to deep tissue damage.[39] Due to this unique microcirculatory system of the heel, offloading of heel pressure during surgery when the patient is in the supine position is recommended to prevent heel pressure injuries.[40] However, offloading the heels may result in increased pressure on the sacrum from weight and pressure redistribution, jeopardizing sacral skin integrity. For example, in one study researchers reported that 23% of the 21 patients in the study who developed sacral pressure injuries had their heels elevated off the OR bed during surgery.[41]

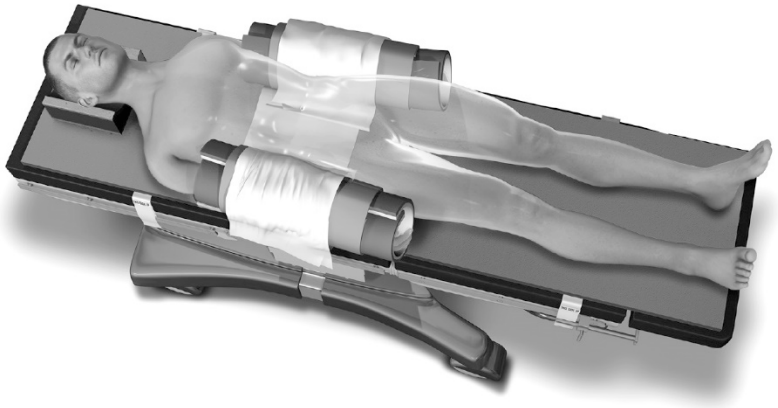
To address heel and associated sacral pressure, the heels should be redistributed by using a heel suspension device that distributes the weight of the leg along the calf without placing pressure on the Achilles tendon[12] because offloading the heels may increase pressure at the Achilles tendon and the sacrum and allow the knee to hyperextend, compressing the popliteal vein and increasing the risk of DVT.[42] Another recommended approach for offloading the heels involves elevating and supporting the patient's calves with a pressure-redistributing surface that is wide enough to accommodate the externally rotated malleolus. This helps prevent localized pressure on the lateral malleolus if the leg externally rotates.[39]

Repositioning Patients Safely During Prolonged Procedures

Positioning injuries can be associated with prolonged procedures. The American Society of Anesthesiologists (ASA) Task Force on Perioperative Visual Loss considers procedures to be prolonged when they exceed an average of 6.5 hours duration, within a range of 2 to 12 hours.[10,43] Repositioning the patient is helpful for providing pressure relief and comfort.[12] Repositioning activities reduce the duration of pressure;[44] the need for patient repositioning in the event of prolonged procedures or other risk should be addressed even when a pressure-redistributing surface is used.[12] In certain cases, such as complicated spinal procedures, the patient is unable to be moved. Monitoring technologies such as neurophysiological monitoring should be closely assessed by the perioperative RN throughout the procedure[10] and these monitoring results should be documented and shared with postoperative providers.

It is also important for the perioperative team to recognize the unique intrinsic and extrinsic factors for the patient and procedure, respectively, as identified in the preoperative assessment. For example, both time and the amount of pressure can impact the risk of skin injury, and it is important to assess how the tissue is responding. Consider that capillary refill pressure is approximately 32 mm Hg, and when it is exceeded, tissue ischemia begins leading to tissue death.[45] In other words, a short length of time with high pressure can have just as much damage as a low amount of pressure over a long period of time.[46] This reinforces the importance of applying a standardized positioning support system that is specifically designed to redistribute pressure and therefore reduce a patient's risk of pressure injury (see Figure 5).

Figure 5 – Example of Full Body Positioning Device to Decrease the Risk of Decreased Capillary Refill



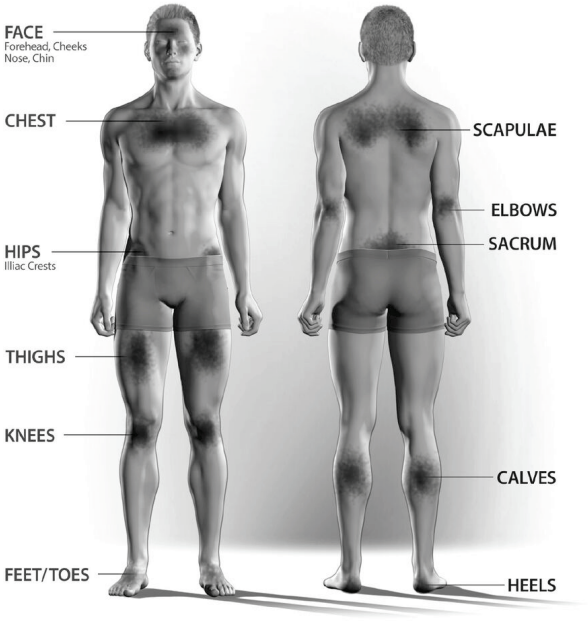
ANATOMICAL AREAS AT HIGH RISK FOR POSITIONING INJURY

Certain anatomical areas of the body present a higher-risk for positioning injury. Perioperative RNs must have an in-depth knowledge of these anatomical and related physiologic risk areas to consider in applying safe positioning strategies to avoid injury. These anatomical areas comprise a number of locations from head to feet.

Skin

Pressure injuries can develop when the positioned patient experiences abnormal amounts of pressure on small areas of the body's surface that can lead to poor tissue perfusion with ischemia, tissue breakdown, and development of pressure injuries.[47] Muscle is more sensitive to pressure than skin; therefore, the underlying tissue may become necrotic before a lesion presents on the skin surface.[46] Friction can occur if the surface of the skin is pulled against a rough surface.[10] Shearing can occur if sliding or pulling action allows the patient's skin to remain stationary while underlying tissues shift; this can happen if a patient is dragged without lifting with a draw sheet or transfer device. Another risk to skin integrity due to pressure is caused by excessive moisture of the skin, which causes weakness of the collagen or elasticity of the skin that leads to maceration of the skin and tissue damage.[46] Areas of redness can appear from either moisture or pressure, as well as at bony prominences such as elbows, iliac crests (hips), and areas of the feet (see Figure 6). Other factors that can pose a risk to the patient's skin during surgery include OR temperature, sliding of positioning devices to an incorrect position, and external devices such as tubing, cardiac leads, probes, identification bands, and security tags.[10]

Figure 6 – Areas of Redness That Are Common Risk Areas for Pressure Injury.



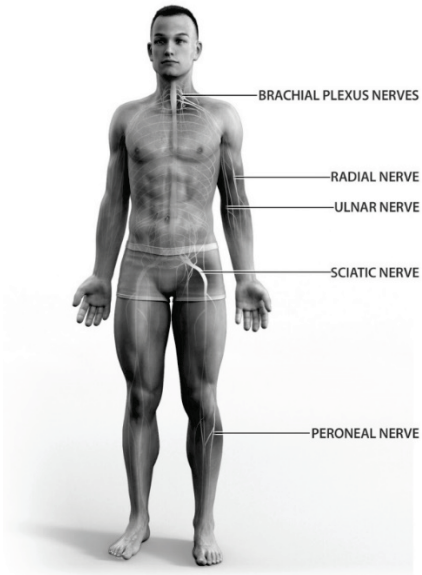
Nerves

Surgical positioning can also increase the risk of perioperative peripheral neuropathies affecting various areas of the body (see Figure 7), including the following.

- Brachial plexus neuropathy may be caused by arm abduction for the prone patient with arm abduction greater than 90°.
- Ulnar neuropathy is possible with supination of the hands or forearms placed above the head with pronation of the hands; elbow flexion of greater than 90° may also increase the risk of ulnar neuropathy.
- Radial nerve neuropathy may result with prolonged pressure on the radial nerve in the spiral groove of the humerus. Extension of the elbow beyond the range that is comfortable during the preoperative assessment may stretch the median nerve.
- Sciatic nerve neuropathy should be assessed periodically during procedures, as positions that stretch the hamstring muscle group beyond the range that is comfortable during the preoperative assessment may stretch the sciatic nerve or its branches that cross both the hip and the knee joints. Therefore, extension and flexion of these joints should be considered when determining the degree of hip flexion that can be tolerated.

- Peroneal neuropathy can be a risk when there is pressure near the fibular head from contact with a hard surface or a rigid support.

Figure 7 – Location of Nerves that are Vulnerable to Injury with Surgical Positioning



Head and Neck

Extreme lateral rotation of the patient's head and neck can cause stretch injury to the brachial plexus,[48,10] and can compress and twist muscles and vessels.[48,49] Neck muscles directly compressed can lead to compartment syndrome.[49] Additionally, reperfusion of the muscles after repositioning the head to its physiologic position can lead to facial and neck swelling, angioedema, upper airway edema, and muscular edema and can increase compartment pressures and worsen muscle ischemia.[49] Extreme neck rotation can also lead to paraplegia in patients with preexisting spinal cord pathology,[50] and can cause postoperative infection of the salivary glands.[51] Compression of the patient's tongue from the endotracheal tube in combination with lateral rotation and flexion of the head can occlude Stensen's duct, which drains the parotid gland, or Wharton's duct, which drains the submandibular gland, these effects to cause salivary stasis and secondary bacterial infection.[51] Ischemic sialadenitis can result when arterial or venous vasculature is compressed or kinked and obstructs the venous return to the head and neck or decreases blood supply to the salivary gland.[52,10]

Arms

If the patient’s arms are improperly tucked, this can interfere with physiological monitoring (eg, blood pressure, arterial catheter) and can also cause an unrecognized infiltrated IV in the tucked arm. All patients, and particularly patients who are thin can be at risk for brachial plexus injury and occlusion of the subclavian or axillary arteries when

the patient's arm is abducted more than 90°.[53] Additionally, turning the patient's head to the side when the arms are extended on arm can stretch the brachial plexus.[54] Brachial plexus injury is also possible if an arm board is set lower than the OR table.[28]

Chest and Abdomen

The perioperative RN should ensure the patient's abdomen is not compressed, and should ensure that vascular congestion is minimal with maximum expansion of the diaphragm and lungs allowed during ventilation;[45] this should be a particular focus during prone positioning. Also, breasts of female patients must be positioned to avoid significant compression, and male patients' genitalia must be adjusted to prevent compression.

Legs and Feet

The lower extremities are at risk for skin and nerve injury, as previously discussed. Positioning the legs in stirrups can pose several risks for injury. For example, the common peroneal nerve can be injured if the fibular neck rests against the vertical post of the stirrup when the patient is in the lithotomy position.[55] This type of injury can lead to paresthesia of the lateral lower leg and dorsum of the foot, resulting in foot drop.[55] Pressure in general that results from from the lower extremities resting against stirrups or stirrup posts can raise compartment pressures and also increase the risk of inadequate lower extremity perfusion.[56] Additionally, if scrubbed personnel lean against the patient's thighs, this can increases abduction and external rotation of the thighs and can cause a femoral neuropathy.[55,10]

POSITIONING STRATEGIES FOR HIGH-RISK PATIENTS AND CHALLENGING POSITIONS

To effectively plan patient positioning and be able to troubleshoot any challenge with patient positioning, the perioperative RN must work with the perioperative team and initiate planning for specific patient positioning needs ahead of time.

Preoperative Assessment

This positioning planning process ideally begins prior to the day of surgery as team members review the scheduled patient procedures for the next day, select appropriate positioning equipment based on input from the team, such as the surgeon's desired approach for surgical access and ensure positioning equipment is available, appropriately cleaned and disinfected.[57] As the perioperative RN collaborates with perioperative team members on this preoperative planning, assessment of the patient's individual needs for positioning must take into account the anatomical positioning injury risks for any patient, as well as patient-specific (intrinsic) and procedure-specific (extrinsic) positioning risks to be addressed. Generally agreed upon intrinsic risk factors for positioning can include:

- age,
- comorbidities (eg, diabetes, cancer, peripheral vascular disease, respiratory, neurologic disorders),
- nutritional deficiencies,
- medications (eg, corticosteroids, vasopressors),

- impaired body temperature regulation,
- low hemoglobin and hematocrit,
- obesity,
- low serum protein,
- smoking,
- low systemic blood pressure,
- fractures, and
- extracorporeal circulation.[46]

Assessment Tools

Several risk assessment tools are used to predict risk of pressure injury affecting skin and nerves. These tools include the Braden Scale, Braden Q + P Scale, Munro Scale, and Scott Triggers tool.

- The Braden Scale has six subscales to estimate sensory perception, skin moisture, activity, mobility, friction, shear, and nutritional status. Lower Braden Scale scores indicate a greater risk for pressure injury development.[58]
- The modified Braden Q + P Scale (designed for pediatric patients) identifies each individual source of pressure, surgical time, number and type of medical devices used intraoperatively, ASA physical status classification, and practice interventions.
- The Munro Scale assesses extrinsic risk factors (eg, friction, shear, moisture), as well as intrinsic risk factors (eg, as age, body mass index, nutritional status, mobility, ASA physical status classification, comorbidities). The Munro Scale also assesses risk factors specific to surgery, including type of anesthesia, patient position, length of surgery, and also assesses the patient throughout the pre-, intra-, and postoperative phases of perioperative care to establish a cumulative score.[59,60]
- The Scott Triggers tool considers patient triggers such as age of 62 years or older, albumin levels less than 3.5 grams (g)/deciliter (dL), ASA physical classification scores of III or greater, and surgery anticipated to last longer than three hours. Patients with two or more defined triggers are defined as high risk of pressure injury.[61]

In addition to the assessment tools used to predict the risk of pressure injury, more research is needed to assess skin redness and the risk of progression to deeper tissue injury. Skin color can indicate positioning injuries including soft tissue injury from compression, friction, and shearing.[5] A baseline assessment of skin redness can help to continuously monitor changes in redness over time. The Incontinence Associated Skin Damage and Its Severity Instrument (IASD) is a tool that is used to assess skin integrity for elderly patients. This tool provides a detailed analysis of skin colors to identify patient skin injury and integrity.[62] This tool has not been validated for use in the OR to address skin redness that is not associated specifically with incontinence, and perhaps should be

considered for future studies to better understand how skin redness might be a predictor of further skin injury in certain populations.

Challenging Patients

As previously introduced, preoperative positioning assessment must address unique challenges for positioning among certain patient groups that can be a higher risk for positioning injury. Some of these groups include the following.

Elderly

Older adults (over age 65) are at increased risk for positioning pressure injury due to decreased skin elasticity, less subcutaneous tissue, dry skin, chronic illness, malnutrition and decreased vascular sufficiency[63] that can delay wound healing. This diminished skin integrity, may initially be seen as skin redness; therefore, skin color assessment is an important step for this patient population, as well as a general assessment principle for all populations. When combined with changes in the musculoskeletal system (eg, loss of muscle mass, degenerative joint changes) the risk of pressure ulcers and thrombus formation can increase.[63] In addition to weakened skin integrity, elderly patients may have poor nutrition, diabetes, arthritis, and limited cardiovascular reserve that can lead to increased risk of cardiovascular compromise or collapse because of hemodynamic changes (eg, reduced cardiac output and cardiac index, increased systemic vascular resistance).[64] The use of tape or other adhesives can further increase the risk for skin injury.

Obese

Patients with a BMI of 30 kg/m^2 to < 35 kg/m^2 are classified as Class I obese, people with a BMI of 35 kg/m^2 to < 40 kg/m^2 are classified as Class 2 obese, and people with a BMI of 40 kg/m^2 or higher are classified as Class 3 extremely obese, according to the Centers for Disease Control and Prevention.[65] Obesity is associated with significant physiologic cardiovascular and pulmonary changes that can compromise airway and breathing mechanisms. Obesity can also pose specific risks due to surgical position. For example (see Figure 8), patients with truncal obesity may have more pronounced hemodynamic changes when increased thoracic and intra-abdominal pressure is introduced with prone positioning, or when the prone positioning is modified to improve surgical access.[67]

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Figure 8 – Example of Extreme BMI Patient Repositioned with Stirrups in Extreme Trendelenburg Position

Pediatric

Unique anatomical factors can influence a pediatric patients risk of pressure injury and also affect the anatomical sites most susceptible to pressure injury, such as the occipital region, which has increased risk of skin breakdown in infants and toddlers in the supine position because of a disproportionately larger head size compared with adults. Neonates are vulnerable to skin and pressure injury due to an immature and underdeveloped epidermis and dermis. Neonates and children can also be at a higher risk of nutritional deficiencies because of their smaller appetites and reduced dietary intake factored with increased nutritional requirements to meet normal growth needs.[12] Head holders or other types of head positioners may lead to an increased incidence of injury in pediatric patients because cranium thickness can vary as it develops.[67] Depending on the pediatric patient's size and preexisting conditions, airway management and IV access may also present unique challenges in positioning.[68]

Co-Morbidities

Patients with preexisting health conditions may require special positioning considerations. Several co-morbidities that can affect the patient during positioning include: body habitus (ie if the patient is over or under weight), neurologic disorders, diabetes, and alcohol dependence, which can lead to nerve injury.[27] Rheumatic diseases can also impact patient positioning and positioning injury risk. For example, arthritis can cause joint swelling that requires special precaution for protecting bony prominences. Also, patients with active rheumatic disease (eg, rheumatoid arthritis) may experience joint swelling, redness, warmth, low-grade fever, and fatigue. These patients are also at increased risk for infection, including surgical site infection.[69]

Challenging Positions

As previously introduced, certain extrinsic factors are associated with all surgical procedures. These can include:

- duration of procedure;
- shear, friction, compression and other forces impacting skin and nerves;
- moisture if skin is overhydrated or exposed to sweat, bodily fluids or skin prep solution;
- OR temperature,
- sliding of positioning devices to an incorrect position, and
- patient contact with external devices such as tubing, or cardiac leads, perioperative personnel or technologies such as a robotic arm.[10]

Specific surgical positions can further increase these extrinsic risks owing to patient positioning risk and sometimes related to the articulation of the OR table. Several of these high-risk patient positions include the following.

Supine

In the supine position the patient's back is in contact with the OR table. The supine position is commonly used because it provides access to a number of body areas. When a patient is in the supine position, the heart rate and vascular resistance are decreased and there is a reduction in lung volume. This reduction in lung volume can result in a decrease of up to 500 milliliters (mL) in the volume of air present in the lungs at the end of passive expiration. The supine position also causes extra pressure on the skin over the occiput, scapulae, olecranon processes, sacrum, coccyx, and calcaneum.[69]

Prone

The prone position provides surgical access to the dorsal aspects of the patient's body.[69] The jack-knife or Kraske position is a variation of the prone used for sacral, rectal, or perineal areas. The knee-chest position is a modification of the prone position used for spinal procedures that can offer reduced abdominal pressure.[70] Complications that can be associated with the prone position include: increased bleeding, compartment syndrome in the abdomen and limbs, thrombosis and stroke.[10]

Trendelenburg and Reverse Trendelenburg

In the Trendelenburg position, the patient's feet are higher than the patient's head by 15° to 30°, in order to move the abdominal viscera cephalad and provide surgical access to the pelvic organs.[4] Trendelenburg positioning can lead to redistribution of the blood supply from the lower extremities into the central and pulmonary circulation. Trendelenburg position also decreases venous return from the head leading to venous pooling and increased intraocular pressure.[71] as well as swelling of the eyes, lips, tongue, and larynx with laryngeal swelling leading to potential respiratory distress, reintubation or delayed extubation.[15]

The risk for sliding and subsequent shear injury increases when the patient's position is changed from supine to reverse Trendelenburg and the risk for injury to the feet is increased, especially if a padded footboard is not used.[10]

Lateral

In a lateral position, the patient is positioned on the nonoperative side;[4] typically this position is used for orthopedic procedures involving the hip, and with some modification for kidney and thoracic procedures.[4,69] The patient in the lateral position is at risk of injury due to pressure on vulnerable points on the dependent side and prolonged lateral positioning can also lead to vascular congestion and relative hypoventilation in the dependent lung.[71] Patients with osteoporosis or other degenerative orthopedic diseases may be at risk of fracture or lumbar misalignment when placed in the lateral position.[72]

Intraoperative Assessment

Monitoring the patient in any position should occur throughout the surgery, for changes that can indicate complications such as intraocular pressure, skin color change, swelling and redness should also be documented to indicate increased risk of skin breakdown.[2] Physiological reactions can occur during the procedure with the introduction of factors such as anesthetics, positioning, and fluid loss, which can be aggravated by prolonged surgery, and these factors can be unique contributors to positioning risks.[73] When poor positioning techniques are used at the beginning of the surgery, the patient's risk of injury is increased even more when the length of the surgical procedure is extended.

Postoperative Assessment

At the conclusion of the surgical procedure, the perioperative nurse should assess the patient for signs of intraoperative injury and should closely inspect the skin for any areas identified during the preoperative assessment as being at high risk for injury. Care should be taken when removing drapes and wraps in preparing to move the patient after surgery as skin tear and other damage can occur at this point of care.[74] Results of this postoperative assessment should be included in the transfer-of-care report to the postanesthesia care nurse.[2]

Careful observation of the patient's skin should continue in the hours and days following surgery. Changes in a patient's skin can appear within 72 hours after surgery showing redness, which can lead to burn-like lesions. The affected skin may appear bruised and possibly show indications of blistering, with the potential of necrosis occurring 2 to 6 days after surgery.[73] Table 1 describes the types of skin changes that can occur and the category of injury assigned by the National Pressure Ulcer Advisory Panel.

In recognition of the potential for peripheral neuropathy, a postoperative assessment of extremity nerve function is beneficial.[27] The signs and symptoms of perioperative peripheral nerve injury are described in Table 2.

Table 1 – Stages of Pressure Injury as Defined by National Pressure Ulcer Advisory Panel

Stage	Skin Changes	Description
Stage 1	Non-blanchable erythema of intact skin.	Intact skin with a localized area of non-blanchable erythema, which may appear differently in darkly pigmented skin. Presence of blanchable erythema or changes in sensation, temperature, or firmness may precede visual changes. Color changes do not include purple or maroon discoloration; these may indicate deep tissue pressure injury.
Stage 2	Partial-thickness skin loss with exposed dermis.	Partial-thickness loss of skin with exposed dermis. The wound bed is viable, pink or red, moist, and may also present as an intact or ruptured serum-filled blister. Adipose (fat) is not visible and deeper tissues are not visible. Granulation tissue, slough and eschar are not present. These injuries commonly result from adverse microclimate and shear in the skin over the pelvis and shear in the heel. This stage should not be used to describe moisture associated skin damage (MASD) including incontinence associated dermatitis (IAD), intertriginous dermatitis (ITD), medical adhesive related skin injury (MARSI), or traumatic wounds (skin tears, burns, abrasions).
Stage 3	Full-thickness skin loss.	Full-thickness loss of skin, in which adipose (fat) is visible in the ulcer and granulation tissue and epibole (rolled wound edges) are often present. Slough and/or eschar may be visible. The depth of tissue damage varies by anatomical location; areas of significant adiposity can develop deep wounds. Undermining and tunneling may occur. Fascia, muscle, tendon, ligament, cartilage and/or bone are not exposed. If slough or eschar obscures the extent of tissue loss this is an Unstageable Pressure Injury.
Stage 4	Full-thickness skin and tissue loss.	Full-thickness skin and tissue loss with exposed or directly palpable fascia, muscle, tendon, ligament, cartilage or bone in the ulcer. Slough and/or eschar may be visible. Epibole (rolled edges), undermining and/or tunneling often occur. Depth varies by anatomical location. If slough or eschar obscures the extent of tissue loss this is an Unstageable Pressure Injury.
Unstageable	Obscured full-thickness skin and tissue loss.	Full-thickness skin and tissue loss in which the extent of tissue damage within the ulcer cannot be confirmed because it is obscured by slough or eschar. If slough or eschar is removed, a Stage 3 or Stage 4 pressure injury will be revealed. Stable eschar (i.e. dry, adherent, intact without erythema or fluctuance) on the heel or ischemic limb should not be softened or removed.
Deep Tissue	Persistent non-blanchable deep red, maroon or purple discoloration.	Intact or non-intact skin with localized area of persistent non-blanchable deep red, maroon, purple discoloration or epidermal separation revealing a dark wound bed or blood filled blister. Pain and temperature change often precede skin color changes. Discoloration may appear differently in darkly pigmented skin. This injury results from intense and/or prolonged pressure and shear forces at the bone-muscle interface. The wound may evolve rapidly to reveal the actual extent of tissue injury, or may resolve without tissue loss. If necrotic tissue, subcutaneous tissue, granulation tissue, fascia, muscle or other underlying structures are visible, this indicates a full thickness pressure injury (Unstageable, Stage 3 or Stage 4). Do not use DTPI to describe vascular, traumatic, neuropathic, or dermatologic conditions.

Source: National Pressure Ulcer Advisory Panel (NPUAP) Pressure Injury Stages. The National Pressure Ulcer Advisory Panel – NPUAP. http://www.npuap.org/resources/educational-and-clinical-resources/npuap-pressure-injury-stages/. Accessed on September 20, 2017.

Table 2 – Examples of Signs and Symptoms of Peripheral Nerve Injury

Examples of Function Affected	Types of Nerves that Can Be Affected	Examples of Motor Symptoms	Examples of Daily Living Activities Affected	Examples of Sensory Symptoms	Typical Symptom
Localized area of the body where nerve is located (eg, outer shoulder, bottom of foot, arm, shoulder, side of hand, back of hand, leg)	Axillary Peroneal Brachial plexus Ulnar Radial Femoral	Arm abduction Arm Flexion and Extension Foot drop Lack of arm muscle control Limp or paralyzed arm Weakness in hand flexion Difficulty straightening elbow or fingers Wrist or finger drop Buckling knees or feeling of knee giving out	Difficulty lifting objects over head Varied walking pattern: (eg, dragging foot) Difficulty moving upper extremity Loss of coordination of upper extremity or fingers (eg, grasping items, holding hands, reaching) Difficulty going up and down stairs	Numbness Pain Tingling Burning Lack of sensation	Extremity Weakness

Adapted from Bouyer-Ferullo, S. Preventing Perioperative Peripheral Nerve Injuries. *AORN J.* 2013; 97:1:110- 124e1-9

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Quality Improvement

Advances in areas of surgery such as minimally invasive and robotic surgery can pose ever-evolving positioning risks that perioperative RNs and other team members must collaborate on to plan and troubleshoot prior to patient surgery and potential injury. New technologies and evidence-based approaches to safe positioning also continue to develop. New and existing approaches to safe positioning can be addressed through quality improvement activities engaged through an established collaborative process for daily positioning practices.[10] For example, checklists may be used as part of the health care organization's quality improvement program for patient positioning that can be combined with vigilant assessment, monitoring, and implementation of established safe practices when transporting, transferring, and positioning patients.[75] Monitoring specific variables (eg, supplemental padding) can be used to measure improvement.

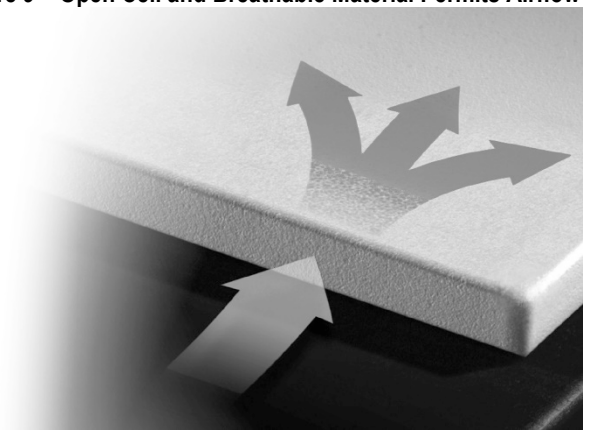
IDEAL CHARACTERISTICS OF A POSITIONING SYSTEM FOR HIGH-RISK PATIENTS, POSITIONS, AND SPECIFIC ANATOMICAL AREAS

A critically important aspect of safe positioning involves the use of standardized and established positioning devices designed for specific positioning uses. Such devices can provide the perioperative team with proven technologies designed for specific positioning needs. The following describes the characteristics a perioperative team should look for in providing safe positioning for all patients, including challenging patient populations, and for challenging positions to protect high-risk anatomical areas.

Use Open Cell and Breathable Material

To reduce skin injury, patients should be positioned on surfaces that are smooth and wrinkle-free, and manage any excess moisture (eg, patient sweat, drainage) to protect the skin.[77] For example, open cell and breathable material permits airflow and can absorb fluid and wick away sweat and body moisture (see Figure 9).

Figure 9 – Open Cell and Breathable Material Permits Airflow



The surface material of the OR table and it's relation to positioning materials should also be considered. Research conducted to assess the different effects of OR mattress cover materials (eg, vinyl, nylon material, foam or gel overlays) have identified different conclusions.[77-79] Standardized practices should be in place with the use of any positioning device or padding to ensure the patient's skin is protected from exposure to natural or chemical liquids. To reduce the risk for skin injury, members of the perioperative team should ensure that surgical prep solutions have dried before draping the patient and that no prep solution has pooled underneath the patient; they should also assess for patient sweating during the case and make adjustments to keep the skin dry.[74]

Prevent Hospital-Acquired Pressure Ulcers

Using patient positioning equipment correctly and without the addition of extra padding or materials beyond the scope of their correct use, can protect patients from developing pressure injuries to the skin and nerves. Each year in the United States, 60,000 patients die from hospital-acquired pressure ulcers.[46] While the incidence of peripheral nerve injury is low, with some research estimating less than 1% of general surgery cases,[81]

perioperative team members should still take precautions for safe positioning to protect patients from experiencing paresthesia, muscle weakness, tingling, or pain in the extremities.[27]

Reduce Shear and Friction

When a patient is in the prone position, there can be intense pressure on specific areas (eg, hips, elbows, forehead, chin); it is harder to redistribute pressure when there is not a broad surface area. These areas of intense pressure are at increased risk for shearing or friction when even slight shifts occur between the patient's skin and the positioning surface. Pressure and friction, skin shearing, and associated tissue damage can result from these unexpected or unwanted patient movements that can occur during surgery.[26,80]

The perioperative team should select positioning systems that reduce the risk of skin shearing. Ideal positioning systems are designed to properly manage the forces of friction and pressure. Designs may vary based on application and equipment configuration. In applications where high pressure on specific areas of the body increase the risk of friction-related tissue damage, positioning solutions can be implemented that transfer frictional forces away from the patient and on to surrounding surfaces. This effectively creates a bearing intended to reduce the impact of friction on the patient's skin in the event of movement. This concept is particularly important when the weight of a heavy patient is distributed over a relatively small surface area, thereby increasing localized pressure.

Perioperative nurses should strive to provide the same level of care for each patient by following the manufacturer's instruction for use, ensuring that supporting positioning systems fit the table properly, and evaluating the type of materials that are most appropriate to redistribute pressure and prevent slipping when moving the patient from the supine to the prone position. Consideration of materials is even more important when working with patients who have a high BMI. In such instances, options should be available for higher density materials to accommodate the varying demands of heavier patients and to prevent "bottoming out" during surgical procedures. Perioperative nurses should give attention to positioning devices that have the right material, are designed to properly fit the specified surgical tables/equipment, and remain focused on patient protection.

Reduce the Risk of Surgical Site Infections

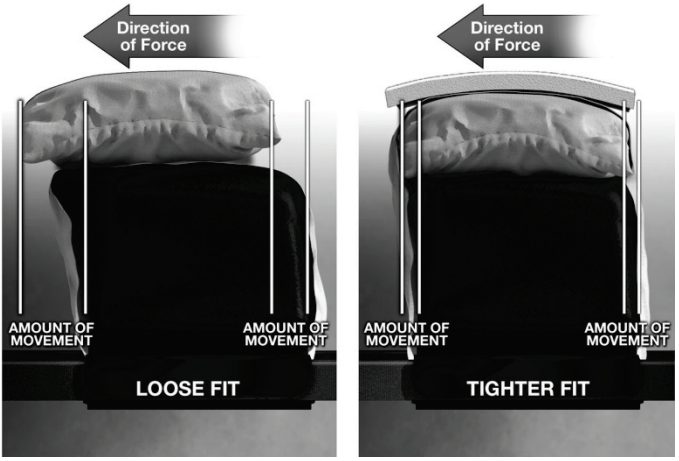
Using single-use positioning products each time can decrease cross-contamination because positioning equipment and devices used during patient care may harbor microorganisms that can contaminate the perioperative environment and pose a risk of infection for patients.[10]

Select Positioners and Covers That Fit the Table Properly

Positioning systems that fit properly prevent unnecessary skin irritation and can help to reduce the risk of pressure-related complications that arise from wrinkled surfaces, excess materials, and materials that were not designed with an emphasis on skin protection. For example, the focus of many OR table covers is infection control, table protection, and not necessarily skin integrity. The ideal positioning system can have a

primary focus on patient protection and, at the same time, address OR equipment concerns, such as those that have unique materials designed specifically for direct skin contact and that cover the table pads with a snug fit (see Figure 10).

Figure 10 – Proper Fit for a OR Table Cover



Ensure Foam Positioning Devices Consistently Expand Fully

Foam positioning devices should expand to their full capacity when unpackaged, ideally in a timely manner. Other desirable characteristics and properties include positioning products designed to decrease skin friction, which is beneficial to patients who are already compromised due to poor circulation and skin breakdown. Positioners should also stay soft to the touch for the duration of the procedure and be latex free and fire retardant.

POSITIVE OUTCOMES ASSOCIATED WITH PROPER POSITIONING

When a patient undergoes a surgical procedure, the risk of positioning injury can lead to significant harm or even death and this risk can only increase if the patient is elderly, pediatric, obese, has co-morbidities or has other intrinsic risk factors for positioning injury and also is undergoing a high-risk procedure.

Patient Outcomes

A review of patient injuries incurred as a result of positioning injury reinforces the importance of safe positioning. A patient undergoing robotic prostatectomy falls from an OR table and dies from his injuries because he was not properly secured.[30] A patient undergoing spinal fusion awakes with corneal abrasions that can lead to permanent visual loss.[14] These documented cases of positioning injuries underscore the important role perioperative RNs play in speaking up for the patient, raising concerns, and contributing to safety actions for safe positioning. These actions must include preoperative assessment, planning and communication through the patient's continuum of surgical care. For example, the preoperative briefing should be used for the

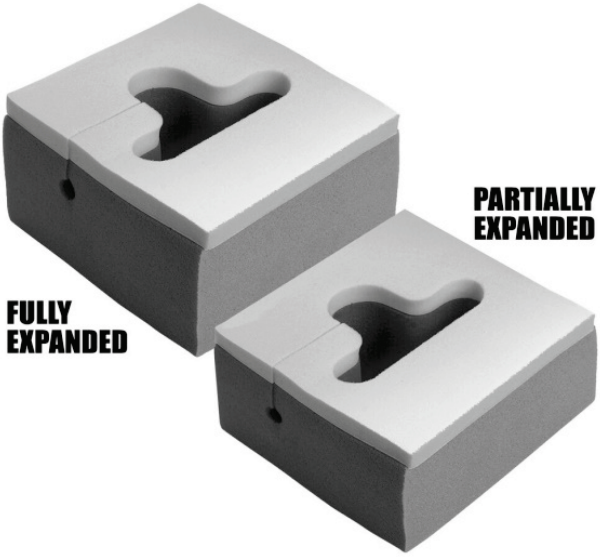
perioperative team to plan and discuss what interventions will be made to prevent positioning injury (eg, extra padding, repositioning)[82] to ensure positioning is successful so the patient can have the best chance for a positive surgical outcome.

Facility Outcomes

These safety actions also protect perioperative team members and the health care facility through reduced patient morbidity and mortality, as well as fewer malpractice lawsuits, potentially shorter hospital stays for patients, improved patient satisfaction, and reduced health care costs.[83] Consider that a pressure injury in a surgical patient adds approximately 44% to the cost of the surgical stay.[84]

Using standardized positioning practices and safe positioning systems that support ideal positioning for surgical procedures also supports efficiency by allowing the surgical team to efficiently plan, select, and apply positioning devices that are tailored for the procedure and OR table. Positioning systems that come in individual, single-use packs that easily and quickly expand to their full effective capacity can support greater efficiency in application for the surgical team (see Figure 11). Procedural delay is one extrinsic factor to pressure injury risk; therefore, team efficiency can also help reduce the need to extend procedural time if care is taken to properly position the patient from the start.

Figure 11 –Positioning Devices Should be Fully Expanded Before Patient Use



SUMMARY

Facing challenging positioning scenarios successfully is possible when perioperative RNs work with surgeons, anesthesia care providers and other members of the team to plan, assess, and communicate positioning actions. By accurately assessing a patient's complete intrinsic and extrinsic risk factors for a procedure, perioperative team members can choose a safe positioning approach and select a positioning support system that meets ideal characteristics supporting this approach and the patient's safety to achieve an optimal surgical outcome. Knowledge is key in this process. Through a clear understanding of the high-risk anatomical structures, patient risks and procedural risks that can combine to create a positioning injury, perioperative RNs can take the necessary actions to advocate for their patients, protect themselves from being part of a patient's injury and support their facility in efficient, cost-effective perioperative care.

GLOSSARY

Body Habitus	The physique or body type.
Braden Scale	A skin assessment tool that has six subscales to estimate sensory perception, skin moisture, activity, mobility, friction, shear, and nutritional status. Lower Braden Scale scores indicate a greater risk for pressure injury development.
Chemosis	Fluid buildup under the mucous membrane of the eyeball caused by increased jugular venous pressure from mechanical ventilation.
Extrinisic Risk Factors	External factors that can damage the skin, such as friction, shear or moisture.
Friction	The force of two surfaces rubbing against each other; it can denude the epidermis and increase the skin's susceptibility to higher stages of pressure ulcer formation.
Intrinsic Risk Factors	Physiologic factors or disease conditions that increase the risk for a pressure ulcer to develop such as a patient's age, nutritional status or decreased arteriolar blood pressure.
Lateral Position	When the patient is positioned on the nonoperative side
Modified Braden Q + P Scale	A skin assessment tool that is designed for pediatric patients; it identifies each individual source of pressure, surgical time, number and type of medical devices used intraoperatively, ASA physical status classification, and practice interventions.

Munro Scale	A skin assessment tool that assesses extrinsic risk factors (eg, friction, shear, moisture), as well as intrinsic risk factors (eg, as age, body mass index, nutritional status, mobility, ASA physical status classification, comorbidities). It also assesses risk factors specific to surgery, including type of anesthesia, patient position, length of surgery, and also assesses the patient throughout the pre-, intra-, and postoperative phases of perioperative care to establish a cumulative score.
Prone Position	When the patient is placed lying with the front or face downward.
Peripheral Neuropathy	Postoperative signs and symptoms related to peripheral nerve injury.
Positioning Device	Products made for immobilizing, positioning, and providing pressure redistribution during a surgical operation, which are proven effective and safe for patient use.
Pressure Injury (Pressure Ulcer)	Localized damage to the skin and underlying soft tissue usually over a bony prominence or related to a medical or other device; injury can present as intact skin or an open ulcer and may be painful. Pressure injury occurs from intense and/or prolonged pressure or pressure in combination with shear.
Redness	The flushing or "redness" appearance to skin caused by irritation, injury, moisture or pressure; also referred to as erythema.
Scott Triggers Tool	A skin assessment tool that considers patient triggers such as age of 62 years or older, albumin levels less than 3.5 grams (g)/deciliter (dL), ASA physical classification scores of III or greater, and surgery anticipated to last

	longer than three hours. Patients with two or more defined triggers are defined as high risk of pressure injury.
Shearing	The folding of underlying tissue when skeletal structures move, but the skin remains stationary.
Skin Impairment	Any alteration of the skin that was due to a direct result of the operation or procedure being performed, which can include a pressure ulcer, burn, blister, skin tear, abrasion or erythema.
Supine Position	When the patient's back is in contact with the OR table.
Trendelenburg Position	When the patient's feet are higher than the patient's head by 15° to 30°.

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