INTRODUCTION

Special attention to correct patient positioning is critical in preventing patient injury during a surgical procedure because a sedated or anesthetized patient is unable to reposition themselves when needed to relieve discomfort or alert team members of the need for repositioning.[1] Perioperative nurses play a critical role in managing positioning details and being alert for the possibility of injury at all times during and after the patient's procedure. Prone positioning can introduce unique challenges because the patient is in the supine position during induction and then is moved to the prone position once intubated and under general anesthesia. Safety considerations with prone positioning practices can include proper use of chest rolls, ensuring adequate padding under the patient's knees, and securing the patient's arms to arm boards.[1] If direct ocular pressure occurs, patients may experience prone positioning-related patient injuries, such as corneal abrasions and ocular damage. Patients may also experience respiratory compromise caused by compression of their abdomen, and may develop pressure injuries on their abdomen, breasts, genitalia, knees, or toes. Nerve and soft tissue injuries can occur secondary to pressure on the face, ears, chest, hips, or extremities (eg, thigh distal to the inguinal ligament, tips of the toes).[2]

Perioperative nurses follow evidence-based standards of care for positioning and should understand the characteristics of an ideal positioning system to reduce the risk of these positioning-related injuries. They should collaborate with other members of the surgical team when implementing the steps to position patients into the prone position and should individualize their care based on patient with special needs such (eg, neonates, geriatric patients, obese patients, patients with arthritis). Throughout the surgical procedure the perioperative nurse and other members of the perioperative team should assess the patient's circulatory, respiratory, integumentary, musculoskeletal, and neurological structures.[1,3] At the conclusion of surgery, the perioperative nurse should assess the patient for skin and musculoskeletal injury and document the results of the postoperative assessment in the transfer-of-care report to the postanesthesia care unit RN.[1]

Perioperative nurses advocate for patients when patients can't speak for themselves. Therefore, nurses play a critical role in safely positioning all surgical patients with consideration to their specific needs and in accordance with practice standards and instructions for use developed by manufacturers of positioning technologies and devices. Technological advances in positioning systems used in combination with correct positioning techniques can result in positive outcomes for surgical patients, perioperative personnel, and health care facilities.

In addition to correct positioning techniques, positioning systems are equally important for the perioperative nurse to understand and apply correctly for an ideal positioning approach, particularly in the prone position. An ideal positioning system used for 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,[4]

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.[5, 6]

Positioning systems designed for the prone position should also include two flat-bottom longitudinal chest supports, padding to support the knees and lower legs, and protectors to keep the feet in a flexed position with the toes pointing downward and elevated off the surface of the bed.[2] The ideal positioning system will be easy to use, provide optimal protection for the patient, and offer efficient application for perioperative personnel. The system should prevent positioning injury that 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).[7] 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.)[8] Pressure injuries that develop during a hospital admission may have long lasting ramifications for the patient and result in additional costs or reimbursement challenges for the health care facility.[7] Perioperative nurses should keep in mind that superficial reddening of the skin may be the first clinical sign of pressure injury development after surgery.[9] Intraoperative pressure injuries may have a purplish appearance in the area of a bony prominence, then progress outward with the actual pressure injury not being identified for 1 to 4 days after surgery.[10]

PHYSIOLOGICAL CHALLENGES ASSOCIATED WITH THE PRONE POSITION

Patients under general anesthesia lack the normal protective reflexes intended to protect them from positioning injuries,[11,12] that are frequently caused by compression or stretching. Compression reduces blood flow and disrupts cellular integrity, resulting in tissue edema, ischemia, and necrosis. Stretching leads to ischemic changes from reduced blood flow.[13] In general terms, positioning injuries can expose a patient to a variety of temporary or permanent injuries, including to a patient's skin and soft tissues, joints, ligaments and bones, eyes, nerves, and blood and lymph vessels.[11] The severity of a positioning injury can cause minor inconvenience, long-term functional restriction, secondary morbidity, or even death.[11,14] The prone position provides good exposure of the dorsal surface of the body. It allows access to the posterior head, neck, and spinal column.[15] The prone position is used for spinal procedures, including cervical, thoracic, and lumbar laminectomies and fusion, as well as parietal, occipital, and suboccipital craniotomies.[2] However, several extrinsic factors associated with prone positioning can pose challenges for the perioperative team to ensure patient safety.

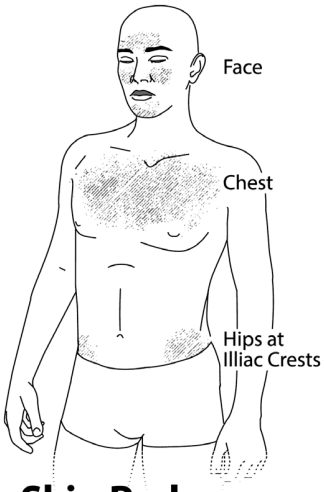
Maintaining Skin Integrity

Abnormal amounts of pressure on small areas of the body's surface can result in poor tissue perfusion with ischemia, tissue breakdown, and development of pressure injuries.[1]

Pressure is defined according to intensity and duration. Muscle is more sensitive to pressure than skin; therefore, the underlying tissue may become necrotic before a lesion presents on the skin surface.[17] Friction can occur if the surface of the skin is pulled against a rough surface.[4] 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.[17] A patient's skin may be more susceptible to damage from pressure and friction as a result of the skin prep or when an intraoperative surgical preparation solution (eg parachoroxylenol, chlorhexidine gluconate, povidone-iodine, isopropyl alcohol)[18] is not used in accordance with the manufacturer's instructions for use. If positioning devices or other materials used to position the prone patient do not allow for appropriate wicking of natural moisture in the skin or if the positioning device or other material that is in direct contact with the patient skin does not have a protective covering that repels absorption of the skin prep solution,[19] the prep solution can change the pH of the skin and remove protective oils.[17] In addition, prep solutions can pool beneath the patient and increase the risk of maceration, blistering, and development of a pressure injury. Areas of redness can appear from either moisture or pressure particularly on the face, chest, hips, and knees[19] (Figure 1). Other extrinsic factors that can increase the risk of skin injury for the prone surgical patient 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.[19-21]

Figure 1 – Areas of Redness that Can Appear on Patient's Skin from Prone Position



Pressure Points

Placing the patient in the prone position and administering anesthesia both can put the patient in a compromised state. As a result of patient positioning, the patient's skin can be at an increased risk of tissue damage when the patient's body weight is not distributed evenly on the OR bed or if poor tissue perfusion is present. Administering anesthesia blocks a patient's sensitivity to pain and pressure and causes vasodilatation that is reflected in a decrease of blood pressure that can lead to decreased tissue perfusion.[17]

Peripheral nerve injury is also a concern in body surface areas where direct pressure is placed on susceptible peripheral nerves during a surgical procedure.[22] Areas of the body that are of particular concern for abnormal pressure during prone positioning include: forehead, eyes, nose, ears, abdomen, thorax, arms, knees, feet, and toes.[1]

Ocular Pressure

In the prone position, the patient's face is in a downward position, which causes concern for potential ocular pressure. Direct pressure on the eyes can cause central retinal artery occlusion that can lead to temporary or permanent blindness.[4]

Ear Pressure

A patient's ears can also be damaged if forced into a bent position when the head is turned to the side in the prone position.[23-25]

Abdominal Pressure

Because intubation and induction occur when the patient is in the supine position, the patient must be moved with care into the prone position and the caregivers should be sure the abdomen is not compressed, vascular congestion is minimal, and

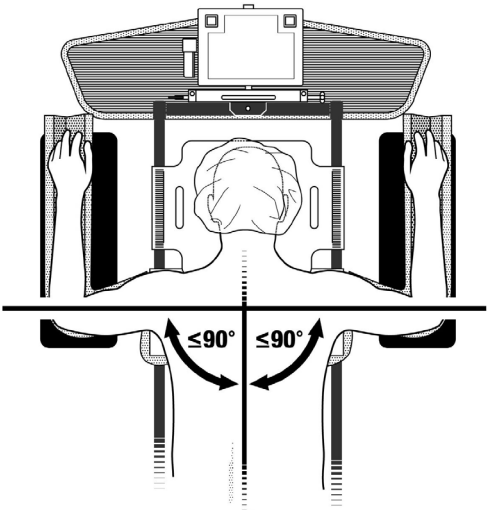
maximum expansion of the diaphragm and lungs are allowed during ventilation.[26] Pressure ulcer development on the chest and iliac crests is a concern. The lateral femoral cutaneous nerve is also vulnerable to injury from compression on the thigh distal to the inguinal ligament.[15] In addition, the breasts of female patients must be positioned to avoid significant compression, and male patients' genitalia must be adjusted to prevent compression.

Pressure on Bony Prominence

Knee pain is a risk if the knees are not flexed and supported correctly. Inguinal nerve injury is a risk because of excessive hip flexion.[15,26] Pressure on the tips of the toes should be avoided to reduce the incidence of pressure ulcers and peripheral nerve injury leading to foot drop. The patient's arms, elbows, and hands are also at risk of pressure ulcers and radial nerve injury is possible if correct padding and positioning are not applied (Figure 2).

The brachial plexus is at risk for stretching when the patient's arms are placed on arm boards. Caregivers must be careful to ensure elbows are flexed, palms are facing downward,[15] and the arms rest slightly lower than the level of the chest before placing pads under the hands and elbows.[27,28]

Figure 2 – Correct Positioning for Arm Abduction is Less than 90 Degrees



Prolonged Exposure

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.[4,29] Prone positioning is identified as a

significant predictor of pressure injury.[9] Assessment of pressure points, skin integrity, and circulatory, respiratory, musculoskeletal, and neurological structures is particularly important throughout the procedure during prolonged cases.[30,31]

Surgical duration is an important factor for the perioperative nurse to consider in planning the positioning approach, particularly as new technologies pave the way for procedures that last 10 to 12 hours or more without the patient being repositioned or moved. For example, in neurosurgery the length of complicated spinal procedures and the inability to move the patient can lead to excessive pressures related to prone positioning.[19]

Although extended duration of the procedure is a recognized risk factor for prone positioning, it is important for the perioperative team to recognize that 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.[26] 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.[17]

Every surgical patient should be considered at risk for a positioning injury and this is particularly true for prone patients. Perioperative team members are required to provide appropriate positioning interventions for all surgical patients. Failing to do so may be deemed negligence or a failure to meet the duty of care owed to the patient.[26] In legal terms, when there is a positioning injury, the doctrine of res ipsa loquitur (ie, the thing speaks for itself) may be applicable[17]; meaning there is an assumption that the event that caused the injury was under the control of the defendant (eg, surgeon, anesthesia professional, perioperative RN) and would not have occurred if proper care had been provided to the plaintiff (ie, patient).[17] The potential for litigation related to patient harm increases stress for surgical team members and health care administrators and strengthens the need for vigilance, assessment, tailored care, and team collaboration to prevent prone positioning injury.

PATIENT ASSESSMENT CONSIDERATIONS FOR PRONE POSITIONING

The previously discussed extrinsic challenges influencing safe prone positioning are essential for perioperative nurses and other surgical team members to address for patient safety. However, intrinsic patient positioning factors are equally important for perioperative nurses to assess, discuss, and document as part of safe prone positioning. These intrinsic patient factors can include:[17]

- 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.

These characteristics unique to each patient can require special attention to prevent harm caused by positioning. For example, in certain cases older adults are at increased risk for pressure ulcer in the prone position due to decreased skin elasticity, less subcutaneous tissue, dry skin, chronic illness, malnutrition and decreased vascular sufficiency[32] that can delay wound healing. This diminished skin integrity, may initially be seen as skin redness and when combined with changes in the musculoskeletal system (eg, loss of muscle mass, degenerative joint changes) can increase the risk of pressure ulcers and thrombus formation.[33] In another example, a patient with limited cardiovascular reserve could be at increased risk of cardiovascular compromise or collapse because of hemodynamic changes (eg, reduced cardiac output and cardiac index, increased systemic vascular resistance)[34] associated with the prone position.[34-37] Obese patients may have more pronounced hemodynamic changes when increased thoracic and intra-abdominal pressure is introduced with prone positioning, particularly if the patient has truncal obesity, or when the prone positioning is modified to improve surgical access.[35] In addition to older adults and obese patients, other special needs patient populations that can require specific positioning considerations include neonates and patients with arthritis.[1] Furthermore, preexisting patient attributes including body habitus, preexisting neurologic symptoms, diabetes, peripheral vascular disease, alcohol dependence, and arthritis may predispose a patient to peripheral nerve injury.[22]

Assessing for Risk

For all patients, as previously discussed, the most prominent anatomical considerations relating to prone surgeries can lead to pressure ulcer formation and nerve damage. The specific anatomical areas affected by these injuries are outlined in Table 1. Perioperative nurses, along with anesthesia professionals and other members of the surgical team must be acutely aware of these risk areas and make efforts to prevent injury.

Table 1 – Anatomical Considerations Related to Pressure Ulcer Formation and Nerve Damage

Pressure Ulcer Formation	Nerve Damage
Orbital (eye socket) Ears Nose Elbows Iliac crests (hips) Knees Breasts Toes	Axillary (shoulder, neck) Brachial plexus (shoulder, neck) Radial (upper arm) Ulnar (elbow) Popliteal (leg, back) Long thoracic (shoulder, neck, arms)

Indications Related to Skin Injury[38]

As part the comprehensive perioperative patient assessment for pressure injury, care givers should evaluate the patient's skin condition and note the:

- color,
- turgor,
- integrity,
- temperature, and
- preexisting damage.

Comorbidities affecting tissue perfusion that should be noted as factors increasing the risk of prone positioning skin injury include diabetes and peripheral vascular disease. Related conditions that can also be influencing factors in diminished skin integrity include peripheral pulses, body mass index (BMI), and nutritional status.

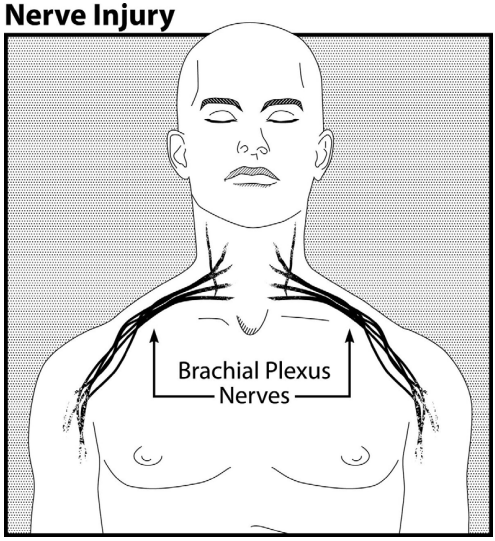
Indications and Predictive Factors Related to Nerve Injury[22]

Peripheral neuropathies occurring in patients with specific preexisting conditions (eg, diabetes mellitus, vascular disease) and extremes in body weight and age can be predictive factors for positioning nerve injuries. Surgical positions can also increase the risk of perioperative peripheral neuropathies as described below.

- Brachial plexus neuropathy may be caused by arm abduction for the prone patient with arm abduction greater than 90 degrees as shown in Figure 2. Figure 3 illustrates anatomical structures related to the brachial plexus.
- 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 degrees 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 3 – Anatomical Structures Related to the Brachial Plexus



Patient assessment for physical predictors and indications of injury at key points before, during, and immediately after surgery[39] can benefit the patient in avoiding or lessening undue injury to the patient's skin, nerves, and other anatomic structures and can support perioperative team members in ensuring every step is taken to assess and manage positioning needs.

Preoperative Assessment

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.[40]
- 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.[41,42]
- 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.[43]

Intraoperative Assessment

Monitoring the patient throughout the surgery should include continuous monitoring of changes in ocular pressure to prevent direct pressure. Ocular complications associated with the prone position include increased intraocular pressure, decreased tissue perfusion, conjunctival edema, hemorrhage, and chemosis that can lead to postoperative vision loss.[44]

Skin color change, swelling and redness should also be documented to indicate increased risk of skin breakdown.[1] 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.[45]

In the prone position, gravity causes an accumulation of extravascular fluid in any dependent body part, including the hands, feet, face, and conjunctiva. This transient edema can also impact the nose, oropharynx, salivary glands, and tongue.[15] Injury can also occur if the patient shifts from positioning devices during surgery. For example, transient ulnar nerve palsy attributed to an unrecognized shift in the arm board could occur during the procedure, particularly when the patient is extremely obese and the procedure time goes beyond 10 hours.

Compartment syndrome of the right anterior thigh compartment syndrome can occur after five hours[46] and right lower leg compartment syndrome with acute renal failure can occur after six hours[47] in the prone or knee-chest position. A fall in the patient's core temperature after induction of anesthesia can lead to a peripheral vasoconstriction, which can result in peripheral hypo-perfusion and cell hypoxia.[15] Neurophysiological monitoring during the procedure can be used to detect changes in the electrophysiological conduction of peripheral nerves and central nervous system pathways that may signal nervous system damage.[48]

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.[19] Results of this postoperative assessment should be included in the transfer-of-care report to the postanesthesia care nurse.[1]

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.[45] Table 2 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.[22] The signs and symptoms of perioperative peripheral nerve injury are described in Table 3.

Table 2 – 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 (ie, 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 January 12, 2017.

Table 3 – 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.

Sources:
The Foundation for Peripheral Neuropathy. Symptoms of peripheral neuropathy. https://www.foundationforpn.org/what-is-peripheral-neuropathy/symptoms/. Accessed November 17, 2017.
National Institute of Neurological Disorders and Stroke (NINDS). Peripheral neuropathy fact sheet. http://www.ninds.nih.gov/disorders/peripheralneuropathy/detail_peripheralneuropathy.htm. Accessed November 20, 2017.

SAFETY CONSIDERATIONS RELATED TO PRONE POSITIONING

Positioning and repositioning patients and equipment during perioperative care can result in patient injury.[50]

Appropriate Positioning Equipment and Accessories

Positioning devices should also be used according to intended use. Bath blankets, sheets, and towels should not be used to pad or protect a patient because these may cause more pressure.[19] Furthermore, if items are not designed for positioning, there is no assurance that pressure is being redistributed correctly.[51]

Repositioning

Certain patient populations presenting with unique challenges may require special positioning considerations to protect the patient's anatomical structures, including his orher skin.[14] Despite correct positioning prior to the procedure, patient movement during the procedure may require repositioning as described in the following case study.[52]

Case Study: The Morbidly Obese Prone Patient

Ms J was scheduled for a posterior lumbar decompression and fusion. Ms J is a morbidly obese, diabetic patient who is 5 ft 6 inches tall, weighs 253 lbs, and has a history of smoking. Her size presented some concern about how surgical team members would position her prone on the spinal surgery and imaging table. Her diabetes and history of smoking indicated she is a higher risk for poor circulation, especially in her extremities, and her skin may be especially susceptible to shearing.

After the anesthesia care professional completed intubation and placed venous and arterial lines, the RN circulator inserted the indwelling urinary catheter and applied antiembolism stockings and a sequential compression device. The patient was turned using the log roll method. Her head was placed face down on a medical grade memory foam prone pillow to protect pressure on her forehead and chin. The anesthesia care provider lubricated and closed Ms J's eyes and secured eye pads on top for protection.

The RN circulator and anesthesia care professional worked cooperatively to properly align Ms J's arms on the arm boards—her shoulders were not posteriorly or superiorly extended, her elbows were at a 90-degree angle, and her hands were pronated to prevent brachial nerve damage. Her arms were placed on padding to protect the pressure points of the elbows and wrists.

Two longitudinal chest supports to protect the patient's chest pressure points were adjusted so that the top of the chest support was at the patient's suprasternal notch. The RN circulator and surgeon ensured that the load of the patient's chest was mainly on the superior aspect of the chest to facilitate ventilation. They also placed her breasts medial and cephalad for better toleration and assessed to be sure pressure was minimized.

The RN circulator placed hip pads under the patient's iliac crest to prevent hyperextension of her lower back. The thigh pads were adjusted under the patient's thighs and up against the hip pads for lower body support. The patient's legs were placed on pillows to bend her knees slightly to prevent peroneal and popliteal nerve damage. Padding was placed under the patient's feet to protect pressure points. The RN circulator placed a safety strap padded with a blanket snugly around the patient's thighs. The RN circulator then prepped the patient, after which the scrub person and surgeon draped the patient, and the procedure began.

In the exposure phase of the procedure, the anesthesia care provider stated that he was no longer satisfied with the patient's position. The RN circulator noticed that Ms J's position was no longer optimum; her neck was hyperextended, and lordosis was very pronounced. The surgical team members were able to visualize the patient's entire body again and could see that the hip and thigh pads had shifted.

Adapted from: Macapagal, ML. Protect your patient – it is never too late to reposition. *AORN J.* 2004;79:5:1017-1018. DOI: 10.1016/S0001-2092(06)60733-3.

Surface Integrity

Failures in surface integrity can contribute to bacterial growth and patient skin breakdown. Use of defective or obsolete equipment and devices can introduce a risk of injury to patients and personnel.[4] Also, patients may experience skin irritation and severe skin reactions may occur when wet, unevaporated solution comes in prolonged contact with the skin. This may occur following preoperative preparation of a patient if the skin prep solution "pools" beneath the patient, in intertriginous creases, or around the drapes during the surgical procedure. A chemical contact dermatitis may result from a combination of the chemical, heat, and pressure. Factors that can aggravate this skin prep pooling include:[53]

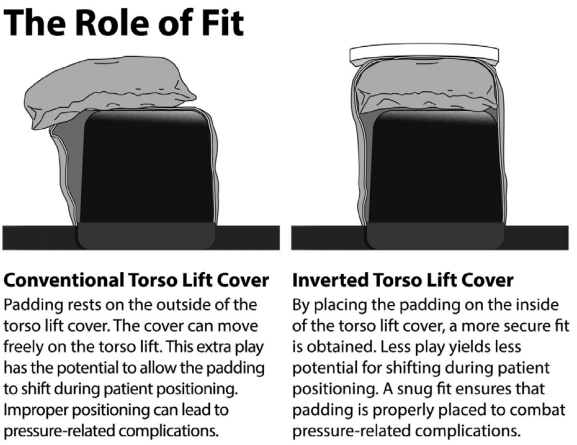
- not tucking disposable, absorbent pads beneath the patient to absorb excess solution;
- supersaturating the skin prep solution applicator causing excess solution to run off the area bring prepped;
- not removing the absorbent pads prior to draping the patient; and
- not following manufacturer's instructions for proper topical application of the skin prep solution to the skin/mucous membranes.

CHARACTERISTICS OF AN IDEAL POSITIONING SYSTEM FOR SPINAL PROCEDURES

Perioperative nurses and other surgical team members should establish standardized practices to ensure that all patients are correctly positioned and that all staff members use positioning devices correctly[1] (ie, only for their intended use)[4] and select devices that are designed to protect the skin based on evidence-based and proven best practices during the intraoperative period.[19] When a standardized positioning system is implemented, it can support optimal positioning of the prone surgical patient for spinal procedures.

Part of optimizing patient positioning includes selecting 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 spinal table pads with a snug fit (see Figure 4).

Figure 4 – Proper Fit for Table Cover



Another aspect of optimizing patient positioning is to ensure foam positioning devices consistently expand to their full capacity when unpackaged, ideally in a timely manner. Other desirable characteristics and properties of spinal/prone positioners 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 spinal procedure and be latex free and fire retardant.

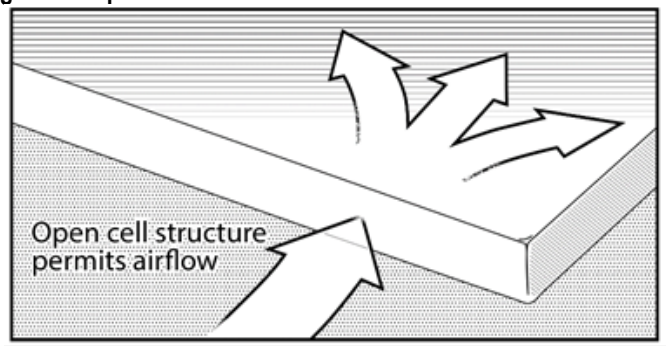
Four priority areas can be used to summarize the characteristics of an ideal positioning system:

- reduce skin injury with surface materials that are open cell and breathable,
- reduce shear and friction,
- prevent hospital-acquired pressure ulcers, and
- reduce the risk of surgical site infections.

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.[23] For example, open cell and breathable material permits airflow and can absorb fluid and wick away sweat and body moisture (see Figure 5).

Figure 5 – 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.[54-56] 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.[19]

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.[57,58]

The perioperative team should make an effort to 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, which is a common concern, for example, in spinal procedures.

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.

Preventing 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.[17] While the incidence of peripheral nerve injury is low, with some research estimating less than 1% of general surgery cases,[59] perioperative team members should still take precautions for safe positioning to protect patients from experiencing paresthesia, muscle weakness, tingling, or pain in the extremities.[22]

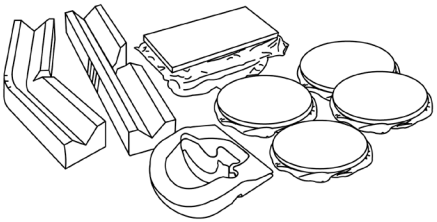
Reducing the Risk of Surgical Site Infections

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.[4] Single-use supportive devices can also reduce the risk for worn supportive devices that can have decreased efficacy.

Supporting Efficiency

Safe positioning systems that support ideal prone positioning for surgical procedures allow 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 6). 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 6 – Example of Components Available in Single-Use Packs



Pre-Configured Kits

Positioning kits that have been pre-configured for your specific table can save valuable O.R. time in set-up.

Preventing Financial Implications

In addition to protecting patients from complications associated with skin events for prone spinal surgery and increasing staff efficiency, perioperative teams who implement safe positioning can also support the financial health of a care facility because financial penalties can be incurred if positioning injuries occur.[7,19] For example, the Centers for Medicare & Medicaid Services do not reimburse the cost of treatment for Stage III or Stage IV pressure ulcers. It is estimated that the cost per patient for a hospital-acquired pressure ulcer is $43,180.[60] Even if pressure ulcers were the only type of skin events decreased, this would save thousands of dollars a year for the hospital.[19]

SUMMARY

Perioperative team members and health care administrators are more likely to have confidence that they are effectively reducing the risk for a positioning injury when they can implement a positioning system with characteristics that support ideal positioning safety, especially for prolonged duration procedures in the prone position. To avoid having a positioning injury that distracts from an otherwise positive surgical outcome, all members of the surgical team must take the unique extrinsic and intrinsic factors of the surgical patient and procedure into consideration and collaborate to select and implement an ideal positioning system according to manufacturer instructions for use. As part of their preoperative evaluation, the perioperative nurse and surgical team members should plan the safe use of the positioning equipment and identify the devices necessary to perform the procedure.[4]

The risk for positioning injuries is more likely to be reduced when the ideal positioning system is in place and applied in the correct way through collaborative efforts of the surgical team. Each team member should be educated about the extrinsic and intrinsic factors that can predict increased risk to a patient's anatomical structures and then lead to the potential for a positioning injury. Education should also extend to standardized practices for assessment and monitoring of patient injury throughout the pre-, intra- and postoperative period, including the days after surgery when the effects of positioning injury are identified. Education should also include strategies for overcoming the

challenges associated with the prone position that may include incorrect fit between positioning devices, overextension of patient limbs beyond natural preoperative limits, and a lack of attention to intraoperative risks such as chemical burns caused by pooling skin prep solutions. Prone positioning for spinal procedures can provide critical access for the surgeon to treat patients. With correct positioning support, prone spinal procedures can end in optimal patient outcomes that also support perioperative team members and their health care organizations.

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.
Extrinsic 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.
Maceration	The softening and breaking down of skin, resulting from prolonged exposure to moisture.
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.
Obese	A patient with a body mass index of 30 or more.
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.
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.

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