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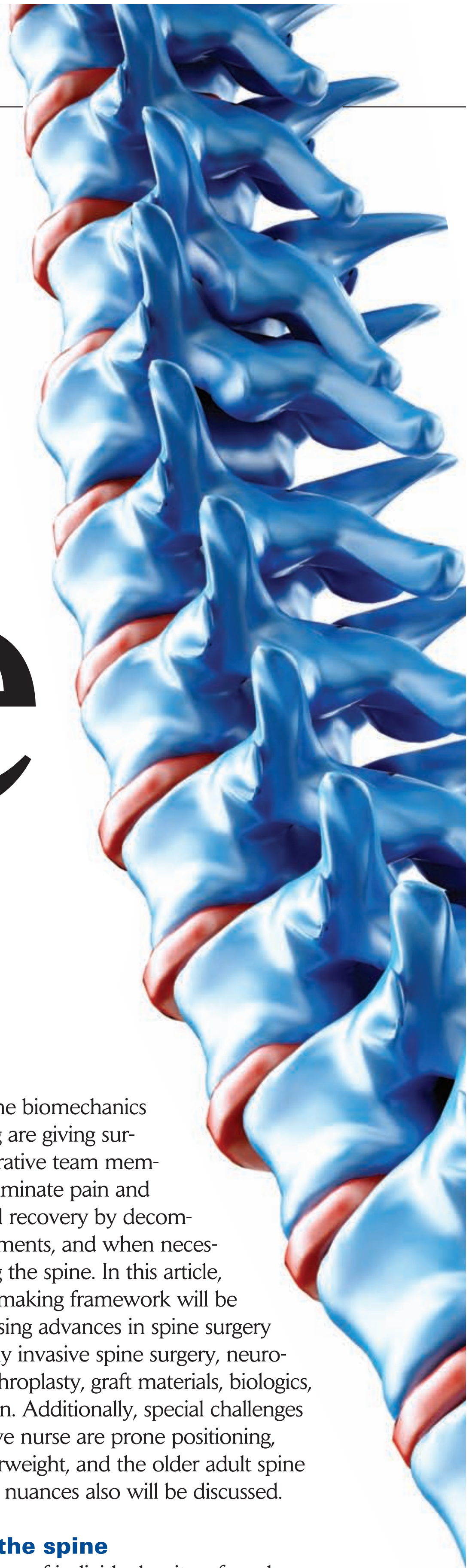
Advances in spine



New technology and special populations require ongoing education.

By Andrea L. Strayer, MS, ANP-BC, GNP-BC, CNRN, and Gregory R. Trost, MD, FAANS

Back and neck pain are common and costly. An average of 27.5% of all American adults over the age of 18 have experienced low back pain and 13.9% had neck pain 3 months prior, according to a 2012 national health survey.[1]

In 2010, the primary reason for more than 31.5 million office visits was spinal disorders. Only hypertension, arthropathies, and acute upper respiratory infection diagnoses had more adult office visits.[2]

Surgery for back pain has skyrocketed, along with the rate of hospital stays for spinal fusion increasing 115% from an estimated 202,000 fusions in 1997 to 492,000 in 2010.[3]

Amidst the marked increase in spinal fusions, 2007 medical spending to treat back pain totaled $30.3 billion and $4.5 billion was spent on prescription medications for back pain treatment.[4] Globally, low back pain causes more disability than any other condition.[5] The statistics are staggering. How can the perioperative nurse positively impact this patient population?

Advances in spine biomechanics and bioengineering are giving surgeons and perioperative team members the tools to eliminate pain and optimize functional recovery by decompressing neural elements, and when necessary, reconstructing the spine. In this article, a surgical decision-making framework will be the basis for discussing advances in spine surgery including: minimally invasive spine surgery, neuronavigation, disk arthroplasty, graft materials, biologics, and instrumentation. Additionally, special challenges for the perioperative nurse are prone positioning, trauma, obese/overweight, and the older adult spine patient. These care nuances also will be discussed.

Structures of the spine

The spine is made up of individual units referred to as motion segments. The motion segments (two vertebral bodies and the disk between them) are "stacked" one on another, forming the spinal column.

surgery

Supported by muscles and ligaments, the spine is central to the capabilities of coordinated motion and strength while protecting the spinal cord and spinal nervous system.

Whether the patient has suffered acute trauma or progressive degenerative changes, the surgical decision making is framed by the overall goals and a patient's specific clinical picture.

For instance, a patient who has spinal cord injury from bony compression from a cervical fracture—surgical goals are: decompression of the spinal cord; stabilization of the fracture site; providing structural support to avoid future deformity; and increasing the patient's chance of the best optimal pain relief with functional recovery. (See *Goals of spine surgery*.)

Alternatively, the surgical goal is to decompress the spinal nerve in an outpatient with 6 weeks of leg pain (radiculopathy) from a herniated lumbar disk compressing a lumbar nerve. After a small keyhole is made in the lamina, the disk material can be visualized and removed to relieve pressure from the nerve.

For the older adult patient with a degenerative lumbar spinal stenosis and spondylolisthesis causing compression on the lumbar and sacral spinal nerves, bony decompression may leave the spine unable to withstand forces placed on it, and the surgeon may recommend internal stabilization with a pedicle screw and rod construct with local harvest autograft to create a fusion.

Minimally invasive spine surgery

Minimally invasive spine surgery (MISS), sometimes referred to as minimal access spine surgery, has steadily gained in its utilization. Development of minimal access technologies began with the use of an endoscope and retractor system for removal of herniated lumbar disks. Smith and Fessler describe the guiding principles of MISS as avoiding self-retaining retractors, preserving midline muscles and tendons, and minimizing soft tissue injury.[6] They describe the traditional open approach as requiring extensive soft tissue exposure and the detachment of posterior muscle tendons leading to pain and muscular atrophy. In contrast, the MISS approach aims directly for the part of the spine that needs surgery.

The surgeon must have a keen anatomic understanding, as open "3D" visualization is lost, and operative landmarks are visualized through small access channels. Complication management can be challenging and may necessitate conversion to an open procedure. Additionally, MISS relies on specialized technical equipment and a surgical team that understands the equipment as well as the surgeon. Special training is necessary to successfully perform MISS.

A review of the literature was conducted by Payer who found that while MISS has been the focus of many spine centers and surgeons, minimizing "access" may have its benefits and reduce morbidity of open "access." MISS also has its downsides. Payer concluded that literature comparing MISS and standard open surgery doesn't clearly demonstrate that MISS is more beneficial than open procedures. Additionally, the procedures are very dependent on technologic equipment that may be more costly in terms of patient safety and price.[7]

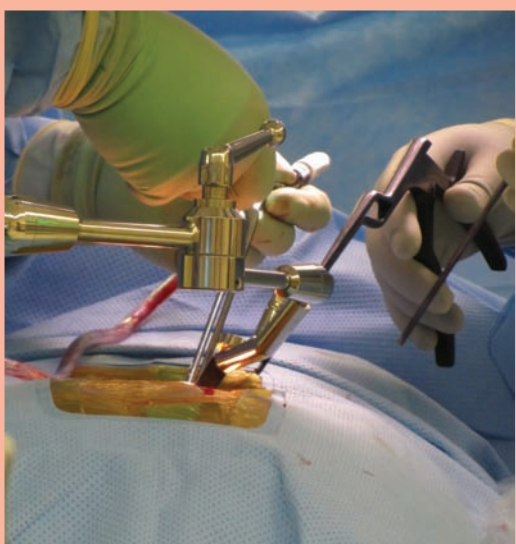
The tubular retractor system has evolved, allowing surgery for lumbar fusions for degenerative spondylolisthesis, degenerative disk disease, short segment deformity correction, and traumatic thoracolumbar fractures.[8] (See *Tubular retractors.*)

Over the past 2 decades, minimal access approaches have also expanded to include: resection of spinal cord tumors, long segment instrumentation, and tethered cord release.

Novel devices and approaches to be able to address expanding roles for MISS are being developed on a continual basis. For instance, the direct lateral minimal access approach for placement of lumbar artificial disks is currently under clinical trials in the United States. Researchers predict increased popularity of lumbar artificial disks via this approach due to reduced risk of arterial injury, as well as neural element and genitourinary tract injury.[8]

The Association of periOperative Registered Nurses (AORN), Perioperative Standards and Recommended Practices for Inpatient and Ambulatory Setting addresses several recommendations regarding minimally invasive surgery (MIS).[9] Applicable to spine surgery, include a multidisciplinary team planning OR remodeling to accommodate for MIS technology and assure adequate safety considerations. Also noted in the AORN recommended practice is that personnel should take extra precautions with electrosurgery devices during minimally invasive surgery. Please refer to the AORN standards for complete practice recommendations.

Tubular retractors



Source: Photo courtesy of Andrea Strayer.

Goals of spine surgery

The overall goals of any spine surgery are:
(1) decompression of the spinal cord and spinal nerves (neural elements)
(2) stabilization of the spine
(3) correction of deformity to provide an environment that is biomechanically sound so that spinal deformity will not develop over time
(4) pain relief and optimization of functional outcome.[29]

Graft materials, biologics, and instrumentation

There is an endless variety of implants, graft options, and biologic materials for which the perioperative nurse should familiarize him- or herself. Options for graft material include: autograft, allograft, ceramics, and adjuvants such as bone morphogenic protein (BMP) and stem cells.

- Autograft, the patient's own bone, can be locally harvested, for instance, bone removed for a laminectomy prior to fusion, or harvested from iliac crest (anterior or posterior), or rib.
- Allograft is cadaver bone from a tissue bank. Typical examples include patella, fibula, and femur.
- Machined allograft is cadaver bone manufactured into specific shapes and sizes, designed to fit using specific tools for insertion.
- Other options include ceramics, or synthetic bone that's made from calcium materials and manufactured to be a similar consistency to autograft. Bone marrow harvest of stem cells utilized in conjunction with another graft material is thought to possibly speed the fusion process.

In the anterior spine, grafts are a scaffold or bridge between the vertebral bodies. The span a graft fills can be short, as with an anterior cervical discectomy and fusion, or long as with a thoracic corpectomy.

Posterior spine surgery uses graft material such as local harvest autograft to encourage spinal fusion over the posterior elements. Posterior fusion with graft materials is used with and without instrumentation.

The ultimate objective is for the vertebral body above and below the graft material to sprout microvasculature, growing into the graft material so that bone remodeling can slowly occur. Bone growth into the graft material will be replaced and eventually lead to a strong bony fusion.

BMP has powerful bone growth-stimulating qualities. In the spine, it's FDA approved for anterior lumbar interbody fusion; however, it's been used by surgeons in many other spine procedures. The ideal dose and use continues to be debated.

A variety of interbody devices, screws, plates, rods, hooks, and wires are manufactured in a multitude of sizes. With ongoing advances in bioengineering and appreciation for spine biomechanics, "new and improved" versions are regularly introduced.

Organized by the manufacturer, each device has its own specifications and many have accompanying instruments. Sets are organized by the portion of the spine in which they are used. Thus, there are anterior cervical plating sets, posterior cervical instrument sets, posterior thoracic, and the like.

Teaching surgical team members about the set components outside the OR setting helps promote their seamless handling of the components during surgery. Additionally, communication with the surgeon and anticipating the needs for each patient's surgery will help decrease operative time, enhancing patient safety.[28]

Neuronavigation

As spinal surgery navigation evolves, so does surgical accuracy and thus patient safety. Intraoperative navigation 2D, C-arm fluoroscopy is widely used. Newer emerging options include 3D-fluoroscopy cone-beam CT, and intraoperative CT/MRI imaging. Developing navigation technology continues to reduce radiation exposure to OR personnel, while reportedly improving accuracy of surgical instrumentation. Neuronavigation is utilized in both open and minimally invasive spine surgeries. Future directions involve the coupling of neuronavigation with minimally invasive spine surgery to allow better surgical accuracy and further decrease radiation exposure.[10] While navigation systems can increase operative time there is a risk of operative field contamination during equipment draping/undraping and placement; and there is an associated learning curve for members of the perioperative team. Education is just as important for the operative nursing staff as it is for the surgeon. Additional considerations include physical space needs of the equipment and maneuvering of the equipment in the operative suite. Continuing support and contacts for problem-solving equipment questions is vital. Anticipation of all possible scenarios to prevent intraoperative delays is beneficial.

Preserving motion with disk arthroplasty

Disk arthroplasty, also referred to as "artificial disk or disk replacement" is a mobile device taking the place of a patient's degenerated disk. The patient who has surgery for a degenerated cervical disk has nerve compression (radiculopathy) and/or spinal cord compression (myelopathy) that can lead to pain, numbness/tingling, and weakness. Developed to preserve normal spinal motion, the first cervical disk arthroplasty (CDA) was approved in the United States by the FDA in 2007. Currently, there are four CDAs that are FDA approved, with others under investigation. Epidemiologic research found that between 2008 and 2010 the growth rate of CDA was twice that of anterior cervical discectomy and fusion (ACDF). However, there was still 50-fold more ACDFs performed than CDAs.[11]

Compared with an ACDF, patients who received the CDA reported less arm and neck pain, better neck-related functional status, and better global health. Although these results seem to favor disk arthroplasty, the Cochrane Review authors described these results as not clinically relevant comparing the differences between the arthroplasty and fusion groups at 2 years. Both are valid treatments, with good results at 2 years. Long-term results are pending.[12]

Currently, there are two FDA-approved lumbar disk replacements with two in the investigational stage. Cochrane Review of the available literature noted that while patients reported higher satisfaction with lumbar disk replacement, clinical improvement was essentially equal between lumbar fusion and lumbar disk replacement surgery. The range of motion with the disk replacement was comparable to patient baseline measures. However, after lumbar fusion there was loss of nearly all motion at the surgery level. Revision surgery in case of device failure or complications is possible, but with variable outcomes and risk of vascular complications.[13]

Perioperative vision loss associated with spine surgery

A rare devastating complication, postoperative vision loss after spinal fusion is most commonly caused by ischemic optic neuropathy (ION). Vision loss ranges from blurred vision to blindness. The complication can occur in healthy patients of all ages with an estimated incidence of 0.017% to 0.1%.[23]

The Postoperative Visual Loss Study Group compared detailed data from 80 patients with ION from the American Society of Anesthesiologist Postoperative Visual Loss Registry with 315 adult control subjects without ION after spinal fusion surgery. The control subjects were randomly selected from 17 institutions. Data regarding preexisting medical conditions and perioperative factors were compared to assess for factors that might predict ION.

Risk factors were Wilson frame use, obesity, male sex, longer duration of anesthesia, greater estimated blood loss, and decreased percent of colloid (for example albumin) administration as compared to crystalloid (for example 0.9% sodium chloride I.V. fluids).

These risk factors were significantly and independently associated with ION after spinal fusion surgery. Factors not statistically associated ION included: type of headrest, number of levels fused, indication for surgery, age, American Society of Anesthesiologists (ASA) Physical Status Classification System score, or other preexisting medical conditions.

At present, the only measures that can be modified in an effort to prevent perioperative visual loss after spinal fusion surgery is surgical frame selection. Namely, avoiding use of the Wilson frame; team effort to expedite time under anesthesia; and being cognizant of the amount of blood loss occurring. Choosing a frame so that the head isn't dependent to the heart, elevating the head of the bed to keep the head neutral with the heart, and staging long surgeries are all considerations to decrease patient risk.[24]

Types of surgeries

Anterior-posterior (A-P) surgeries are treated as two separate surgeries from the perioperative nurses' perspective, including requiring two surgery teams of record. A-P surgeries are complex, requiring a lot of preplanning. Spine trauma and deformity correction are two examples of patient conditions that may require A-P surgery.

In cervical cases, spinal cord decompression and anterior support (graft) with internal stabilization (plate) are completed. An anterior lumbar interbody fusion, the discectomy, and placement of the graft are completed in the supine position. (See *Graft materials, biologics, and instrumentation.*) Upon completion of the initial portion of the procedure, all counts are completed. The order of the procedures is based on the surgeon's preference and goals of surgery.

Prior to repositioning the patient, padding, pillows, and straps are applied. All strap clasps are to be on the same side with two straps below the waist and two above. All lines accounted for and free, there's clear communication with the surgical team, and the patient is turned prone. Anticipation to assure all equipment needs are ready for both cases prior to the first case will aid in a seamless day.

Positioning related peripheral nerve injuries

Inappropriate positioning is the primary factor leading to postoperative brachial plexus injury. While the majority of the cases recover, weeks to month of therapy may be required.[14] The brachial plexus is at risk for compression and stretch injuries. Prevention of brachial plexus injuries includes attention to padding the arms, chest, and neck. The axilla should be free from pressure. When patients are prone, arm abduction should be less than 90 degrees. (See *Correct shoulder, arm, and elbow placement in the prone position*).

Extension and external rotation are avoided. Rotation and lateral flexion of the neck toward the same side is avoided as this increases the tension on the contralateral brachial plexus. If the patient is in the lateral decubitus position, the lower arm should be placed in front of the thorax to avoid compression of the brachial plexus between the table and the thorax. The head and cervical spine are to stay in a neutral position. If the patient is supine, the elbow should be elevated and padded to prevent stretch on the brachial plexus.[14]

The ulnar nerve travels around the elbow, care is taken to not excessively flex the elbow, causing tension on this nerve. The radial and ulnar nerves are close to the humerus. If the arms are secured at the patient's side, they should be fully padded. In patients with restricted shoulder range of motion or in upper thoracic cases, the arms should be placed at the patient's side.

The pelvis and knees should be adequately padded and the legs supported by pillows with the toes hanging free. The peroneal nerve is the most common lower extremity nerve injury because it wraps around the head of the fibula. In the lateral position, pressure must be avoided.[15]

Correct shoulder, arm, and elbow placement in the prone position

Source: Photo courtesy of Andrea Strayer.

Special considerations: The spinal trauma patient

The spinal trauma patient requires expedited preparation and planning. Clinical researchers note that spinal cord decompression, prior to 24 hours after injury, is associated with improved neurologic outcomes.[16] Preparation may include grafts and instrumentation (also potentially needed implants), additional personnel for positioning and neuromonitoring may be required.

Some patients may be mechanically ventilated on arrival, while others are alert and conversive. The trauma patient during positioning should have neurologic function monitored for any changes. If there's any decline in neurologic function, the patient should be immediately placed back into the position they were in prior to the decline and reexamined. The surgical team will then need to problem solve the next steps.

Patients with ankylosing spondylitis (AS), who have suffered a spinal trauma, are an especially fragile population. AS is an autoimmune disorder and AS patients have very brittle, weak spines. They require positioning in their current posture. Attempting to change that posture will cause injury, similar to breaking a twig. For instance, patients with AS often cannot lie their head flat on the bed so that it's even with their shoulders because of an abnormal curvature. They must have a pillow placed under their head to match their normal position.

Special considerations: The overweight and obese patient

A meta-analysis investigating the association between obesity and risk of spinal surgical site infection (SSI) demonstrated a positive relationship between body mass index (BMI) and the risk of SSI after spine surgery. Their conclusions estimated a 13%-21% increase in risk of SSI for every 5-unit increase in BMI. Thus, a patient with a BMI of 30 has a 21% increased risk of developing a SSI than someone with a BMI of 25.[17]

Positioning is more challenging with an obese patient, especially in prone procedures.[18] The Wilson frame may contribute to an increase in intra-abdominal pressure and decrease in venous return. This results in problems with ventilation, elevated diaphragm, increased intrathoracic pressure, venous congestion, and increase in blood loss. With a large pannus, spine table and positioning modifications may have to be problem solved to allow for intraoperative fluoroscopy machines to be placed.[19] Special retractor and extra-long instruments will need to be available as usual sets may not be adequate in the larger patient.

Preplanning is crucial, regardless of the specific spine procedure being performed. Extra attention needs to be paid to having available equipment–room and surgical, potential equipment needed for the particular body habitus and staffing to safely position the patient.[20-22] Reducing operative time decreases risks such as: infection, blood loss and pressure ulcers. Reducing the operative time can also help prevent postoperative vision loss, a rare complication that can occur with spinal fusion.[23,24] (See *Perioperative vision loss associated with spine surgery*.) Peripheral nerve palsies are a particular risk due to positioning challenges and weight of the patient's extremities.

Special considerations: Spine surgery in the older adult

Data from the 2010 census revealed 40.3 million people are age 65 years or older, an increase of 5.3 million people since the 2000 census. This represents 13% of the total population.[25] The United States is expected to continue experiencing a rapid growth in the older adult population with an estimated 72.5 million in 2030 (19.3% of total population) and 88.5 million (20.2% of total population) in 2050.[26]

Aging in the spine begins with the disk. Over time the nucleus pulposus loses hydration and the disk becomes stiff and thin, unable to be effective against loads and forces placed upon it. As the disk ages and thins, ligaments also buckle and bony surfaces come into contact with one another. With bone contact, more bone or osteophytes are formed. At the same time, the bone loses strength and becomes osteoporotic. This process is called the degenerative cascade, which leads to diagnoses including: spinal stenosis (cervical and lumbar), degenerative spondylolisthesis, degenerative scoliosis, and vertebral fractures. The result can be nerve root compression leading to radiculopathy. Radiculopathy results in pain, paresthesias, and weakness. Weakening of the bone causes a greater risk of osteoporotic vertebral fractures, which often causes significant pain.

All ages, but especially older adults, may have decreased large joint range of motion–such as shoulders, hips, and knees. Preoperative assessment by the perioperative nurse of joint range of motion will allow safe handling and positioning after the patient is anesthetized.

Older adults are also at a higher risk of pressure ulcer development because of a thinner layer of subcutaneous fat.[27] Extra care in padding bony areas is warranted.

Age alone doesn't eliminate an individual from undergoing spine surgery. In the older adult, surgical consideration is made after nonoperative management has been unsuccessful in relieving pain or neurologic deficits and functional decline are progressive, interfering with the patient's quality of life. Surgical decision making includes an individual's prior level of activity and comorbidities, as well as an honest discussion of surgical goals. Decompression and, if needed, spine stabilization can give an older adult patient a very positive outcome.

Summary

Spine surgery poses special challenges for the perioperative nurse. Being knowledgeable about the technologic advances in minimally invasive spine surgery, neuronavigation, and disk arthroplasty as well as a growing multitude of instrumentation, implant, graft, and biologics available can be overwhelming. Continuing education outside the OR is crucial to stay up to date. Additionally, special populations such as spine trauma patients, overweight/obese patients, and older adult patients have unique needs and rely on the perioperative nurse to be their advocate for a seamless, safe operative experience. **OR**

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