Best Practice Guideline

Spinal Fusion

Author

Carrie Coppola, MSN, RN-BC, ONC

Reviewers

Diane Ryzner, RN APRN CNS OCNS-C
Karen K. Fake, M.Ed., BSN, RN, ONC

Published for NAON by:

SmithBucklin
330 N. Wabash Ave. Suite 2000
Chicago, IL 60611-4267
Toll Free: 800.289.NAON (6266)
Fax: 312.673.6941
naon@orthonurse.org

Disclaimer

This Best Practice Guideline (BPG) was developed by experts in clinical practice who work in Joint Commission Disease Specific Certified environments. The BPG was guided by the NAON Executive Board with oversight from NAON's Director of Education. It is provided as an educational tool based on an assessment of current scientific and clinical research information, as well as quantifiable best practices. The tool is not intended to replace a clinician's independent judgment and critical thinking, but to enhance the clinician's knowledge regarding the care and the needs of the total joint patient throughout the continuum of care.

Levels of Evidence

The evidence within this best practice guideline is rated to differentiate evidence of varying strengths and quality. "The underlying assumption is that recommendations from strong evidence of high quality would be more likely to represent best practices than evidence of

lower strength and less quality" (Newhouse, 2007, p. 90). Refer to the Appendix for an explanation of the levels of evidence contained within this guideline.

Table of Contents

Introduction

Back pain is one of the most common medical problems in the United States with almost everyone experiencing it at some point in their lives. Men and women are affected equally by low back pain that can begin as a result of an accident, by lifting something heavy, or it can develop slowly over time due to degenerative disk disease of the spine (NIH, 2019). Everyone experiences pain a little different and the pain can be described as mild or severe. Back pain can also be short lived or chronic in nature and make performing activities of daily living a challenge.

Most cases of back pain resolve on its own or with a combination of conservative therapies such as medications and physical therapy. In certain instances, surgical intervention is warranted. Spine surgery may be recommended after conservative therapies have failed and when the physician can pinpoint the source of pain with the assistance of x-rays, computerized tomography (CT) scans, or magnetic resonance imaging (MRI) scans (AAOS, 2013a).

Trends in spine surgery indicate an increasing frequency and cost associated with degenerative spine disease care (Dagal, et al., 2019). The number of spinal surgeries performed in the United States has increased significantly over the past several decades. The volume of lumbar fusions alone increased 62.3% from 2004 to 2015 (Martin, Mirz, Spina, Spiker, Lawrence, & Brodke, 2019). With advances in technique, implants, and pain management the prevalence of spine surgery is steadily increasing.

Purpose

The purpose of the best practice guidelines for Spinal Surgery is to gather current literature to provide best practice information aimed at the continuum of nursing care for the patient undergoing spinal surgery. This guideline will focus on standardizing and improving patient care pathways for lumbar spinal fusion.

Rationale for Guideline

The rationale for the guideline is to emphasize the importance of identifying standardized practice guidelines for the lumbar spinal fusion patient. Standardized guidelines have been shown to have a positive impact with patient outcomes.

Goal of Best Practice Guideline

The guideline offers an assessment of the benefits and harms of various care and practice options for the lumbar spinal fusion patient. This will assist to empower nurses to effectively manage the acute care requirements of the lumbar spinal fusion patient. The overarching goal of the Best Practice Guideline is to improve patient outcomes through the dissemination and of relevant literature and proven best practices. Ultimately, adoption of recommended practices offers the potential for an enhanced patient experience and recovery.

Description

Lumbar Fusion is a surgical procedure in which two or more vertebrae are fused together to prevent motion between vertebrae as well as to prevent the stretching of nerves and surrounding ligaments and muscles, allowing them to heal into a single, solid bone (AAOS, 2018a). There are several different types of spinal fusion procedures as well as different approaches, and open versus minimally invasive.

Posterolateral fusion involves removal of the arthritic bone and anything else putting pressure on the spinal nerves. A bone graft is typically placed along the sides of the vertebrae to stimulate bone growth. Rods and screws may be used to provide immediate stability to the spine (AAOS, 2018a).

Lumbar interbody fusion is accomplished by removing the intervertebral disk and placing a metal, plastic, or bone spacer between the 2 vertebrae. The spacer, also known as an "interbody cage", usually contains bone graft material which promotes bone healing and aids in the fusion (AAOS, 2018b). This type of fusion can be performed using different approaches.

There is a lack of literature regarding fusion approach and technique compared to patient reported outcomes. In a study of three hundred and ninety one patients who underwent a 1-3 level lumbar fusion Divi et al. (2019) found the relationship between type of fusion and patient reported outcomes was not established as they remained similar between all three fusion types.

Laminectomy is a surgical procedure in which the lamina, bone spurs, and ligaments that are compressing the nerves are removed. This is also known as a "decompression (AAOS, 2013b). This procedure can be performed alone or in conjunction with a lumbar fusion. We will not be including laminectomy procedures in this guideline.

Definition of the Problem

Due to the upward trend in spinal surgeries being performed in the United States, healthcare professionals recognize the need for standardization of evidence-based guidelines for patients undergoing spinal surgery. Research regarding care of surgical spine patients is continuing to grow as new techniques and pathways are being looked at. These best practice guidelines will assist in guiding the care of spine surgery patients.

Pathophysiology

The most common cause for spinal fusion is spinal stenosis, usually the result of osteoarthritis. This can cause narrowing of the space holding the spinal cord and nerves. The pinching of the spinal cord or nerves leads to pain, weakness, or numbness. Depending on where the narrowing takes place, the symptoms may be described as in the lower back and legs, neck, shoulder or arms (Duarte, 2019).

According to the American Academy of Orthopaedic Surgeons (AAOS, 2018c) spinal fusion may help to relieve symptoms of certain back problems including:

- Degenerative disk disease
- Spondylolisthesis

- Spinal Stenosis
- Scoliosis
- Fractured vertebra
- Infection
- Herniated disk
- Tumor

Continuum of Care

Preoperative Care

Preoperative Patient Optimization

Preoperative optimization is important and feasible for elective spine surgery patients; the date of surgery can be postponed until the patient is in the best shape possible. Favorable patient outcomes have been linked to optimization of the patient preoperatively. A preoperative risk assessment performed prior to surgery can identify any comorbidities and modifiable risk factors. According to Chakravarthy, Yokoi, Coughlin, Manlapaz & Krishnaney (2019) the risk assessment should include one or more of these items:

- Body Mass Index (BMI)
- Smoking and substance use
- Diabetes
- Anemia
- Age greater than 75 or Frailty
- Functional status

Enhanced Recovery After Surgery

Enhanced recovery after surgery (ERAS) protocols are evidence-based, multidisciplinary pathways that help decrease complications and improve functional recovery. ERAS focuses on the entire surgical episode, starting preoperatively, then concentrating on intraoperative care, followed by the postoperative period. ERAS protocols are proving beneficial in multiple surgical specialties and have recently started to be utilized in spine surgery. The increasing awareness of ERAS protocols is helping to break down communication silos between caregivers, patients, and the different medical specialties, encouraging them to work together to optimize the patient and improve the patients whole surgical experience (Dietz, Sharma, Adams, Alhourani, Ugiliweneza, Wang, Nuno, Drazin, & Boakye, 2019). Table 1 describes interventions performed in the different phases of care and the anticipated outcomes based on the literature for ERAS for spine surgery. Although the studies that were reviewed showed favorable outcomes with use of the ERAS protocols, further studies of surgical spine patients are needed to confirm the benefits in regards to complications, functional outcomes, and costs.

Table 1: Enhanced Recovery after Surgery

Phase of Care	Intervention	Outcome
Preoperative Phase	• Preoperative assessment to include comorbidities and nutrition assessment by a physician or advanced practice practitioner • Preoperative education and goal setting with patient and care partner • Minimal fasting time • Complex carbohydrate loading • Preemptive analgesia • Pre-emptive PONV prophylaxis for high risk patients • Mechanical VTE prophylaxis	• Optimization of the patient • Prepare the patient for what to expect and set realistic goals • Optimized preoperative care • Improved nutritional status immediately preoperatively • Prevention of VTE
Intraoperative Phase	• If possible: Minimally invasive surgical technique • Goal directed fluid balance • Warming techniques • Avoid surgical drains/foley catheter	• Reduced length of stay • Reduced surgery times • Maintenance of normothermia • Maintenance of normovolemia
Postoperative Phase	• Mechanical VTE prophylaxis • Early mobilization • Early oral intake • Multimodal pain approach • Wound dressings	• Prevention of VTE • Reduced length of stay • Optimized postoperative care

Nutrition Screening

Nutritional status is a major determinant of outcomes for any type of surgery. Enhanced Recovery after Surgery (ERAS) protocols incorporate preoperative nutrition screening for all surgical patients as well as limits fasting time. Malnutrition can include both deficiencies and excesses in nutrients. Optimizing the nutritional status of a patient prior to surgery helps to improve surgical outcomes and decrease rates of complications. Malnourished patients are more susceptible to surgical site infections, impaired wound healing (Cross, Yi, Thomas, Garcia, & Della Valle, 2014), longer length of stay, increased cost in care, increased risk of morbidity and mortality, and increased risk of readmission (Adogwa, O., Elsamadicy, A., Mehta, A., Cheng, J., Bagley, C., & Karikari, I., 2016). According to the CDC, BMI greater than 30 is considered obese. Increased BMI is associated with longer OR times, increased blood loss, increased risk of venous thromboembolism, high revision rate, and higher rate of surgical site infection (Jiang, Teng, Fan, Khan, & Xia, 2014)

There is not a consensus on what is the best way to measure nutritional status preoperatively for spinal patients. Nutrition status measured by prealbumin and transferrin does not appear to be associated with complication risks (Takemoto, Yoo, Blizzard, Shannon, & Marshall, 2019). A nutrition screening tool can help by providing a snapshot of the patient's nutritional status, although more research is needed to

identify the best tool for surgical spine patients. According to the National Council on Aging (2017), some examples of validated nutritional screening tools are:

- Malnutrition Screening Tool
- Malnutrition Universal Screening Tool
- Nutrition Risk Screening
- Mini-Nutritional Assessment

Preoperative Education

Patient education is an important factor to consider prior to spine surgery. Education related to the whole surgical and recovery process will help set expectations on what is going to happen as well as the role the patient is going to play in his or her recovery. Education regarding pain management is important for this population and should include how and when to take opioids (if required), side effects, use of non-pharmacologic methods for reducing postoperative pain, and proper reporting of inadequate pain control. Eastwood et al. (2019) found that elective spinal fusion patients, who attended a multidisciplinary preoperative education session that included nursing, physical therapy, and occupational therapy, were significantly more satisfied with their surgical outcomes and were less likely to visit the emergency room within 12 weeks of surgery.

Planning for Postoperative Destination

Planning for discharge should begin early on when the plan for surgery is discussed. This will ensure that both the patient and surgeon agree on the safest discharge as well as give the patient time to prepare and make any necessary arrangements. Predictive factors can be used to assist in preoperative planning for post-acute care. The physician or care navigator can look at the patient's age, BMI, impacting comorbidities, current living situation, assistance at home, and the number of levels the surgery will encompass to help develop a discharge plan.

Pain Management Plan before Surgery

Adequate pain management following a spinal fusion is imperative to improved functional outcomes. One commonly seen challenge in this population is the preexisting pain along with long-term use of analgesics and/or opioids which can alter pain perception in some patients thereby complicating pain management. According to Hilliard et al. (2018), one of the strongest indicators of long-term postoperative opioid use is long term use of opioids preoperatively. Preoperative opioid use has also been associated with poor surgical outcomes, poor pain control postoperatively, psychological distress, decreased functional status postoperatively, increased hospitalization duration, increased hospital costs, and postop complications (Yerneni, Nichols, Abecassis, Karras, & Tan, 2020). Optimization of these patients may include tapering of opioids to a lower dose prior to surgery as it may result in improved outcomes.

Nonpharmacological methods for pain management are becoming increasingly popular and have had noted effects on emotional, cognitive, behavioral, and sociocultural dimension of pain. Some examples of these methods include distraction, imagery, relaxation, hot and cold application, massage,

positioning, exercise, transcutaneous nerve stimulation, acupuncture, aromatherapy, and music therapy (Gumus, Musuroglu, Ozlu, & Tasci, 2019)

Discussing the surgical procedure and expected outcomes, having the patient participate in developing a plan for pain management prior to surgery, reviewing non-opioid and non-pharmacological methods for pain management, and having consistent information relayed to the patient throughout the continuum of care can all help decrease some of the anxiety associated with a planned spinal fusion. The pain management plan should be individualized to the patient and may include non-opioid medications that are given preoperatively and postoperatively as well as non-pharmacological methods for pain management. Since there is no single drug or therapy that has proven to control pain or be considered as the "gold standard" and a multi modal approach has been recommended (Bajwa & Haldar, 2015). There is good evidence that gabapentin, acetaminophen, and extended release local anesthetics reduce postoperative pain and narcotic requirements. (Devin & McGirt, 2015).

VTE Prophylaxis Plan

Venous thromboembolism (VTE) is a serious adverse event that can affect the recovery of surgical spine patients. The risk of VTE in surgical spine patients varies by the procedure and degree of neurologic compromise (Kepler, McKenzie, Kreitz, & Vaccaro, 2018). According to a meta-analysis study performed by Xin et al. (2019) a higher rate of postoperative VTE is associated with increased age, longer surgery time, increased blood loss, patients with a history of hypertension, preoperative walking disability or diabetes. Other risk factors include dehydration, clotting disorders with history of previous clot, varicose veins with phlebitis, oral hormonal contraceptive use, malignancy, obesity, and smoking (AAOS, 2015).

There is no consensus on the use of pharmacological VTE prophylaxis due to the risk of postoperative bleeding leading to a spinal epidural hematoma but there is agreement on the safety and effectiveness of early postoperative mobilization and sequential compression devices (Lee, Allen, & Garfin, 2019).

Patients and their care partner(s) should be educated on the patient's risk factors for VTE, mechanical VTE prophylaxis, signs and symptoms of VTE, and what to do if VTE is suspected. This can be done preoperatively and/or prior to being discharged home.

Preoperative Surgical Skin and Nares Preparation

Surgical site infections (SSIs) are among the most common, preventable complications after surgery. SSIs are a significant cause of morbidity and mortality after surgery as well as the leading cause of readmissions following surgery (U.S. Department of Health and Human Services, 2019). Multiple studies have shown that implementation of a decolonizing protocol can decrease the rate of SSIs in spinal fusions. This process includes nasal swabbing to assess for *Staphylococcus* colonization and decolonization when appropriate as well as Chlorhexidine showers prior to surgery (Chakravarthy, Yokoi, Coughlin, Manlapaz & Krishnaney, 2019).

Another important factor in reducing the risk of surgical site infections is skin antisepsis. Preoperative bathing or showering is widely recommended to reduce the risk of surgical site infections although the evidence is mixed in regards to which method is preferred (Boyce, 2019). Chlorhexidine gluconate (CHG) bathing, whether with wipes or liquid form in the shower, is recommended by multiple sources but

there is no set guidelines in regards to length of time before surgery the bathing should begin. Patients should follow the recommendations of their surgeon for the method and timeframe of use. Further studies are needed to make a strong recommendation for one particular preoperative washing method.

Intraoperative Care

Skin Antisepsis

Skin antisepsis in the operating room has a goal of sterilizing the skin just prior to incision. A study performed by Ghobrial et al. (2018) comparing the use of CHG, specifically Chloraprep™, and Betadine, showed no significant difference in SSI rates in surgical spine patients. Although there is no clear consensus between various skin preparations current evidence is favoring alcohol-containing solutions, often along with Chlorhexidine gluconate (CHG) or povidone-iodine for surgical site preparation (Boyce, 2019).

Anesthesia

General anesthesia is most commonly used for lumbar spine fusion procedures. General anesthesia is performed when medications are administered which cause loss of consciousness, muscle paralysis, and impaired ventilation (American Society of Anesthesiologists (ASA), 2020).

Potential complications/side effects of general anesthesia:

- Postoperative nausea and vomiting
- Chills
- Delirium
- Sore throat

Antibiotic Prophylaxis

Antibiotic prophylaxis for spinal surgery is utilized to reduce surgical site infections. Appropriate selection of antibiotic, dosing adjustments based on body weight, and timing of the administration is significant. According to Attenello & Allen (2019) Cephalosporin administration 30 minutes prior to skin incision has shown significant decrease in surgical site infection risk compared to the previous recommendation of 31-60 minutes prior to incision. Clindamycin can be used as a substitute for patients with a beta lactam allergy and Vancomycin can be used for patients with a history of Methicillin-resistant Staphylococcus aureus (MRSA).

Positioning

Patient positioning for spine surgery is important to avoid injury to the eyes, peripheral nerves, and bony prominences. A risk assessment should be performed prior to surgery to identify risks for developing positioning injuries. Measures should be taken to ensure that the patient has correct padding for pressure points, is repositioned, and kept in the position for the shortest time required (Burlingame, 2017). The anterior approach requires a laparotomy which is performed in the supine position while posterior procedures require a prone position (Brown, 2020).

Sequential Compression Device (SCD and/or Compression Stockings

Venous thromboembolism is a serious postoperative complication after spinal fusion. Use of mechanical compression via sequential compression device (SCD) or compression stockings can help to decrease the risk of developing a venous thromboembolism by preventing blood from pooling in the patients lower extremities during and after surgery (Lall, 2018). SCDs work to prevent DVT by enhancing blood flow in the deep veins of the legs preventing venous stasis. Compression stockings apply constant pressure which ultimately decreases the amount of venous stasis (Pai & Douketis, 2020).

Normothermia

Intraoperative hypothermia can develop in all unwarmed surgical patients and results from the combination of anesthesia induced thermoregulatory impairment, cool operating room ambient temperature, and exposure of open body cavities during certain surgical procedures (Sessler, 2020).

Intraoperative hypothermia has been linked with multiple postoperative complications including cardiac events, increased blood loss, longer hospital stay, and SSIs. Hypothermia can increase the risk of SSI by impairing the body's defense against infection by reducing tissue perfusion and decreasing motility to key immune cells. Various perioperative warming strategies are available and include prewarming before induction of anesthesia, passive insulation, skin surface warming with forced air warming or circulating-water garment devices, and fluid warming (Sessler, 2020).

Intraoperative Neurophysiological Monitoring & Intraoperative Fluoroscopy

Perioperative neurological injury is a feared complication of spine surgery. Intraoperative neurophysiological monitoring (IONM) is the use of physiological monitoring techniques to assess neural integrity and/or to navigate within the at risk neural structures during various procedures such as spine surgery (Gertsch et al., 2019). According to one study in which the National Inpatient Sampler database was looked at for use of IONM between 2008 and 2014 there was a 296% increase in use (Laratta et al., 2018). There is a growing body of evidence supporting the effectiveness of IONM but limited studies with high level evidence to validate that evidence. Therefore the use of IONM is still guided by surgeon preference and institutional policies. Further studies are recommended to develop clinical practice guidelines (Charalampidis et al., 2020).

Intraoperative fluoroscopy is the use of x-rays to view internal body structures on a screen during the surgical procedure. In order to evaluate the positioning of the screws and hardware alignment during spinal fusions, the consensus is that intraoperative fluoroscopy should be utilized (Fletcher, Glotzbecker, Marks, & Newton, 2017).

Postoperative Care

Multimodal Pain Management

Multimodal pain management is the use of 2 or more different methods or medications to manage pain. Multimodal pain management started preoperatively and continued postoperatively aids in reducing pain and opioid consumption in spinal fusion patients helping to increase mobility, decrease

complications and increase patient satisfaction. In the past, opioids had been the most effective medicine for controlling pain after spinal fusions but now by utilizing various combinations of methods such as nonpharmacological practices as well as medications we are able to create a synergistic effect for pain relief through various pain pathways (Yoo, Ahn, Buvanendran, & Singh, 2019). This helps to decrease opioid consumption as well as some of the side effects commonly seen with opioid use such as drowsiness and/or sedation, altered cognition, respiratory depression, and pruritus, cardiovascular stress, delayed wound healing, urinary and gastrointestinal dysfunction, and acquired tolerance. Evidence supports multimodal pain management regimens including preoperative use of NSAIDS, acetaminophen, and the neuromodulatory agent's gabapentin and pregabalin in combination with opioids (Kurd, Kreitz, Schroeder, & Vaccaro, 2017).

Early Mobilization and Exercise

Early mobilization on day of surgery or postoperative day 1, unless contraindicated, is part of the enhanced recovery after surgery pathway and has shown to have a positive impact on pain, decreased complications such as deep vein thrombosis, pneumonia, constipation, and decreased length of stay (Chakravarthy, Yokoi, Coughlin, Manlapaz & Krishnaney, 2019). Early mobilization for spinal fusion patients may entail basic exercises, such as routine walking during the first few weeks after surgery. During this time frame it is important to avoid bending, twisting, or lifting anything heavy (AAOS, 2016). Multiple studies revealed decreased rates of infections, medical complications, and average length of stay after instituting early mobilization protocols (Elsarrag et al., 2019).

Postoperative Nutrition

Early oral nutrition is a component of ERAS which has shown to decrease complications and hospital length of stay. There is evidence that early oral intake after spine surgery is safe and may accelerate the return of bowel function and possibly reduce length of stay (Elsarrag et al., 2019).

Postoperative Incisional Care

Dressings may vary per surgeon and per location/hospital. There is insufficient evidence on the efficacy of any particular dressing type or in regards to the duration for which the dressing should remain in place (Tan et al., 2020). Nursing care should be focused on making sure dressing is intact, monitoring dressing for drainage, and monitoring patients for possible reactions including sensitivity and skin irritation.

Patients and their home support should be educated on dressing care. This education should include how to keep the dressing clean and dry, when it is okay to shower and how to protect the dressing if necessary, and how to recognize and report signs and symptoms of SSI's.

Bracing

Bracing is sometimes used during the early postoperative period after a spinal fusion to immobilize the spine, improve fusion, and relieve pain. There is a lack of evidence in regards to the benefit of bracing with limited evidence showing that postoperative bracing does not result in improved outcomes. This leaves the decision to use a brace or not on the surgeon and other factors related to the surgery (Zhu, Tetreault, Sorefan-Mangou, Garwood, & Wilson, 2018).

Urinary Catheter

The use of indwelling urinary catheters has decreased significantly throughout the years and is not considered best practice any longer. If an indwelling urinary catheter is placed it is recommended that the catheter be removed as soon as possible postoperatively, no later than postoperative day 2 (Fletcher, Glotzbecker, Marks, & Newton, 2017).

Drain

The routine use of portable wound suction drains (such as hemovac™) in lumbar spinal fusion patients has decreased throughout the years with current studies finding no benefit in routine use. Drains had previously been used to help decrease the occurrence of symptomatic epidural hematomas and infection. With the advantage of less blood loss and less soft tissue destruction the risk of hematoma formation has declined. Also by reducing pathways between the epidural space and external pathogens can reduce the risk of SSI's (Hung et al., 2017). If a drain is used, nursing would need to monitor and document output.

Vascular Complications

Vascular injury during a spinal procedure is a complication that can be life threatening. Structures that are at risk include the aorta, vena cava, common iliac artery and vein, middle sacral vessel, and the iliolumbar vein. Early detection and treatment of such injuries is of the utmost importance in preventing disastrous or fatal patient outcomes. Bleeding in the disc space, hypotension, tachycardia, and abdominal rigidity may be early signs of major vessel injury (Reid, Patel, Daniels, & Rihn, 2019). If this is suspected the surgeon should be notified immediately.

Constipation Prevention

Constipation is a complication that can occur after spinal fusion surgery. Many factors can contribute to constipation such as anesthesia, a decrease in activity, decreased fluid intake, and medications such as opioids. Nurses play a critical role in patient education with both non-pharmacological and pharmacological techniques. Patient education is extremely important to inform and engage patients to help prevent this complication. Risk of constipation in post-surgical patients can be decreased with an increased intake of fluids and fiber, early mobilization, and a decrease in opioid medications (National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK), 2018).

Web Sites

For Professionals

- American Academy of Orthopaedic Surgeons: http://www.aaos.org
- National Association of Orthopaedic Nurses: http://www.orthonurse.org
- North American Spine Society: http://www.spine.org
- Orthopaedic Nurses Certification Board: http://www.oncb.org
- The Joint Commission: http://www.jointcommission.org
- The ERAs Society: https://erassociety.org

For Patients and Families

- American Academy of Orthopaedic Surgeons OrthoInfo: https://orthoinfo.aaos.org/
- North American Spine Society: http://www.spine.org/KnowYourBack/Resources/Patient-Information-Resources

References

Adogwa, O., Elsamadicy, A., Mehta, A., Cheng, J., Bagley, C., & Karikari, I. (2016). Preoperative nutritional status is an independent predictor of 30-day hospital readmission after elective spine surgery. *Spine,* 41(17), 1400-1404. DOI: 10.1097/BRS.0000000000001551

American Academy of Orthopaedic Surgeons (AAOS). (2016). Anterior lumbar interbody fusion. Retrieved from https://orthoinfo.aaos.org/en/treatment/anterior-lumbar-interbody-fusion/

American Academy of Orthopaedic Surgeons (AAOS). (2015). Deep vein thrombosis. Retrieved from https://orthoinfo.aaos.org/en/diseases--conditions/deep-vein-thrombosis

American Academy of Orthopaedic Surgeons (AAOS). (2013a). Low back pain. Retrieved from https://www.orthoinfo.org/en/diseases--conditions/low-back-pain/

American Academy of Orthopaedic Surgeons (AAOS). (2013b). Lumbar spinal stenosis. Retrieved from https://orthoinfo.aaos.org/en/diseases--conditions/lumbar-spinal-stenosis/

American Academy of Orthopaedic Surgeons (AAOS). (2018a). Posterolateral lumbar fusion. Retrieved from https://orthoinfo.aaos.org/en/treatment/posterolateral-lumbar-fusion

American Academy of Orthopaedic Surgeons (AAOS). (2018b). Posterior lumbar interbody fusion and transforaminal lumbar interbody fusion. Retrieved from https://orthoinfo.aaos.org/en/treatment/spinal-fusion-plif-tlif/?topic=A00596

American Academy of Orthopaedic Surgeons (AAOS). (2018c). Spinal fusion. Retrieved from https://orthoinfo.aaos.org/en/treatment/spinal-fusion/

American Society of Anesthesiologists. (2020). Types of anesthesia: General anesthesia. Retrieved from https://www.asahq.org/whensecondscount/anesthesia-101/types-of-anesthesia/general-anesthesia/

Attenello, J. & Allen, T. (2019) Postoperative spine infections. *Seminars in Spine Surgery,* 31(4) DOI: 10.1016/j.semss.2019.100754

Bajwa, S. & Haldar, R. (2015). Pain management following spinal surgeries: An appraisal of the available options. *Journal of Craniovertebral Junction & Spine,* 6(3), 105-110.

Boyce, J. (2019). Best products for skin antisepsis. *American Journal of Infection Control,* 47, A17-A22. DOI 10.1016/j.ajic.2019.03.012.

Brown, M. (2020). Anesthesia for elective spine surgery in adults. Retrieved from https://www.uptodate.com/contents/anesthesia-for-elective-spine-surgery-in-adults#H101148328

Burlingame, B. (2017). Guideline implementation: Positioning the patient.*AORN Journal,* 106(3), 227-237. DOI: 10.1016/j.aorn.2017.01.010

Charalampidis, A., Jiang, F., Wilson, J., Badhiwala, J. H., Brodke, D. S., & Fehlings, M. G. (2020). The use of intraoperative neurophysiological monitoring in spine surgery. *Global Spine Journal*, *10*(1 Suppl), 104S–114S. DOI: 10.1177/2192568219859314

Chakravarthy, V., Yokoi, H., Coughlin, D., Manlapaz, M., & Krishnaney, A. (2019). Development and implementation of a comprehensive spine surgery enhanced recovery after surgery protocol: the Cleveland Clinic experience. *Neurosurg Focus,* 46(4), 1-9

Cross, M., Yi, P., Thomas, C., Garcia, J., & Della Valle, C. (2014). Evaluation of malnutrition in orthopaedic surgery. *Journal of the American Academy of Orthopaedic Surgeons*, 22(3), 193-199.

Dagal, A., Bellabarba, C., Bransford, R., Zhang, F., Chesnut, R., O'Keefe, G., Wright, D., Dellit, T., Painter, I., & Souter, M. (2019). *Spine.* 44(13), 959-966. DOI: 10.1097/BRS.0000000000002968

Devin, C & McGirt, M. (2015). Best evidence in multimodal pain management in spine surgery and means of assessing postoperative pain and functional outcomes. *Journal of Clinical Neuroscience.* 22(6), 930-938. DOI: 10.1016/j.jocn.2015.01.003

Dietz, N., Sharma, M., Adams, S., Alhourani, A., Ugiliweneza, B., Wang, D., Nuno, M., Drazin, D., & Boakye, M. (2019). Enhanced recovery after surgery (ERAS) for spine surgery: Asystematic review. *World Neurosurgery.* 130, 415-426

Divi, S., Schroeder, G., Goyal, D., Radcliff, K., Galetta, M., Hilibrand, A., Anderson, G., Kurd, M., Rihn, J., Kaye, I., Woods, B., Vaccaro, A., & Kepler, C. (2019). Fusion technique does not affect short-term patient-reported outcomes for lumbar degenerative disease. *The Spine Journal.* 19(12), 1960-1968. DOI: 10.1016/j.spinee.2019.07.014

Duarte, A. (2019). Spinal stenosis. Retrieved from https://www.rheumatology.org/I-Am-A/Patient-Caregiver/Diseases-Conditions/Spinal-Stenosis

Eastwood, D., Manson, N., Bigney, E., Darling, M., Richardson, E., Paixao, R., Underwood, T., Ellis, K., & Abraham, E. (2019). *The Spine Journal.* 19(5), 840-845. DOI: 10.1016/j.spinee.2018.11.010

Elsarrag, M., Soldozy, S., Patel, P., Norat, P., Sokolowski, J., Park, M., Tvrdik, P., & Kalani, M. (2019) Enhanced recovery after spine surgery: A systematic review. *Neurosurgical Focus,* 46(4), 1-9. DOI: 10.3171/2019.1.FOCUS18700

Fletcher, N., Glotzbecker, M., Marks, M, & Newton, P. (2017). Development of consensus-based best practice guidelines for postoperative care following posterior spinal fusion for adolescent idiopathic scoliosis. *Spine.* 42(9), 547-554.

Gertsch, j., Moreira, J., Lee, G., Hastings, J., Ritzi, E., Eccher, M., Cohen, B., Shils, J., McCaffrey, M., Balzer, J., Boucharel, W., Guo, L., Hanson, L., Hemmer, L., Jahangiri, F., Mendez Vigil, J., Vogel, R.,

Wierzbowski, L., Wilent, W., Zuccaro, J., & Yingling, C. (2019). Practice guidelines for the supervising professional: Intraoperative neurophysiological monitoring. *Journal of Clinical Monitoring and Computing.* 33(2), 175-183. DOI: 10.1007/S10877-018-0201-9

Ghobrial, G., Wang, M., Green, B., Levene, H., Manzano, G., Vanni, S., Starke, R., Jimsheleishvili, G., Crandall, K., Dididze, M., & Levi, A. (2018). Preoperative skin antisepsis with chlorhexidine gluconate versus povidone-iodine: a prospective analysis of 6959 consecutive spinal surgery patients. *Journal of Neurosurgery,* 28(2), 131-225. DOI: 10.3171/2017.5.SPINE17158

Gumus, K., Musuroglu, S., Ozlu, Z., & Tasci, O. (2019). Determining the use of nonpharmacological methods by surgical nurses for postoperative pain management and the influencing professional factors: A multicenter study. *Journal of PeriAnesthesia Nursing,* 35(4), 75-79. DOI: 10.1016/j.jopan.2019.04.011

Hilliard, P., Waljee, J, Moser, S., Metz, L., Mathis, M., Goesling, J., Cron, D., Clauw, D., Englesbe, M., Abecasis, G., & Brummett, C. (2018). Prevalence of preoperative opioid use and characteristics associated with opioid use among patients presenting for surgery. *JAMA Surg,* 153(10), 929-937. DOI:10.1001/jamasurg.2018.2102

Hung, P., Chang, M., Chou, P., Lin, H., Wang, S., & Liu, C. (2017). Is a drain tube necessary for minimally invasive lumbar spine fusion surgery? *European Spine Journal,* 26, 733-737. DOI: 10.1007/s00586-016-4672-4

Jiang, J., Teng, Y., Fan, Z., Khan, S., & Xia, Y. (2014). Does obesity affect the surgical outcome and complication rates of spinal surgery? A meta-analysis. *Clinical Orthopaedics and Related Research.* 472(3), 968-975. DOI: 10.1007/s11999-013-3346-3

Kepler, C., McKenzie, J., Kreitz, T., & Vaccaro, A. (2018) Venous thromboembolism prophylaxis in spine surgery. *Journal of the American Academy of Orthopaedic Surgeons.* 26(14), 489-500. DOI:10.5435/JAAOS-D-17-00561

Kurd, M., Kreitz, T., Schroeder, G., & Vaccaro, A. (2017). The role of multimodal analgesia in spine surgery. *Journal of the American Academy of Orthopaedic Surgeons*. 25(4), 260-268. DOI:10.5435/JAAOS-D-16-00049

Lall, M. (2018). Nursing care of the patient undergoing lumbar spinal fusion. *Journal of Nursing Education and Practice, 8(5), 44-53.* DOI: 10.5430/jnep.v8n5p44

Laretta, J., Shillingford, J., Lombardi, J., Saifi, C., Ludwig, S., Lehman, R., & Lenke, L. (2018). Utilization of intraoperative neuromonitoring throughout the United States over a recent decade: an analysis of the nationwide inpatient sample. *Journal of Spine Surgery*. 4(2), 211-219. DOI:10.21037/jss.2018.04.05

Lee, S., Allen, T., & Garfin, S. (2019). Venous thromboembolism in spine surgery: Review of the current literature and future directions. *Seminars in Spine Surgery.* 31(4), 1-5. DOI:10.1016/j.semss.2019.100757

Martin, B., Mirza, S., Spina, N., Spiker, W., Lawrence, B., & Brodke, D. (2019). Trends in lumbar fusion procedure rates and associated hospital costs for degenerative spinal diseases in the United States, 2004 to 2015. *Spine,* 44(5), 369-376. DOI: 10.1097/BRS.0000000000002822

National Council on Aging. (2017). Malnutrition screening and assessment tools. Retrieved from https://www.ncoa.org/assesssments-tools/malnutrition-screening-assessment-tools/

National Institute of Diabetes and Digestive and Kidney Diseases. (2018). Constipation. Retrieved from https://www.niddk.nih.gov/health-information/digestive-diseases/constipation

National Institute of Health. (2019). Low back pain fact sheet. Retrieved from https://www.ninds.nih.gov/Disorders/Patient-Caregiver-Education/Fact-Sheets/Low-Back-Pain-Fact-Sheet

Pai, M & Douketis, J. (2020). Prevention of venous thromboembolic disease in acutely ill hospitalized medical patients. Retrieved from https://www.uptodate.com/contents/prevention-of-venous-thromboembolic-disease-in-acutely-ill-hospitalized-medical-adults?search=compression%20stockings&source=search_result&selectedTitle=10~113&usage_type=default&display_rank=10#H25

Reid, D., Patel, S., Daniels, A., & Rihn, J. (2019). Vascular complications in spine surgery. *Seminars in Spine Surgery,* 31 (4), 1-9. DOI: 10.1016/j.semss.2019.100756

Sessler, D. (2020). Perioperative temperature management. Retrieved from https://www.uptodate.com/contents/perioperative-temperature-management#references

Takemoto, E., Yoo, J., Blizzard, S., Shannon, J., & Marshall, L. (2019). Preoperative prealbumin and transferrin: Relation to 30-day risk of complication in elective spine surgical patients. *Medicine,* 98(9) e14741. DOI: 10.1097/MD.0000000000014741

Tan, T., Lee, H., Huang, M., Rutges, J., Marion, T., Matthew, J., Fitzgerald, M., Gonzalvo, A., Hunn, M., Kwon, B., Dvorak, M., & Tee, J. (2020). Prophylactic postoperative measures to minimize surgical site infections in spine surgery: Systematic review and evidence summary. *The Spine Journal*, 20(3), 435-447. DOI: 10.1016/j.spinee.2019.09.013

U.S. Department of Health and Human Services. (2019). Surgical site infections. Retrieved from https://psnet.ahrq.gov/primer/surgical-site-infections

Xin, W., Xin, Q., Ming, H., Gao, Y., Zhao, Y., Gao, Y., & Yang, X. (2019). Predictable risk factors of spontaneous venous thromboembolism in patients undergoing spine surgery. *World Neurosurgery,* 127, 451-463. DOI: 10.1016/j.wneu.2019.04.126

Yerneni, K., Nichols, N., Abecassis, ZA., Karras, C., & Tan, LA. (2020). Preoperative opioid use and clinical outcomes in spine surgery: A systematic review. *Neurosurgery,* nyaa050. DOI:10.1093/NEUROS/NYAA050

Yoo, J., Ahn, J., Buvanendran, A., & Singh, K. (2019). Multimodal analgesia in pain management after spine surgery. *Journal of Spine Surgery,* 5(2), 154-159.

Zhu, M., Tetreault, L., Sorefan-Mangou, F., Garwood, P., & Wilson, J. (2018). Efficacy, safety, and economics of bracing after spine surgery: A systematic review of the literature. *Spine Journal,* 18(9), 1513-1525. DOI: 10.1016/j.spinee.2018.01.011.

Appendix: System for Rating the Strength of Evidence

System for Rating the Strength of Evidence

System for Rating the Strength of Evidence	
Level I	High-quality randomized controlled trial with large sample and statistically significant difference or no statistically significant difference but narrow confidence intervals Evidence from a systematic review, a meta-analysis, or an evidence-based clinical practice guideline where only results from randomized controlled clinical trials were used.
Level II	Evidence from at least one well-designed randomized prospective comparative clinical trial. Systematic review of primarily Level II studies.
Level III	Evidence from well-designed case controlled trials without randomization, comparative studies and evidence from a systematic review, a meta-analysis, or an evidence-based clinical practice guideline where results from randomized clinical trials and controlled clinical trials were used. Systematic review of primarily Level III studies.
Level IV	Evidence from case series and cohort studies. Evidence from well-designed descriptive, qualitative, or psychometric studies. Evidence from a systematic review, a meta-analysis, or meta-synthesis of descriptive or qualitative studies.
Level V	Evidence from the opinion of authorities or experts.
Level VI	Common practice, as documented in clinical articles or nursing textbooks.
Modified from the Rating System for the Hierarchy of Evidence by Melnyk, B.M., & Fineout-Overholt, E. (2005). Evidence-based practice in nursing & healthcare: A guide to best practice (p.10). Philadelphia: Lippincott, Williams & Wilkins.	
Modified by E.C. Devine (2007) for the Knowledge-Based Nursing Initiative. Knowledge - Based Nursing Initiative Protocol (2007). Unpublished manuscript.	
Modified from Centre for Evidence-Based Medicine, Oxford, UK. See www.cebm.net.	