

Horseshoes and Hand Grenades:

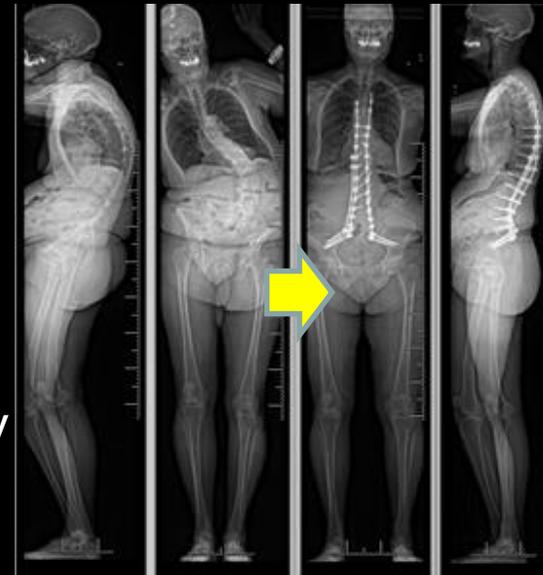
Complication Avoidance and Optimizing Risk Factors Before, During, and After Spine Surgery



Kristen Jones MD, FAANS

Assistant Professor, Department of Neurosurgery

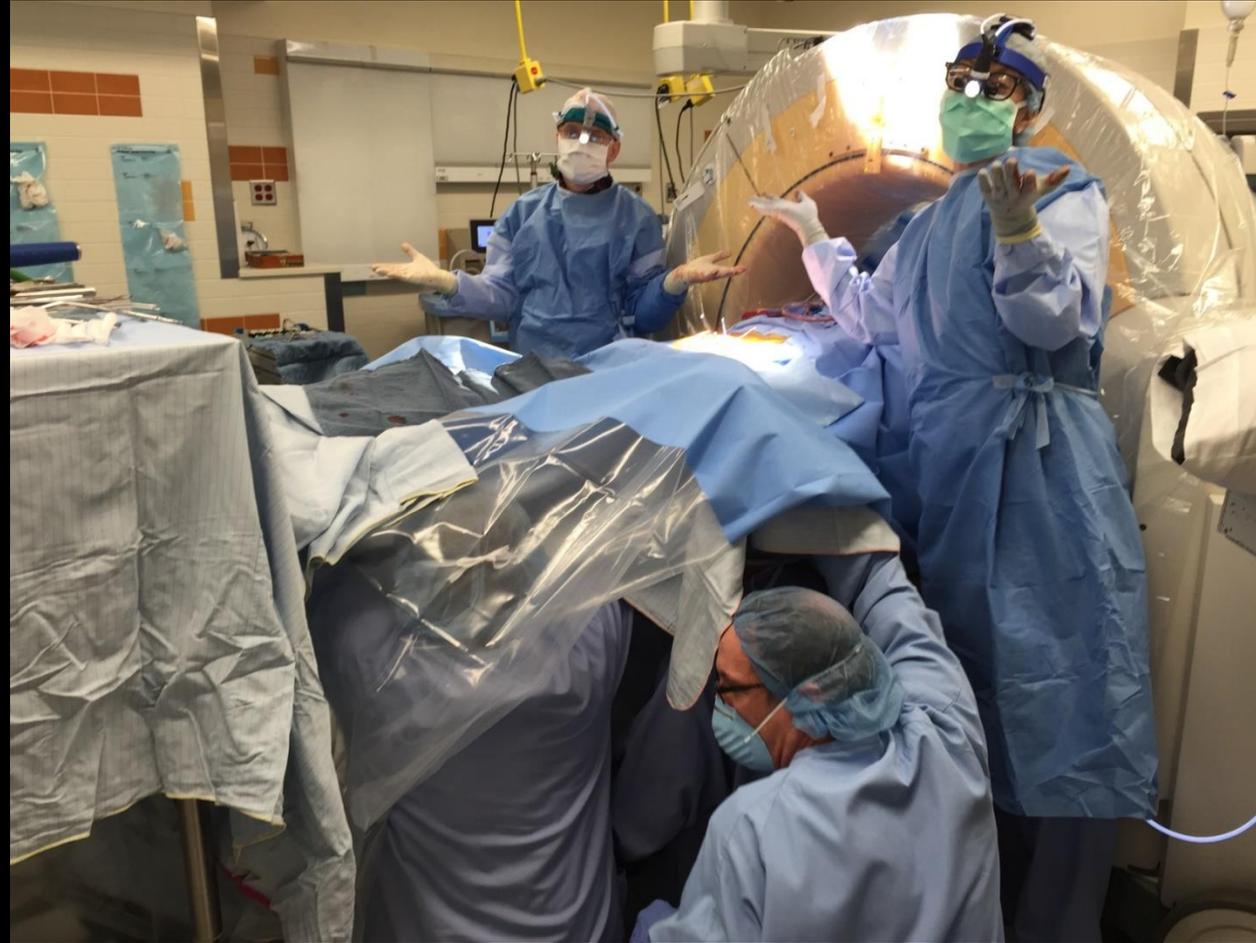
Adj Assistant Professor, Department of Orthopaedic Surgery



Goal of this talk:

The Real Answers as to How to Avoid
Complications in Spine Surgery.....

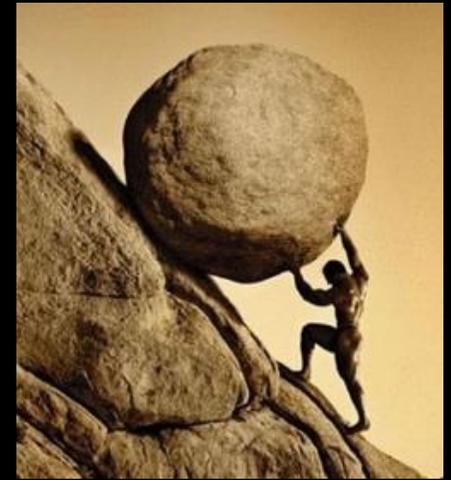
The Real Answers as to How to Avoid Complications in Spine Surgery.....



Overview

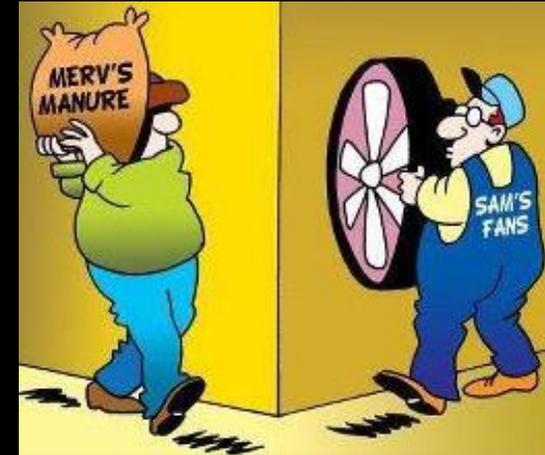
M_N Preoperative Risk: Identify & Optimize

-Checklist for Care Pathway and Management Strategy



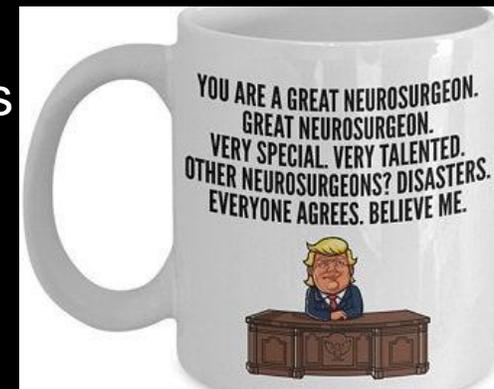
M_N Intraoperative Risk: Mitigate

-Briefing the Room, Setting Expectations, Managing Disasters



M_N Postoperative Risk: Prevent

-Strategies for Decreasing Postoperative Complications



Preoperative Risk Identification/Optimization

Rule #1- Have good indications for surgery.



Preoperative Risk Factor Optimization

Literature-based evidence that a systemic, collaborative approach to preoperative workup reduces patient complications in complex spine surgery

SPINE Volume 35, Number 25, pp 2232-2238
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Standardizing Care for High-Risk Patients in Spine Surgery

The Northwestern High-Risk Spine Protocol

Ryan J. Halpin, MD,* Patrick A. Sugrue, MD,* Robert W. Gould, MD,† Peter G. Kallas, MD,‡
Michael F. Schafer, MD,§ Stephen L. Ondra, MD,* and Tyler R. Koski, MD*

Study Design. Review article of current literature on the preoperative evaluation and postoperative management of patients undergoing high-risk spine operations and a presentation of a multidisciplinary protocol for patients undergoing high-risk spine operation.

Objective. To provide evidence-based outline of modifiable risk factors and give an example of a multidisciplinary protocol with the goal of improving outcomes.

Summary of Background Data. Protocol-based care has been shown to improve outcomes in many areas of medicine. A protocol to evaluate patients undergoing high-risk procedures may ultimately improve patient outcomes.

Methods. The English language literature to date was reviewed on modifiable risk factors for spine surgery. A multidisciplinary team including hospitalists, critical care physicians, anesthesiologists, and spine surgeons from neurosurgery and orthopedics established an institutional protocol to provide comprehensive care in the pre-, peri-, and postoperative periods for patients undergoing high-risk spine operations.

Results. An example of a comprehensive pre-, peri-, and postoperative high-risk spine protocol is provided, with focus on the preoperative assessment of patients undergoing high-risk spine operations and modifiable risk factors.

Conclusion. Standardizing preoperative risk assessment may lead to better outcomes after major spine operations. A high-risk spine protocol may help patients by having dedicated physicians in multiple specialties focusing on all aspects of a patient's care in the pre-, intra-, and postoperative phases.

Key words: spinal deformity, risk stratification, spine surgery, spine protocol. *Spine* 2010;35:2232-2238

Spinal deformity operations are focused on treating, pain, disability, sagittal and coronal imbalance, and reducing the risk of progressive deformity. The investment by the patient, physician, and health care industry in these procedures is enormous. The complications and reoperation rates on these patients are not trivial. As the population ages, more and more patients are seeking treatment for spinal disease. With improved surgical techniques and equipment, patient selection is being focused on not only the patients' spinal pathology itself, but also on the associated medical comorbidities. Before surgery, identifying and treating risk factors for peri- and postoperative complications can lead to a reduction in morbidity and overall improvement in patient outcomes.

■ The Northwestern High-Risk Spine Protocol

Preoperative Protocol

Our high-risk spine protocol was instituted in January 2007 with the goal of implementing a comprehensive pre-, intra-, and postoperative management strategy to reduce complications associated with spinal surgery. Protocol-based care has been shown to successfully decrease the number of days on mechanical ventilation,¹⁻⁶ reduce the incidence of thromboembolism,⁷ improve mortality from sepsis,^{8,9} reduce costs of a hospitalization,⁹ and reduce the incidence of drug-resistant bacterial infections.¹⁰ Our protocol facilitates improved collaboration and communication between the surgical, medical, and anesthetic teams. Patients are determined to be high risk if the surgeon anticipates >6 hours of sur-

Spine Deformity

www.spine-deformity.org

Spine Deformity 2 (2014) 95-103

Clinical Series

The Seattle Spine Team Approach to Adult Deformity Surgery: A Systems-Based Approach to Perioperative Care and Subsequent Reduction in Perioperative Complication Rates

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Received 6 May 2013; revised 4 December 2013; accepted 8 December 2013

Abstract

Study Design: Retrospective consecutive case review pre- and postintervention.

Objectives: Characterize the effects of the intervention.

Summary of Background Data: Complication rates in adult spinal deformity surgery are unacceptable. System approaches are necessary to increase patient safety. This group reported on the dual-attending surgeon approach, a live multidisciplinary preoperative screening conference, and the intraoperative protocol for the management of coagulopathy. The outcomes were demonstrated by complication rates before and after the institution of this protocol.

Methods: Forty consecutive patients in Group A were managed without the 3-pronged approach. A total of 124 consecutive patients in Group B had a dual-attending surgeon approach, were presented and cleared by a live multidisciplinary preoperative conference, and were managed according to the intraoperative protocol.

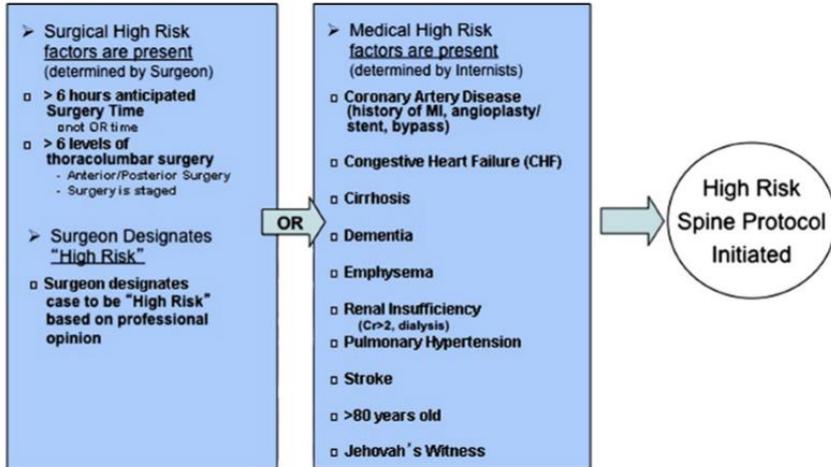
Results: Group A had an average age of 62 years (range, 39-84 years). Group B had an average age of 64 years (range, 18-84 years). Most patients in both groups had fusions from 9 to 15 levels. Complication rates in Group B were significantly lower (16% vs. 52%) ($p < .001$). Group B showed significantly lower return rates to the operating room during the perioperative 90-day period (0.8% vs. 12.5%) ($p < .001$). Group B also had lower rates of wound infection requiring debridement (1.6% vs. 7.5%), lower rates of deep vein thrombosis/pulmonary embolism (3.2% vs. 10%), and lower rates of postoperative neurological complications (0.5% vs. 2.5%) (not significant). Group B had significantly lower rates of urinary tract infection requiring antibiotics (9.7% vs. 32.5%) ($p < .001$).

Conclusions: These data suggests that a team approach consisting of a dual-attending surgeon approach in the operating room, a live preoperative screening conference, and an intraoperative protocol for managing coagulopathy will significantly reduce perioperative complication rates and enhance patient safety in patients undergoing complex spinal reconstructions for adult spinal deformity.

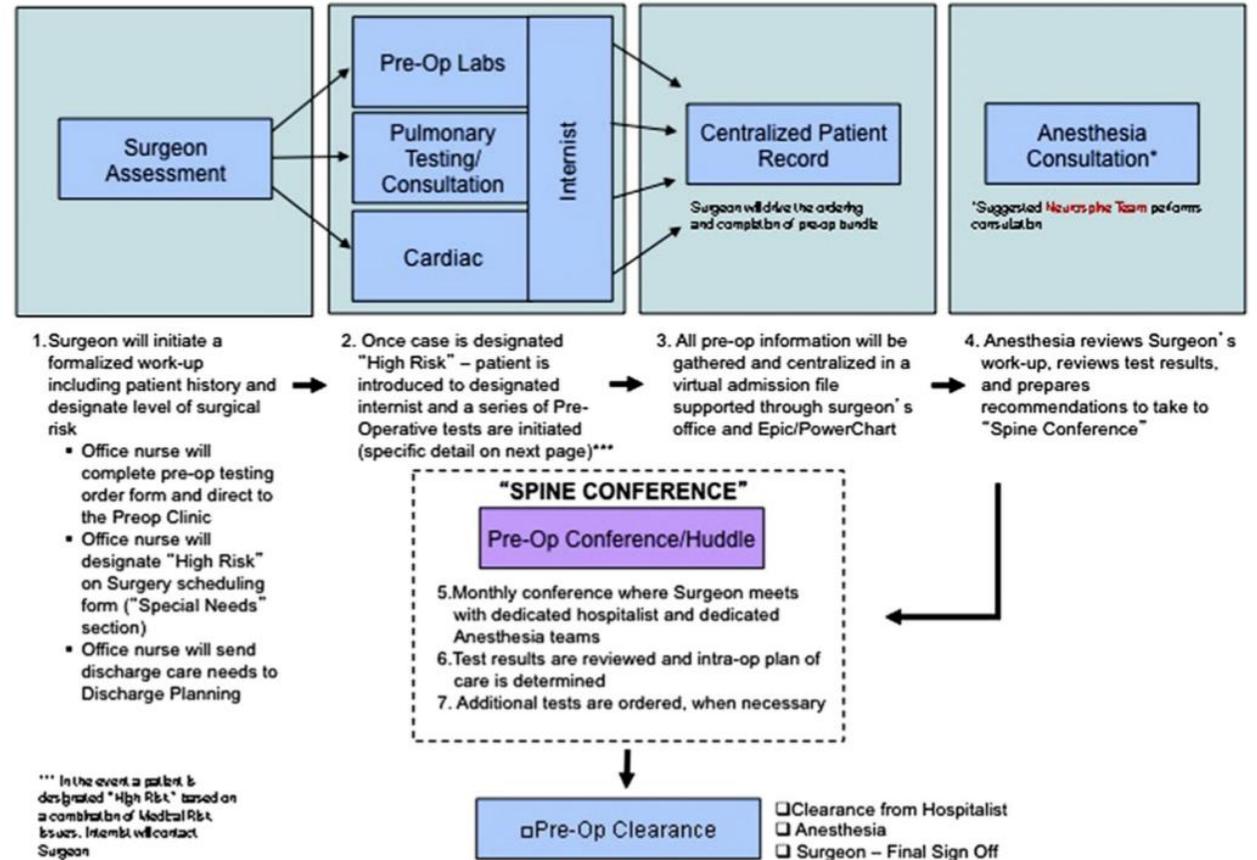
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High Risk Spine – Patient Criteria

A patient is determined "High Risk" when:

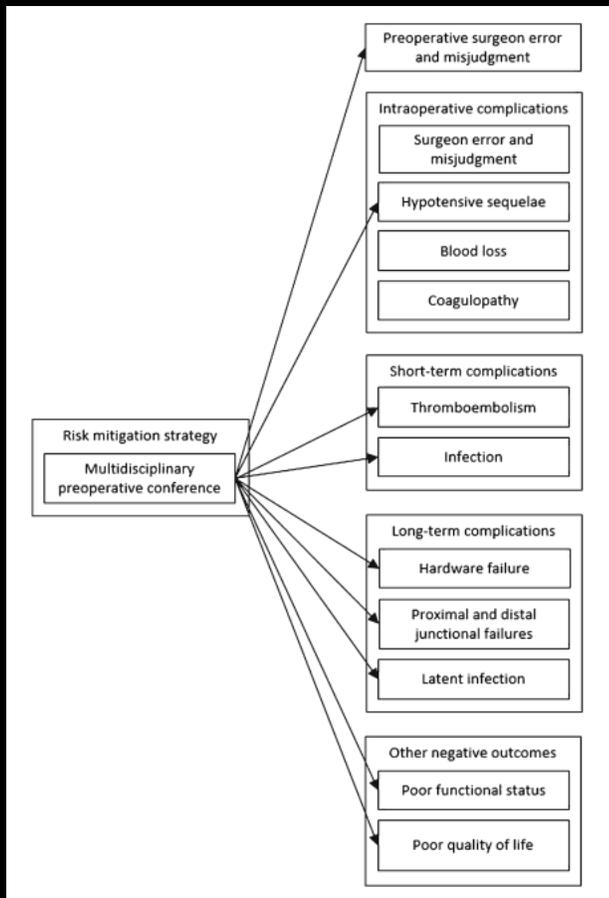


High Risk Spine - Pre-Operative Process



Adapted from: Sugrue PA, Halpin RJ, Koski TR. Treatment algorithms and protocol practice in high-risk spine surgery. Neurosurg Clin N Am. 2013 Apr;24(2):219-30.

University of Minnesota Complex Spine Preoperative Care Pathway



- protocol developed to identify preoperative patients at high risk
- standardized pre-operative workup imaging and lab checklist initiated by surgeon
- consultation with Preoperative Assessment Center (PAC)
- further workup performed as needed
- Multidisciplinary Complex Spine Conference held monthly; decisions on operative plan made collaboratively

Buchlak QD, Yanamadala V, Leveque JC, Sethi R. Complication avoidance with pre-operative screening: insights from the Seattle spine team. Curr Rev Musculoskelet Med. 2016 Sep;9(3):316-26.

Preop Risk Factors in Spine Surgery

-Age

-Medical co-morbidities

-Cardiac, Pulmonary, Renal, Hepatic; Anti-coagulation usage; Cancer

-Bone health/healing

-osteoporosis, vitamin D deficiency, diabetes, steroid-usage, nicotine

-Soft tissue health/healing

-obesity, protein malnutrition, nicotine, rheumatoid arthritis, DMARDs, scar tissue

-Perception of pain/functional outcome

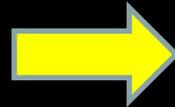
-depression, long-term opioid dependency, workman's compensation claim, nicotine



Preop Risk Factor Evaluation in Spine Surgery

-Age

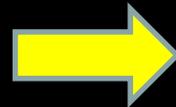
-Medical co-morbidities



Preoperative Subspecialty Eval

-Cardiac, Pulmonary, Renal, Hepatic; Anti-coagulation usage; Cancer

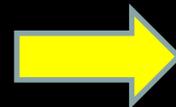
-Bone health/healing



DEXA and 25-OH vitamin D level

-osteoporosis, vitamin D deficiency, diabetes, steroid-usage, nicotine

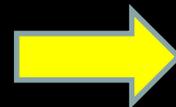
-Soft tissue health/healing



BMI, albumin, prealbumin, Hgb A1C,
Nutrition consultation, Pre-Hab

-obesity, protein malnutrition, nicotine, rheumatoid arthritis, DMARDs, scar tissue, cancer

-Perception of pain/functional outcome



Mental Health and Chronic Pain Referral/Evaluation

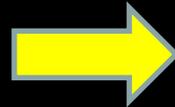
-depression, long-term opioid dependency, workman's compensation claim, nicotine



Preop Risk Factor Management in Spine Surgery

-Age

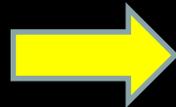
-Medical co-morbidities



Preoperative Subspecialty Eval

-Cardiac, Pulmonary, Renal, Hepatic; Anti-coagulation usage; Cancer

-Bone health/healing



DEXA and 25-OH vitamin D level

-T-score < -2.5 or BMD <0.6, anabolic osteogenic medication
-25-OH D <30 needs preop supplementation

-Soft tissue health/healing



BMI, albumin, prealbumin, Hgb A1C,
Nutrition consultation, Pre-Hab

-Hard Stops: BMI >40 in elective surgery, albumin <3.5 or prealbumin <15, Hgb A1C >7.5

-Perception of pain/functional outcome



Mental Health and Chronic Pain Referral/Evaluation

-plan by Chronic Pain team for perioperative pain management strategy, and clearance from Mental Health provider



Nutrition

Controllable Risk Factors in Spine Surgery

M_N *Normal or obese weight does NOT mean someone has normal or “extra good” nutrition*
“Malnutrition”- Serum albumin <3.5g/dL or total lymphocyte count less than 1500-2000 cells/mm³

M_N Direct relationship between surgical complexity and caloric/protein requirements for healing

Lenke LG, Bridwell KH, Blanke K, Baldus C. Prospective analysis of nutritional status normalization after spinal reconstructive surgery. *Spine (Phila Pa 1976)*. 1995 Jun 15;20(12):1359-67. PubMed PMID: 7676333.

M_N albumin, pre-albumin, total protein, transferrin, and the absolute lymphocyte count were investigated before surgery and at various time points after surgery.

M_N RESULTS: Forty-four patients (Group A) with an average 6.4 fusion levels returned to their preoperative baseline nutritional values by 6 weeks after surgery, whereas 13 patients (Group B) with a statistically increased number of fusion levels of 13.8 (P = 0.0009) took 12 weeks or longer to return to their preoperative baseline.

M_N Risk factors: increased total number of fusion levels, especially 10 or more (P < 0.05); patients undergoing circumferential fusions (P < 0.05); and, to a lesser extent, older patients undergoing multiple fusion levels (P = 0.055).

M_N Malnutrition increased risk for infection and wound dehiscence

Klein JD, Hey LA, Yu CS, Klein BB, Coufal FJ, Young EP, Marshall LF, Garfin SR. Perioperative nutrition and postoperative complications in patients undergoing spinal surgery. *Spine (Phila Pa 1976)*. 1996 Nov 15;21(22):2676-82. PubMed PMID: 8961455

M_N METHODS: 114 patients, elective lumbar fusion, retrospective review

M_N preoperative nutritional status was an extremely significant independent predictor of postoperative complications in patients undergoing elective lumbar spinal fusion (P = 0.0018).

M_N 25% of patients undergoing elective lumbar spine surgery are nourished inadequately at surgery. This number is higher (42%) in older patients

Nutrition

Controllable Risk Factors in Spine Surgery

M_N Dx: Serum albumin <3.5g/dL
or total lymphocyte count less
than 1500-2000 cells/mm³

M_N Rx: preoperative nutritional
supplementation to achieve
per day intake:

1 gram protein/kg/day

M_N Perioperatively: 1.5-2 g/kg/day

Chernoff R. Protein and older adults. *J Am Coll Nutr.* 2004;23(6 suppl):627S-630S.

Escott-Stump S. *Nutrition and Diagnosis-Related Care.* 7th ed. Baltimore, MD: Lippincott Williams & Wilkins; 2011.



Obesity

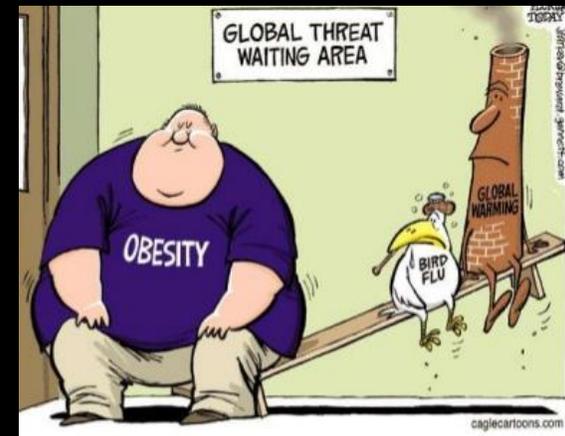
Controllable Risk Factors in Spine Surgery

- MN** 10, 387 patients; retrospective cohort analysis of prospectively collected data using the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) database from 2005 to 2010.
- MN** 4.5% anterior fusion, 17.9% posterior fusion, 6.3% TLIF/PLIF, 40.7% discectomy, and 30.5% decompression.
- MN** OUTCOME MEASURES: 30-day postsurgical complications (UTI, PE, DVT, wound infection). Secondary outcomes were time spent in the operating room, blood transfusions, length of stay, and reoperation within 30 days.
- MN** RESULTS: On multivariate analysis, BMI >35 patients had a significantly increased risk of wound complications.
- MN** BMI>40 patients had a statistically increased risk of having increased time spent in the operating room, an extended length of stay, pulmonary complications, and having one or more complications (all $p<.05$).
- MN** CONCLUSIONS: *Patients with high BMI appear to have higher complication rates after lumbar surgery than patients who are nonobese. However, the complication rates seem to increase substantially for BMI >40.* These patients have longer times spent in the operating room, extended hospitals stays, and an increased risk for wound, urinary, and pulmonary complications and for having at least one or more complications overall. Surgeons should be aware of the increased risk of multiple complications for patients with BMI greater than or equal to 40 kg/m².

Buerba RA, Fu MC, Gruskay JA, Long WD 3rd, Grauer JN. Obese Class III patients at significantly greater risk of multiple complications after lumbar surgery: an analysis of 10,387 patients in the ACS NSQIP database. Spine J. 2014 Sep 1;14(9):2008-18.

Obesity

Controllable Risk Factors in Spine Surgery



You CAN definitively tell your patients that obesity is associated with increased complications after spine surgery.

- Morbid obesity (BMI >40) is prohibitive for elective spine surgery at our institution due to risk-benefit stratification

Management Strategies:

- Referral to Nutrition/Dietary
- Referral to Weight Management; potential for Bariatric Surgery referral
- Referral to Physical Therapy for exercise regimen
- set weight goals and check-ins (Accountability!)

Intraoperative Risk Mitigation

The Implementation and Efficacy of the Northwestern High Risk Spine Protocol

Carine Zeeni¹, Louanne M. Carabini^{2,3}, Robert W. Gould², John F. Bebawy^{2,3}, Laura B. Hemmer^{2,3}, Natalie C. Moreland², Tyler R. Koski³, Antoun Koht^{2,4}, Michael F. Schafer⁵, Stephen L. Ondra², Dhanesh K. Gupta^{2,3}

Key words

- Checklist
- Critical pathways
- Hemostasis
- Patient care team
- Spinal fusion

Abbreviations and Acronyms

CRYO: Cryoprecipitate
FFP: Fresh frozen plasma
HRS: High risk spine
PRBC: Packed red blood cells
RBC: Red blood cells

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<http://dx.doi.org/10.1016/j.wneu.2014.06.020>

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Available online: www.sciencedirect.com

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■ **OBJECTIVE:** The aims of this study were to determine the efficacy and feasibility of implementation of the intraoperative component of a high risk spine (HRS) protocol for improving perioperative patient safety in complex spine fusion surgery.

■ **METHODS:** In this paired availability study, the total number of red blood cell units transfused was used as a surrogate marker for our management protocol efficacy, and the number of protocol violations was used as a surrogate marker for protocol compliance.

■ **RESULTS:** The 548 patients (284 traditional vs. 264 HRS protocol) were comparable in all demographics, coexisting diseases, preoperative medications, type of surgery, and number of posterior levels instrumented. However, the surgical duration was 70 minutes shorter in the new group (range, 32–108 minutes shorter; $P < 0.0001$) and the new protocol patients received a median of 1.1 units less of total red blood cell units (range, 0–2.4 units less; $P = 0.006$). There were only 7 (2.6%) protocol violations in the new protocol group.

■ **CONCLUSIONS:** The intraoperative component of the HRS protocol, based on two Do-Confirm checklists that focused on 1) organized communication between intraoperative team members and 2) active maintenance of oxygen delivery and hemostasis appears to maintain a safe intraoperative environment and was readily implemented during a 3-year period.

-Checklists are utilized throughout medical care to enhance process adherence and standardization

-Defining roles for each team member in the Operating Room helps each person work to their maximal capacity

-Checklists for each personnel role encourage accountability and increase safety in stressed environments

Zeeni C, Carabini LM, Gould RW, Bebawy JF, Hemmer LB, Moreland NC, Koski TR, Koht A, Schafer MF, Ondra SL, Gupta DK. The implementation and efficacy of the Northwestern High Risk Spine Protocol. *World Neurosurg.* 2014 Dec;82(6):e815-23.

Intraoperative Risk Mitigation in Spine Surgery

PEER-REVIEW REPORTS

CARINE ZEENI ET AL. NORTHWESTERN HIGH RISK SPINE PROTOCOL

Table 1. Intraoperative Verbal Communication Guidelines	Table 2. Active Management of Oxygen Delivery & Hemostasis Guidelines
<p>1. Anesthesia Team to Surgical Team</p> <p>a. Vital signs</p> <ul style="list-style-type: none"> i. Hemodynamics ii. Temperature iii. Cumulative blood loss <p>b. Laboratory data</p> <ul style="list-style-type: none"> i. Hemoglobin and oxygenation ii. Acid-base status iii. Coagulation <p>c. Any potential issues for balance of case</p> <p>2. Surgical Team to Anesthesia Team</p> <p>a. Current step in surgical procedure</p> <p>b. Observed blood loss and clotting</p> <p>c. Warning before performing major vertebral osteotomies</p> <ul style="list-style-type: none"> i. If coagulopathic or anemic, pause for management of administration of appropriate blood products before next step ii. After 6 hours, Go/No-Go decision to proceed based on patient's current physiologic state <p>3. Neurophysiological Monitoring Team to Anesthesia Team and Surgical Team</p> <p>a. Change in evoked potentials</p> <ul style="list-style-type: none"> i. >10% increase latency ii. >50% decrease amplitude 	<p>1. Oxygen delivery</p> <p>a. Intravascular volume</p> <ul style="list-style-type: none"> i. Calculate estimated blood volume ii. Monitor hourly estimated blood loss iii. Monitor hourly urine output iv. Maintain clinical euvolemia with intravascular fluid therapy <p>b. Hemoglobin transfusion trigger</p> <ul style="list-style-type: none"> i. Moderate/severe cardiovascular disease: Hgb \geq10 g/dL ii. Mild/minimal cardiovascular disease: Hgb \geq8 g/dL <p>c. Goal mean arterial pressure</p> <ul style="list-style-type: none"> i. Moderate/severe cardiovascular disease: \pm10%–15% baseline ii. Mild/minimal cardiovascular disease: \pm20% baseline <p>d. Laboratory evaluation</p> <ul style="list-style-type: none"> i. Hemoglobin, hematocrit ii. Arterial blood gas (including ventilator settings, lactate) iii. Electrolytes (Na⁺, K⁺, Ca⁺⁺, bicarbonate) <p>2. Hemostasis</p> <p>a. Laboratory evaluation</p> <ul style="list-style-type: none"> i. Platelet ii. PT, PTT, INR iii. Fibrinogen (Fib) <p>b. Platelet transfusion</p> <ul style="list-style-type: none"> i. Order platelet dose when <150,000 ii. Transfuse platelet dose when <100,000 <p>c. Fibrinogen maintenance</p> <ul style="list-style-type: none"> i. Thaw cryoprecipitate when fibrinogen <200 mg/dL ii. Administer cryoprecipitate when fibrinogen <150 mg/dL <p>d. If patient is oozing and Fib >200 mg/dL and Plt >100,000</p> <ul style="list-style-type: none"> i. Desmopressin (DDAVP) 0.3 μg/kg <p>e. If patient is still oozing after DDAVP and INR >2.0</p> <ul style="list-style-type: none"> i. 20 μg/kg activated Factor VII (rVIIa)
Reported hourly or when significant changes occur.	Laboratory tests measured every 2 hours for initial 6 hours, then hourly. Hgb, hemoglobin; Plt, platelet; PT, prothrombin time; PTT, partial thromboplastin time; INR, international normalized ratio; Fib, fibrinogen.

development of checklists specifically targeting neurosurgical procedures (1, 27, 31). The aim of this study was to determine the efficacy of the intraoperative component of the HRS Protocol in improving intraoperative patient safety in complex spine fusion surgery. We used

Zeeni C, Carabini LM, Gould RW, Bebawy JF, Hemmer LB, Moreland NC, Koski TR, Koht A, Schafer MF, Ondra SL, Gupta DK. The implementation and efficacy of the Northwestern High Risk Spine Protocol. *World Neurosurg.* 2014 Dec;82(6):e815-23.

Intraoperative Risk Mitigation in Spine Surgery

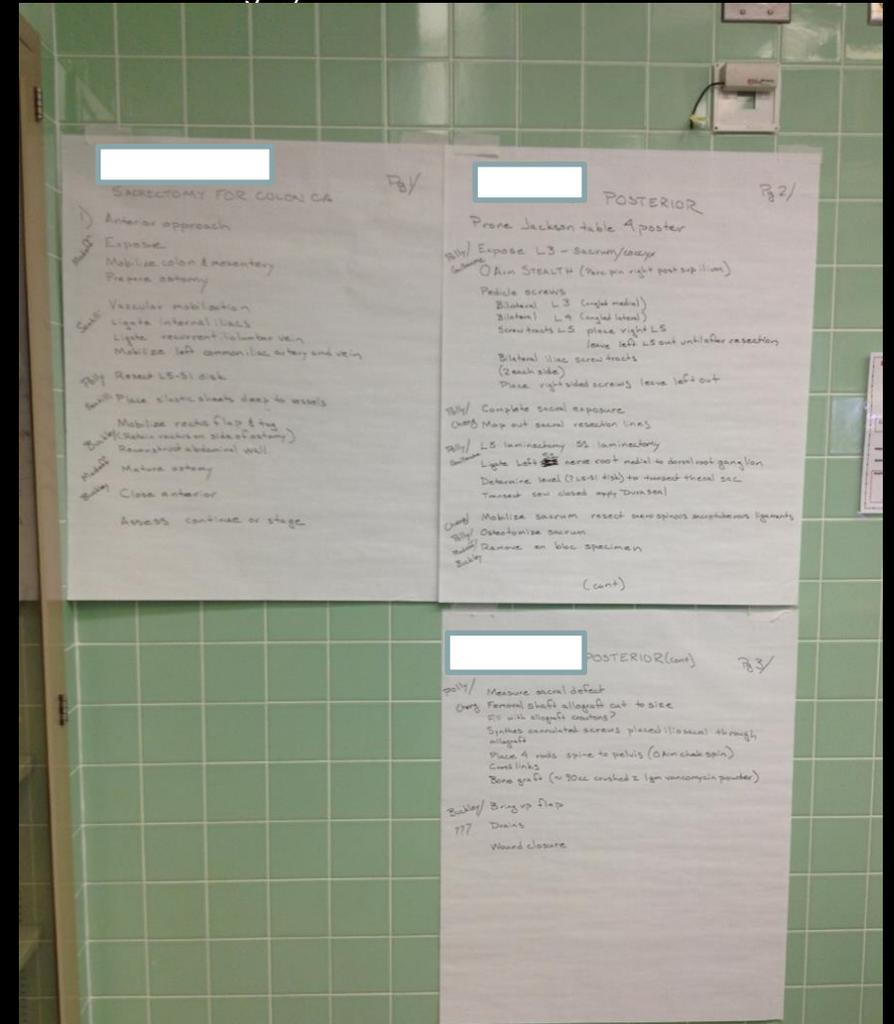
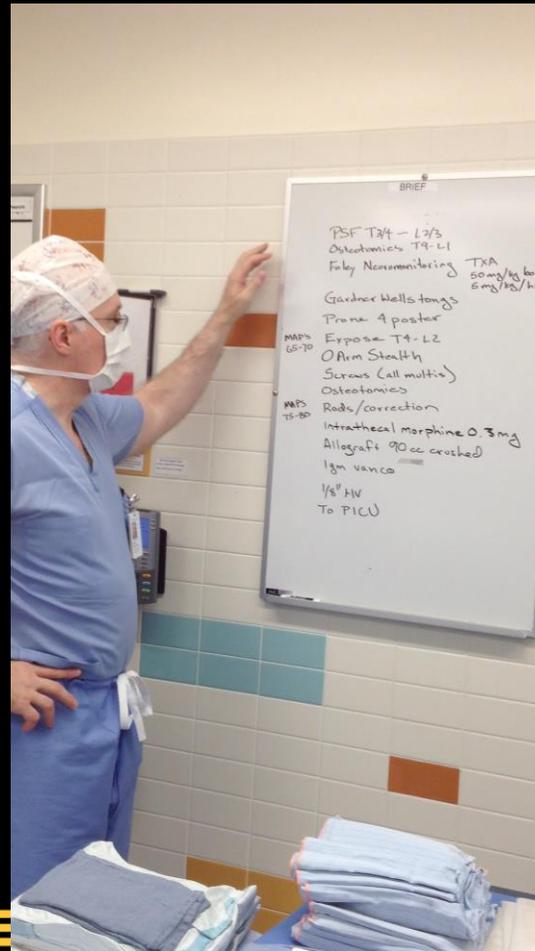
- M_N** Dual-surgeon approach for complex cases
- M_N** Tranexamic acid and Cell-Saver for reduced EBL
- M_N** My discussion with Anesthesia before EVERY case starts:
 - Anticipated blood loss and operative time
 - any decision points or critical portions of case
 - “I’d like the attending anesthesiologist to be in the room for...”
 - Blood product availability, lab timing, Transfusion thresholds
 - Neuromonitoring usage, pharmacologic paralytic strategy
 - Goals of blood pressure for case
 - (reduction to minimize EBL vs. elevation for cord perfusion)



Intraoperative Risk Mitigation: The In-Room Brief Prior to Patient Arrival

Purpose:
Organize the entire team for a shared vision on the surgery

DiGeorge Syndrome
Irridated blood
Calcium issues
Prior heart surgery
[Hourly updates EBL / U/O / PH / Cat+]
Foley
Halo already on (cut slot in face pillow)
Prone 4 poster
Tx ~ 25#
Prep drape
Expose T2 - L5
O Arm STEALTH
Place screws (see map)
Temporary distraction rod
DECISION POINT - PICU
IF no, close (1/8 HV), leave HALO
Smith Petersen Osteotomies ~ T10 - L4
Possible vertebral resection L1/T12/L2
Allograft 90-120cc crushed 1gm vanco
1/8" Hemovac
Closure
Peds ICU



Intraoperative Risk Mitigation

Patient Positioning Pearls



GERY

N

Intraoperative Risk Mitigation

Room Setup to Maximize Work Flow and Minimize Traffic



Intraoperative Risk Mitigation

Infection Reduction Pathway

- M_N** Utilize frequent wound irrigation
- M_N** Change gloves at set intervals
- M_N** Re-dose IV antibiotics prior to half-life
- M_N** Use intrawound topical antibiotics for open posterior fusions
- M_N** Minimize operative time and blood loss
- M_N** Minimize traffic through room

Intraoperative Risk Mitigation

Neuromonitoring Alert Checklist Protocol

- Entire room has “Hard Stop” and is informed of Alert
- Turn off ambient music and focus attention on checklist
- Checklist posted in room for easy viewing
- Many alerts are false positive, but the routine is the same

Checklist for Neuromonitoring (MEP) Alert in Patients with Myelopathy or Deformity

Spine Surgeon:

- Stop current manipulation
- Assess field for structural cord compression (misplaced hardware or bone graft, osteophytes, or hematoma)
 - Perform further decompression if stenosis is present
- Consider reversing correction of a spinal deformity

Neurophysiologist:

- Repeat trials of MEPs and SSEPs to rule out potential false positive
- Check all leads to make sure no pull-out, may add leads in proximal muscle groups if possible
- Assess the pattern of changes
 - Asymmetric changes (associated with cord or nerve root injury)
 - Symmetric changes (associated with anesthetic or hypotension issues)
- Quantify improvement and communicate to the surgical team

Anesthesiologist:

- Check if neuromuscular blockade (muscle relaxant) given
 - If yes, Check train of four (TOF)
- Verify that no change in anesthetic administration occurred
- Assess anesthetic depth
 - BP RR HR BIS monitor (if available)
- Restore or maintain blood pressure (goal mean arterial pressure of 90-100)
- Check Hemoglobin/Hematocrit (goal hemoglobin >9-10)
- Check temperature and I/O's for adequate resuscitation
- Check extremity position in case of plexus palsy
- Lighten depth of anesthesia
 - Reduce to 1/3 MAC or temporarily eliminate inhaled agents (i.e. desflurane)
 - Reduce intravenous anesthetics such as propofol (which may accumulate systemically during the case and blunt MEPs)
 - Add adjuvant agents such as Ketamine to permit reduction of MEP suppressive agents (i.e. propofol and inhalational anesthetics)

IF No Change:

- Increase MAP >100
- Consider Steroid Administration
- Consider Wake-up test
- Consider Aborting surgery
- Consider Calcium Channel Blocker (topical to cord or iv)

*The checklist assumes baseline anesthetic regimen is 1/3-1/2 MAC of halogenated anesthetic (desflurane) and TIVA (total intravenous anesthesia) with propofol +/- ketamine.

Fig. 2. Checklist for the response to an intraoperative neuromonitoring alert. BIS = bispectral index; BP = blood pressure; HR = heart rate; I/O = input/output; MAC = minimum alveolar concentration; MAP = mean arterial pressure; MEP = motor evoked potential; RR = respiration rate; SSEP = somatosensory evoked potential.

Ziewacz JE, Berven SH, Mummaneni VP, Tu TH, Akinbo OC, Lyon R, Mummaneni PV. The design, development, and implementation of a checklist for intraoperative neuromonitoring changes. Neurosurg Focus. 2012 Nov;33(5):E11.

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Postoperative Risk: Prevention!!!

- Actually starts far before the time of surgery
- Enhanced Recovery After Surgery (ERAS) pathway
 - early ambulation/mobilization
 - nutrition supplementation (protein; vita A/C/D/E/zinc/calcium)
 - tight glucose control (goal <110)
 - multimodal pain management, not just opioids
 - IV Tylenol, gabapentin, IV lidocaine, liposomal bupivacaine*

Postoperative Risk: Prevention!!!

- Early identification of concerns: nursing hotline, outpt workup
 - can use CRP trend at about 7-8 days postop if infection concern
- Clear communication with patient about medications
 - anticoagulants, NSAIDs, steroids, DMARDs
 - importance of continuing protein supplementation and vitamins
 - involvement of PCP with postop medication strategy

University of Minnesota ERAS Pathway- Complex Spine

Result of Collaboration Between :

- Orthopaedic Spine Surgery
- Neurosurgery
- Anesthesiology
- Critical Care Medicine
- Pain Management Service
- Internal Medicine
- Pharmacology
- Nursing
- IT Dept
- Epic Support Staff
- Physical and Occupational Therapy

MINNESOTA
NEUROSURGERYSM

M Health ERAS Pathway Complex Spine Thoraco/Lumbar Fusion – ADULT

The Complex Spine ERAS Pathway is appropriate for an ADULT patient undergoing a Thoracic or Lumbar Spinal fusion greater than or equal to 3 levels or with expected blood loss of 500cc or greater. This Pathway is not intended for a PEDIATRIC patient.

Some patients (i.e. progressive neurologic deficits or myelopathy) may be scheduled for surgery even if they have a "hard stop" (per Surgeon discretion).

Surgeon Clinic

- Assess patient for "Hard Stops." IF patient exceeds one of the markers below, delay surgery until the deficiency is corrected.
 - BMI in excess of 40. IF BMI greater than 40, refer patient for a Nutrition consult.
 - Any nicotine use. If suspicion of nicotine use, order urine nicotine. If patient is active smoker or if they have a positive screen, offer smoking cessation counseling.
 - IF no DEXA available, Surgeon will assess bone density using the Hounsfield units tool on the CT scan.
 - Assessment is made at the L1 level using axial cuts at the level of the pedicle.
 - ROI measurement is taken, but the circle should not touch the cortices.
 - IF the Hounsfield units are less than 135, Surgeon orders a formal DEXA scan and the patient is referred for bone density management.
 - IF clinical suspicion of osteoporosis (i.e. patient is post-menopausal, diabetic, former smoker, severely osteopenic on x-ray, or has first degree relative with osteoporosis), surgeon may order DEXA.
 - IF patient has a DEXA, refer patient for Endocrine management if the lowest T-Score is below -2.
- LAB work: albumin, hemoglobin, 25-OH Vitamin D, HbA1c.
 - Obtain 25 – OH Vitamin D levels on every patient.
 - IF result LESS than 30, delay surgery until treated with ergocalciferol 50,000IU once per week AND cholecalciferol 2000 IU daily is initiated. Recheck Vitamin D in 4 weeks.
 - IF 25-OH vitamin D level remains LESS than 30, refer patient to Endocrinology.
- IF patient on time specific, short-term anti-coagulation, notify Surgical Coordinator and delay surgery until need for anti-coagulation passes.
- Order PAC visit with "Complex Spine Fusion" noted as reason.
- Consider Chronic Pain Consult for complex opioid history.
- Order TXA as appropriate (see below).
- Surgeon or team member will order appropriate Antibiotic:
 - ceFAZolin (ANCEF) with appropriate weight based dosing.
 - clindamycin (CLEOCIN) with documented allergy.
 - Consider allergy testing referral if history of allergy (or severity of allergy) is unclear. ceFAZolin (ANCEF) provides broader coverage than clindamycin (CLEOCIN) and is the antibiotic of choice.
 - vancomycin (VANCOCIN) with MRSA positive history or if MRSA carrier by nasal testing.
- Order Peri-Incisional injection cocktail if appropriate (see Intra-Operative Management section below).

The ERAS pathway elements are evidence based using statistical averages and expert opinions; they are NOT an inflexible set of dogmatic rules. Clinical judgment is always required to adjust to an individual patient.

- Order "Pre-hab" and explain benefits to the patient. Pre-hab will consist of 6-weeks of water based aerobics or low impact cardiovascular strengthening (stationary bicycle) with additional emphasis on static core strengthening exercises (such as plank holds). Advise patient to participate in Pre-hab three times per week. Patient reports are mailed to Surgeon.

PRE-OPERATIVE MANAGEMENT

Pre-Admission Clinic (PAC)

- Assess current and prior narcotic usage.
- Document daily Oral Morphine Equivalents (OME) for EVERY patient.
 - IF daily OME over 60 mg, patient to see clinical pharmacist to develop and document post-op pain management plan.
 - IF daily OME over 120 mg obtain a Pain Management Referral.
- Assess Anti-Coagulation:
 - IF patient on chronic warfarin (COUMADIN), enoxaparin (LOVENOX), clopidogrel (PLAVIX), or novel oral anticoagulants hold and bridge per the guidelines for patient having total joint arthroplasty.
 - IF patient on ASA: Hold for 5-7 days pre-operatively. Define timeline for postoperative resumption of aspirin therapy on an individual basis.
- Laboratory work and follow up on results from surgeon visit.
 - HbA1c: If result GREATER than 8 g/dL, consider delay of surgery (PCP vs. Endocrine consult).
 - Serum albumin: If result LESS than 3.5, refer patient for Nutrition counseling. Notify Surgical Coordinator and delay surgery. Recheck serum albumin in 1 month.
 - Hgb < 12: Consider delay until Hgb is 12 g/dL or higher.
 - Anemia management: Order iron panel (TIBC, Serum Ferritin, and Serum Iron). If iron deficient, start oral iron therapy and notify Surgical Coordinator. Recheck Hgb in 30 days. If Hgb still LESS than 12 gm/dL, initiate iron infusions (1 gm) over 2 weeks.
 - IF patient has anemia NOT due to iron deficiency, refer to Hematology for workup
 - CBC, BMP, T&S, and Urinalysis on all. EKG per policy.
 - Consider: Stress echo IF patient has a prior history of MI/CHF/ Arrhythmia.
 - Consider: PFT's and Pulmonology consult IF patient has a history of restrictive lung disease or COPD, or they are undergoing a thoracic osteotomy for kyphosis correction.
 - Staph nasal swabs for MRSA and MSSA:
 - IF patient is MRSA positive, give 2% mupirocin ointment to use twice a day for 5 days PRIOR to surgery. Notify Surgical Coordinator to change antibiotic order to vancomycin (VANCOCIN).
 - F patient is MSSA positive, give 2% mupirocin ointment to use twice a day for 5 days PRIOR to surgery. Notify Surgical Coordinator to change the antibiotic order to vancomycin (VANCOCIN).
 - Give every patient chlorhexidine 4% soap and incentive spirometer. Instruct patient to use chlorhexidine 4% soap ONCE daily for 5 days PRIOR to surgery, and day of surgery.
 - Call patient 1 week prior to surgery to confirm use of 2% mupirocin ointment and use of body scrub.
 - Teach ERAS guidelines for nutrition, activity, food intake,

University of Minnesota ERAS Pathway- Complex Spine

- and pain management.
- Place all pre-operative medication orders approved by the Surgeon in the PRE OP holding area.
 - Oral acetaminophen (TYLENOL) 975mg
 - Oral gabapentin (NEURONTIN) 600 mg
 - Scopolamine patch (if appropriate)
- Assess need for bronchodilators and order if needed.

PRE OP and DAY of SURGERY MANAGEMENT

Nursing

- Follow [Glycemic Management of the Adult Perioperative Patient - UMMC Guideline](#).
- Encourage patient to void within 30 minutes of going to the OR. (Document time of void).
- Insert indwelling urinary catheter (Foley) in the OR.
- Place Pneumatic Compression Device (PCD) and forced air warmer (BAIR) on patient. DO NOT use compression stockings.
- Give PO meds and nebulizers as ordered.
- Continue routine opioids on the day of surgery and document dose and time of home opioid.
- Leave fentaNYL (SUBLIMAZE) patches in place during surgery and document dose and time of patch placed at home.
- IF vancomycin (VANCOCIN) ordered, start infusion in PRE OP no later than 30 minutes before scheduled surgery start time to ensure infusion has time to complete prior to incision.

Anesthesia

- Limit benzodiazepine unless warranted.

INTRA-OPERATIVE MANAGEMENT

Surgeon

- Peri-Incisional injection administered at end of case. Surgeon will inject 1/5 of above the fascia and 1/5 below the fascia in the paraspinal muscles. **NOTE:** Peri-Incisional injection is Surgeon or case dependent. 100 mL solution of: ropivacaine 400 mg, morphine 5 mg, epinephrine 0.6 ml (1:1000), diluted in NS.
- tranexamic acid (CYKLOKAPRON) if ordered.

Anesthesia

- Goal-directed fluid therapy (FloTrak)
- Bispectral Index (BIS) monitoring
- IF acetaminophen (TYLENOL) not given in PRE OP, consider rectal administration.
- Dexamethasone (DECADRON) 10 mg of at the start of case **ONLY** if approved by Surgeon. (*Steroid use by Anesthesia MUST be cleared with Surgeon at time of case*).
- Use forced air warming device to maintain body temperature GREATER than 36 C.
- Anesthetic Management:**
 - Magnesium Sulfate: 2 gm IV once unless contraindicated
 - Induction with propofol or etomidate
 - Paralysis for induction and positioning UNLESS baseline MEPs needed. Limit induction dose of Rocuronium to 0.6 mg/kg (IDEAL BODY WEIGHT). No dosing after patient is in prone position.
 - Ketamine (KETALAR): 0.2 mg/kg load (IDEAL BODY WEIGHT) followed by 5-10 mg/hour infusion. Continue

- infusion UNINTERRUPTED into PACU (continue OR infusion pump until PCA pump available) on PCU.
- Volatile agent as allowed by neuromonitoring.
 - Propofol (DIPRIVAN) 25 – 150 mcg/kg/min, (TOTAL BODY WEIGHT). Titrate to BIS between 40 and 60. AVOID burst suppression.
- Opioid Management:**
 - Sufentanil (SUFENTA) infusion beginning at 0.2 mcg/kg/hour (titrate as needed), based on IDEAL BODY WEIGHT. Titrate infusion as indicated by hemodynamic and respiratory parameters. Sufenta boluses 5 mcg IV PRN as indicated by hemodynamic and respiratory parameters through end of surgery. Terminate sufenta infusion 30 - 40 minutes prior to end of surgery (approximately at beginning of skin closure).
- Antibiotics:** Administer *WITHIN* 60 minutes of incision:
 - ceFAZolin (ANCEF): 2 gram bolus prior to incision, repeat 1 gram every 2 hours
 - vancomycin (VANCOCIN): 1 gram administered over 60 minutes to finish prior to incision; repeat 1 gram every 8 hours or as indicated by pharmacy.
- Follow [Glycemic Management of the Adult Perioperative Patient - UMMC Guideline](#).
- PONV Prevention:** ondansetron (ZOFRAN) 4mg IV if not given earlier in the case.
- Tranexamic acid (CYKLOKAPRON) infusion. Discuss with Surgeon. Do NOT use if high risk of coronary thrombosis or CVA.
 - **High** dose: 30 mg/kg bolus followed by 10 mg/kg/hour
 - **Medium** dose: 10 mg/kg bolus followed by 5 mg/kg/hour
 - **Low** dose: 10 mg/kg bolus followed by 1 mg/kg/hour
- Labs drawn on schedule:**
 - Hemoglobin and coags every 2h
 - Fibrinogen hourly
 - TEG q2h or as clinically indicated. TEG to be performed prior to infusion of any coagulation product (platelet, cryoprecipitate, fresh frozen plasma)
- Blood and Factor Replacement:**
 - Cell saver in the operating room for any open exposure of more than 3 levels or anticipated EBL of over 500 cc.
 - Packed red blood cells transfused to maintain intra-operative Hg greater than 8mg/dL.
 - Factor replacement as determined by TEG (or in 1:1 ratio with blood products starting with the second unit of transfused pRBC if TEG is not available). Cryoprecipitate infused if fibrinogen is LESS than 150.

POST- ANESTHESIA RECOVERY UNIT (PACU)

Nursing – PACU

- EVERY patient receives Sequential Compression Device (SCD). Nursing will verify placement and confirm the machine is on with each vitals check.
- HOLD all *Pharmacological* DVT prophylaxis unless otherwise directed by Surgeon.
- Clear liquids as tolerated. Encourage PO intake.
- LR at 125 mL/hr until taking adequate oral fluids; NS only if dialysis. If bolus needed to maintain UOP, page Anesthesia.
- Anesthesiologist to discuss with PACU RN analgesia management; preference is for fentaNYL (SUBLIMAZE), not HYDRORPHONE (DILAUDID) boluses.
- Assess adequacy of analgesia
- Prior to PCU transfer, administer 5 mg PO oxyCODONE and

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975 mg PO acetaminophen (TYLENOL). Do NOT exceed 4 gm of acetaminophen (TYLENOL) in 24 hours.

- **PONV treatment:**
 - ondansetron (ZOFRAN) 4 mg q6h PRN
 - prochlorperazine (COMPAZINE) 5-10 mg IV q6h PRN
 - metoclopramide (REGLAN) 10 mg IV q6h PRN
- POCT BG q1h if patient on insulin infusion. Discontinue insulin transfusion prior to PCU transfer, if possible.
- Transition to corrective SQ insulin until tolerating PO. Refer to [Glycemic Management of the Adult Perioperative Patient - UMMC](#) Guideline
- XR ordered by Surgeon if needed.

Anesthesia / Nursing / Surgery

- Transfusion trigger at Hgb of 7 g/dL. Notify surgery of any intention to transfuse and include nursing and Anesthesia.

PATIENT CARE UNIT (PCU) MANAGEMENT

Nursing on Patient Care Unit (PCU)

- Encourage Incentive Spirometry (IS).
- Advance diet as tolerated. Nursing may advance diet per protocol without Surgeon order.
- Discontinue PCA on morning of POD 1 or as soon as the patient tolerates oral meds.
- Discontinue Foley in AM on POD 1, or POD 2 if patient received intrathecal morphine, or if ICU patient. Order bladder scan *IF* patient unable to void by 4 hours post-procedure or post-Foley removal. Bladder scan every 4-8 hours if no voiding. Straight catheterize if bladder scan is greater than 300 mL OR use bladder scanner and intermittent straight catheterization per unit / population specific criteria or specific provider order. *IF* straight catheterization is required for greater than 48 hours, notify Surgeon.
- Discontinue antibiotics at 24 hours post surgery.
- Vital Signs every 15 minutes X 2, 30 minutes X 2, every 1 hour X 2 then per unit routine.
- Maintenance fluids of weight-based mL/hr until PO intake greater than 500 mL/shift. After this point may saline lock IV.
- **Bowel Management:**

HOLD **all** meds if patient has loose stools.

 - docusate sodium (COLACE) 200 mg BID scheduled.
 - polyethylene glycol (MIRALAX/GLYCOLAX) 17 gm QD scheduled.
 - bisacodyl (DULCOLAX) suppository PRN if no bowel movement has occurred 48 hours after surgery.
 - phosphate (FLEET) enema at Surgeon discretion if no bowel movement after bisacodyl (DULCOLAX).
 - senna-docusate (SENOKOT-S; PERICOLACE) PRN.

- **Nutrition:**
 - Juven/zinc sulfate/vitamin A/C/E for wound healing adjunct.
 - Give *Ensure* shakes BID *IF* patient has Serum Albumin LESS than 4 g/dL.
- **Cold Therapy:**
 - Administer ice packs as needed. Do NOT get wound wet.
- **Pain Medications:**
 - ketamine (KETALAR) infusion at starting dose at 5 mg/hour for 24-36 hours
 - **No** NSAIDs or ORAL/IV STEROIDS for any fusion patient without direct Surgeon order.
 - Discontinue IV pain medication within 48 hours of surgery to facilitate transition to oral pain management.
 - Oral acetaminophen (TYLENOL) 975 mg q8h scheduled for 3 days.
 - Oral acetaminophen (TYLENOL) 650 mg q4h PRN after last scheduled dose.
 - Oral oxyCODONE (ROXicodone) immediate release 5-10 mg q3h PRN for breakthrough pain.
or
Oral HYDRomorphone (DILAUDID) 2-4 mg q3h PRN if patient allergic to oxyCODONE (ROXicodone).
 - Oral tramadol (ULTRAM) 50 mg q6h PRN *IF* ordered.
 - Additional or long acting Oral narcotics *IF* ordered.
 - Oral gabapentin (NEURONTIN) – dose based on patient age and CrCl in the Complex Spine POST OP order set.

Ambulation/PT/OT

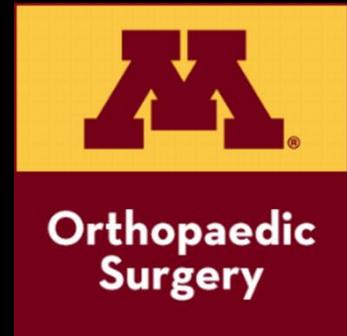
- No brace unless otherwise directed by Surgeon.
- WBAT for every patient unless otherwise directed by Surgeon.
- First session, full weight bearing, afternoon or evening of POD 0.
- Out of bed day of surgery *IF* patient tolerates. Otherwise dangle feet at bedside day of surgery.
- Patient mobilized out of bed to chair TID.
- PT sessions 2 x per day.
- PT session on AM of discharge if possible.
- OT session 1 x per day.

Discharge

- Discharge from Patient Care Unit (PCU) when patient tolerating regular diet, passing gas (no need to have a stool), has mobilized and cleared PT/OT, and pain is controlled on an oral regimen.
- Need for TCU or Rehab placement per PT/OT recommendations.
- Glucose management, if needed, per Surgeon/Hospitalist.
- Post-operative visit scheduled by clinic at pre-operative visit and should not be rescheduled unless per patient/surgeon request.
- Perform Standing Radiographs *PRIOR* to discharge *IF* ordered.



Spine Surgery at the University of Minnesota



-Team approach to patient care and research

M_N “The more eyes that come from different viewpoints, the more that can be seen.”

M_N What happens inside the operating room is just one small piece of surgery.

M_N **Spine Surgery requires far more than surgeons:** PT/OT, PM&R, radiology, pain specialists, research team, clinic staff, nurses, operating room staff, anesthesia, primary care team, hospitalist team, administrative team



Neurosurgery

Thank You!!!

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Orthopaedic
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