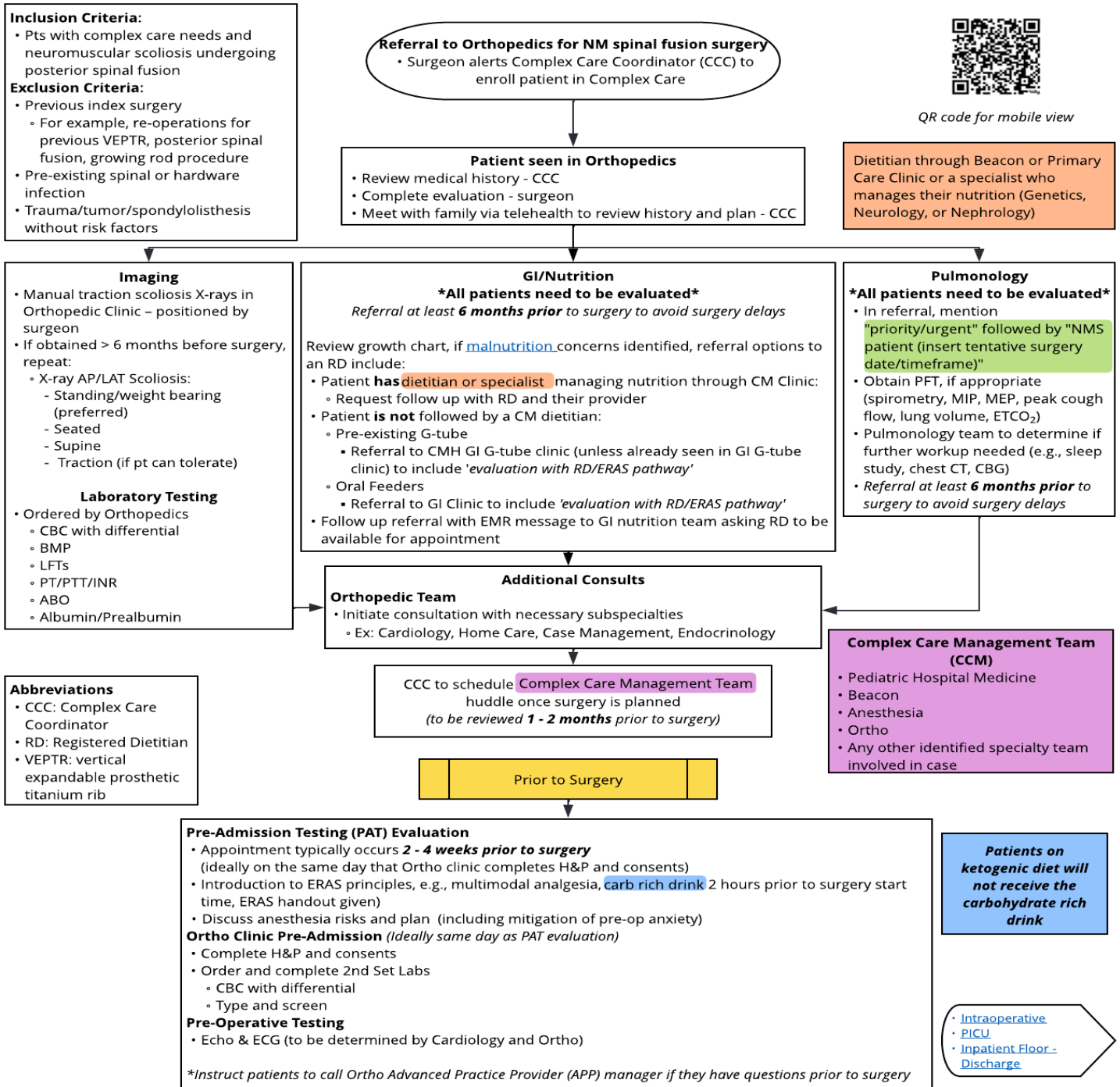


Neuromuscular Spinal Fusion Enhanced Recovery After Surgery Pathway Synopsis

NM Spine: Assessment/Referral Algorithm

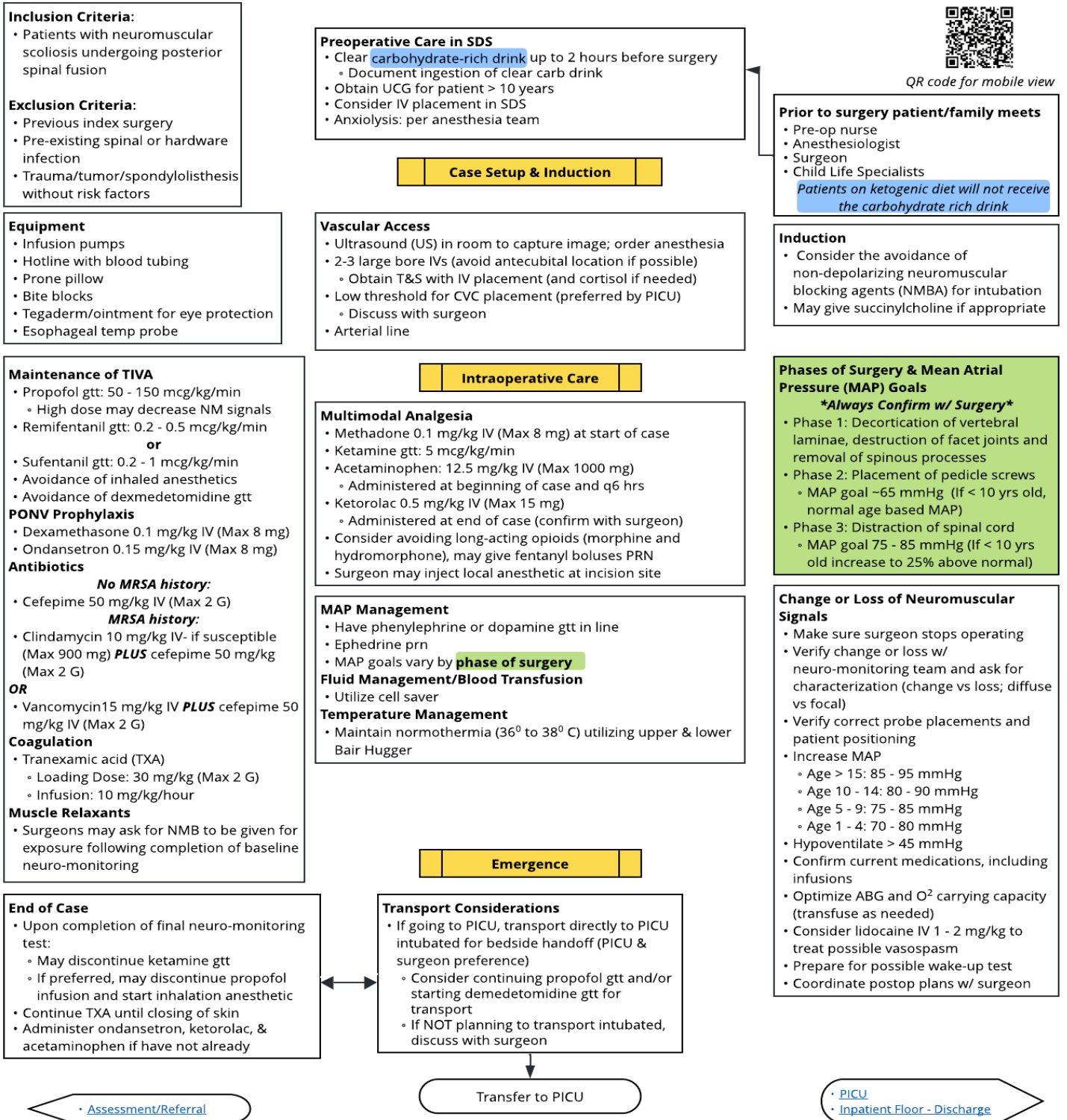


* These pathways do not establish a standard of care to be followed in every case. It is recognized that each case is different, and those individuals involved in providing health care are expected to use their judgment in determining what is in the best interests of the patient based on the circumstances existing at the time. It is impossible to anticipate all possible situations that may exist and to prepare a pathway for each. Accordingly, these pathways should guide care with the understanding that departures from them may be required at times.

NM Spine: Intraoperative Algorithm

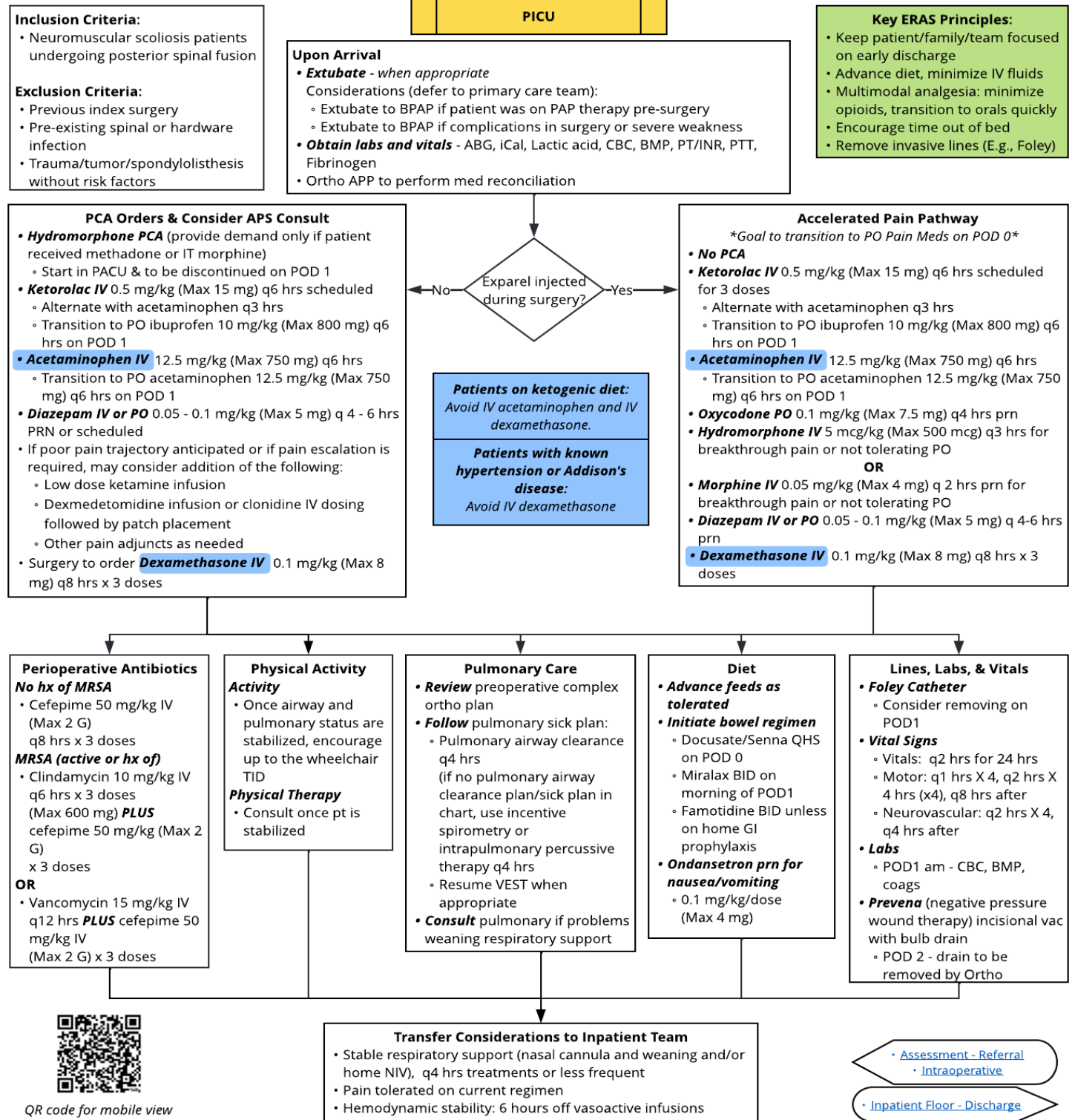


QR code for mobile view



* These pathways do not establish a standard of care to be followed in every case. It is recognized that each case is different, and those individuals involved in providing health care are expected to use their judgment in determining what is in the best interests of the patient based on the circumstances existing at the time. It is impossible to anticipate all possible situations that may exist and to prepare a pathway for each. Accordingly, these pathways should guide care with the understanding that departures from them may be required at times.

NM Spine: PICU Algorithm



* These pathways do not establish a standard of care to be followed in every case. It is recognized that each case is different, and those individuals involved in providing health care are expected to use their judgment in determining what is in the best interests of the patient based on the circumstances existing at the time. It is impossible to anticipate all possible situations that may exist and to prepare a pathway for each. Accordingly, these pathways should guide care with the understanding that departures from them may be required at times.

NM Spine: Inpatient Floor to Discharge Algorithm

Inclusion Criteria:

- Neuromuscular scoliosis patients undergoing posterior spinal fusion

Exclusion Criteria:

- Previous index surgery
- Pre-existing spinal or hardware infection
- Trauma/tumor/spondylolisthesis without risk factors

Key ERAS Principles:

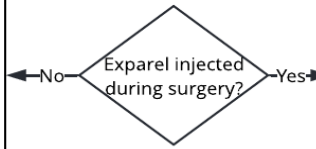
- Keep patient/family/team focused on early discharge
- Advance diet, minimize IV fluids
- Multimodal analgesia: minimize opioids, transition to orals quickly
- Encourage time out of bed
- Remove invasive lines (E.g., Foley)

Post Operative - Henson Hall

Consider consult for social work or case management for continued inpatient and outpatient support

PCA Orders & APS Consult

- **Hydromorphone PCA** (provide demand only if patient received methadone or IT morphine)
 - Start in PACU & to be discontinued on POD 1
- **Ketorolac IV** 0.5 mg/kg (Max 15 mg) q6 hrs scheduled
 - Alternate with acetaminophen q3 hrs
 - Transition to PO ibuprofen 10 mg/kg (Max 800 mg) q6 hrs on POD 1
- **Acetaminophen IV** 12.5 mg/kg (Max 750 mg) q6 hrs
 - Transition to PO acetaminophen 12.5 mg/kg (Max 750 mg) q6 hrs on POD 1
- **Diazepam IV or PO** 0.05-0.1 mg/kg (Max 5 mg) q 4-6 hrs PRN or scheduled
- If poor pain trajectory anticipated or if pain escalation is required, may consider addition of the following:
 - Low dose ketamine infusion
 - Dexmedetomidine infusion or clonidine IV dosing followed by patch placement
 - Other pain adjuncts as needed
- Surgery to order **Dexamethasone IV** 0.1 mg/kg (Max 8 mg) q8 hrs x 3 doses immediately post-op



Patients on ketogenic diet:
Avoid IV acetaminophen and IV dexamethasone.

Patients with known hypertension or Addison's disease:
Avoid IV dexamethasone

Accelerated Pain Pathway

Goal to transition to PO Pain Meds on POD 0

- **No PCA**
- **Ketorolac IV** 0.5 mg/kg (Max 15 mg) q6 hrs scheduled for 3 doses
 - Alternate with acetaminophen q3 hrs
 - Transition to PO ibuprofen 10 mg/kg (Max 800 mg) q6 hrs on POD 1
- **Acetaminophen IV** 12.5 mg/kg (Max 750 mg) q6 hrs
 - Transition to PO acetaminophen 12.5 mg/kg (Max 750 mg) q6 hrs on POD 1
- **Oxycodone PO** 0.1 mg/kg (Max 7.5 mg) q4 hrs prn
- **Hydromorphone IV** 5 mcg/kg (Max 500 mcg) q3 hrs for breakthrough pain or not tolerating PO

OR

- **Morphine IV** 0.05 mg/kg (Max 4 mg) q 2 hrs prn for breakthrough pain or not tolerating PO
- **Diazepam IV or PO** 0.05-0.1 mg/kg (Max 5 mg) q 4-6 hrs prn
- **Dexamethasone IV** 0.1 mg/kg (Max 8 mg) q8 hrs x 3 doses immediately post-op

Patient is off pathway if surgical complications identified
*Provide appropriate supportive care
Otherwise proceed with ERAS pathway

Lines, Labs, & Vitals

- **Foley Catheter and PICC line**
 - Remove as soon as possible
- **Vital Signs**
 - Vitals/Motor/Neurovascular q4 hrs X 24 hrs, then per provider discretion

Labs

- No routine labs scheduled

Physical Activity Activity

- Encourage out of bed to wheelchair

Physical Therapy

- Consult, if not already done in PICU

Pulmonary Care

- **Review** preoperative complex care ortho plan
- **Provide** pulmonary airway clearance QID (if no pulmonary airway clearance/sick plan, use IS or IPV QID)
- **Switch** airway clearance to BID or home 'well plan' when back to baseline respiratory support
- **Resume** VEST when appropriate
- **Consult** pulmonary if problems weaning respiratory support or needing increased O₂ flow

Diet

- **Encourage return to preoperative nutritional intake** - advance as tolerated
- **Initiate bowel regimen**
 - Docusate/Senna QHS on POD 0 or 1
 - Miralax BID on morning of POD 1
 - Famotidine BID unless on home GI prophylaxis
- **Ondansetron prn for nausea/vomiting**
 - 0.1 mg/kg/dose (Max 4 mg)

Abbreviations

IS: Incentive spirometry
IPV: Intrapulmonary percussive therapy

Discharge Readiness

Discharge Goal POD2 vs POD3

<p>Discharge Requirements</p> <ul style="list-style-type: none"> • Stable respiratory status per home routine • Tolerating preoperative nutritional intake • Transitioned to oral/PG pain medication with good pain control • Transition to home Prevena vacuum canister • Cleared by PT - safe transfers and appropriate DME 	<p>Discharge Teaching</p> <ul style="list-style-type: none"> • Post-op care instructions reviewed by team with family • If constipation remains at time of discharge, consider Miralax and senna for home
---	--

• [Assessment - Referral](#)
• [Intraoperative](#)
• [PICU](#)

Discharge home

Follow-up appointment scheduled with surgeon 6 weeks postop



QR code for mobile view

* These pathways do not establish a standard of care to be followed in every case. It is recognized that each case is different, and those individuals involved in providing health care are expected to use their judgment in determining what is in the best interests of the patient based on the circumstances existing at the time. It is impossible to anticipate all possible situations that may exist and to prepare a pathway for each. Accordingly, these pathways should guide care with the understanding that departures from them may be required at times.

Table of Contents

NM Spine: Assessment/Referral Algorithm..... 1

NM Spine: Intraoperative Algorithm 2

NM Spine: PICU Algorithm..... 3

NM Spine: Inpatient Floor to Discharge Algorithm 4

Objective of ERAS Pathway 6

Background 6

Target Users..... 6

Target Population 6

Core Principles of ERAS..... 6

ERAS Management Recommendations: 7

Additional Questions Posed by the ERAS Committee 7

Key Metrics To Be Monitored: 8

Value Implications..... 8

Potential Organizational Barriers and Facilitators 8

Power Plans..... 8

ERAS Pathway Preparation 8

Neuromuscular Spine ERAS Committee Members and Representation 8

ERAS Development Funding 9

Approval Process..... 9

Implementation & Follow-Up 9

Disclaimer 10

References 11

** These pathways do not establish a standard of care to be followed in every case. It is recognized that each case is different, and those individuals involved in providing health care are expected to use their judgment in determining what is in the best interests of the patient based on the circumstances existing at the time. It is impossible to anticipate all possible situations that may exist and to prepare a pathway for each. Accordingly, these pathways should guide care with the understanding that departures from them may be required at times.*

Objective of ERAS Pathway

To minimize the variation of care for the neuromuscular spine patient undergoing spinal fusion surgery and improve patient outcomes. The Neuromuscular Spinal Fusion Enhanced Recovery After Surgery (ERAS) Pathway assists the multidisciplinary team with a standardized approach to care before, during, and after surgery to achieve optimal patient outcomes.

Background

Surgical correction is the most effective treatment for severe neuromuscular scoliosis; however, it is not without complications (Antolovich et al., 2022; Simpson et al., 2022). The children who require this surgery are medically complex, often presenting with multiple comorbidities such as decreased pulmonary function, inadequate nutritional status, decreased mobility, and cognitive difficulties (Antolovich et al., 2022; Miller et al., 2020). These factors contribute to a higher risk of perioperative complications such as pneumonia, respiratory failure, surgical blood loss, and wound infections, which can result in longer hospital stays (Miller et al., 2020; Simpson et al., 2022). A multidisciplinary care approach throughout all stages of surgical care will help mitigate potential complications and promote optimal outcomes for these children (Beery et al., 2020; Zhang et al., 2024). The Neuromuscular Spinal Fusion ERAS Pathway, a multimodal perioperative care approach, aims to enhance surgical outcomes and expedite recovery. ERAS protocols encompass preoperative, intraoperative, and postoperative strategies such as optimized pain management, early mobilization, and nutritional support. These evidence-based practices improve patient and family satisfaction, reduce hospital stays, and promote quicker returns to daily activities (Liu, 2017; Rafeeqi & Pearson, 2021; Roberts et al., 2020). The Neuromuscular Spinal Fusion ERAS committee seeks to implement a comprehensive care management protocol to optimize pre-surgery health and minimize complications like surgical site infections (SSI), prolonged opioid use, and extended mechanical ventilation.

Target Users

- Anesthesiologists, Orthopedic Surgeons, Intensivists, Hospitalists, Gastroenterologists, Pulmonologists, Fellows, Residents
- Advanced Care Nurses, Physician Assistants
- Dieticians
- Nurses
- Physical Therapists

Target Population

Inclusion Criteria

- Patients with neuromuscular scoliosis undergoing posterior spinal fusion

Exclusion Criteria

- Previous index surgery
 - Re-operations for previous vertical expandable prosthetic titanium rib (VEPTR)
 - Posterior spinal fusion
 - Growing rod procedure
- Pre-existing spinal or hardware infection
- Trauma/tumor/spondylolisthesis without risk factors

Core Principles of ERAS

- Preoperative education of patients and their families with an introduction to ERAS
- Reduced pre-operative fasting, with clear liquid oral carbohydrate loading until 2 hours prior to surgery
- Goal-directed strict intraoperative intravenous fluid therapy guidelines to avoid hypo- or hypervolemia
- Avoidance of pre-operative mechanical bowel preparation
- Avoidance of routine nasogastric tube use
- Minimizing long-acting opioid analgesia in favor of regional anesthesia with epidural and/or local anesthesia for intra-operative and postoperative pain control when appropriate and using alternative non-opioid medications when appropriate (e.g., non-steroidal anti-inflammatories or acetaminophen)
- Early post-operative mobilization

** These pathways do not establish a standard of care to be followed in every case. It is recognized that each case is different, and those individuals involved in providing health care are expected to use their judgment in determining what is in the best interests of the patient based on the circumstances existing at the time. It is impossible to anticipate all possible situations that may exist and to prepare a pathway for each. Accordingly, these pathways should guide care with the understanding that departures from them may be required at times.*

ERAS Management Recommendations:**Pre-Operative Care**

- This ERAS protocol begins well before the surgical date with a referral and assessment in Orthopedic Surgery. Once surgery is recommended, the complex care coordinator begins the process of pre-surgery consults and presents the concept of ERAS to the patient/family. The ERAS protocol is also reviewed and reinforced preoperatively.
- At the initial surgical appointment, the patient and family are provided with educational items on preoperative diet restrictions, risks of anesthesia, and pain management.
- Some of the core concepts of ERAS, including the emphasis on early post-operative oral intake and a multimodal pain management approach, are also discussed. Expectation management is crucial in the preoperative phase. A handout, approved by CM's Health Literacy Committee, is given to the family before departing their pre-surgery appointment.
- Patients and families are provided with contacts for the complex care coordinator to answer any questions they may have before the procedure.
- On the morning of surgery, the patient drinks or is provided carbohydrate-rich clear fluids via a G-tube up to two hours before the procedure start time.

Intra-Operative Care

The principal goals during the intraoperative care of these patients are:

- Multimodal approach to pain management
 - Local anesthetic injection to be determined by the surgeon
 - Minimize the use of long-acting opioids
- Mean arterial pressure (MAP) management during the three phases of surgery
- Postoperative nausea and vomiting prophylaxis with dexamethasone and ondansetron
- Fluid management goal of clinical euvolemia
- Provide antibiotics based on MRSA history
- Maintain normothermia throughout the entire procedure
- The standard will be for the patient to go to the PICU intubated

Post-Operative Care

The principal goals during the postoperative care of these patients in the PICU are:

- Upon arrival to the PICU, extubate once the patient meets the criteria and obtain labs and vitals
- Advance feeds as tolerated
- Consider removing the Foley catheter on postoperative day one
- Prevent/treat postoperative nausea and vomiting with dexamethasone and ondansetron as needed
- Multimodal pain control: Minimize opioids and transition to oral or G-tube-administered medications as soon as possible.
- Pulmonary hygiene: Review preoperative complex care plan for adjustments to medication
- Physical therapy (PT): Consult once airway and pulmonary status are stabilized
- Administer perioperative antibiotics per protocol
- Remove wound drain postoperative day two (by Ortho)

The principal goals during the postoperative care of these patients once stabilized and moved to inpatient floor are:

- Transition to oral or G-tube-administered pain medications with good pain control
- Encourage PO/PG intake for nutrition and advance as tolerated
- Initiate bowel regimen
- Stabilize respiratory status
- Establish appropriate durable medical equipment (DME) is in place for home
- Meets criteria for safe transfers per PT

Additional Questions Posed by the ERAS Committee

No clinical questions were posed for this review.

** These pathways do not establish a standard of care to be followed in every case. It is recognized that each case is different, and those individuals involved in providing health care are expected to use their judgment in determining what is in the best interests of the patient based on the circumstances existing at the time. It is impossible to anticipate all possible situations that may exist and to prepare a pathway for each. Accordingly, these pathways should guide care with the understanding that departures from them may be required at times.*

Key Metrics To Be Monitored:

Pre-Op	Intra-Op	Post-Op
Carbohydrate-rich drink	IV acetaminophen	Extubate as early as possible
Anxiolysis (Midazolam IV)	PONV prophylaxis	Ondansetron
	ABX prior to incision (based on MRSA history)	Perioperative antibiotics
	Methadone	Prevena wound therapy
	Ketamine	Length of stay
	Ketorolac	Safe transfers
	Long-acting opioids	
	Normothermia	
	Mean Arterial Pressure (MAP) management	
	Coagulation	
	Neuromuscular block	

Value Implications

The following potential improvements may reduce healthcare facility costs and resource utilization and reduce healthcare costs and non-monetary costs (e.g., missed school/work, loss of wages, stress) for patients and families.

- Decreased inpatient length of stay
- Decreased unwarranted variation in care
- Improved communication between patients and the care team throughout the perioperative period
- Improved post-operative pain control

Potential Organizational Barriers and Facilitators

Potential Barriers

- Variability of acceptable level of risk among providers
- Challenges with follow-up faced by some families

Potential Facilitators

- Collaborative engagement across care continuum settings during ERAS development
- High rate of use of ERAS
- Streamlined patient and parent/caregiver education throughout the surgical experience

Power Plans

- There are no Power Plans associated with this ERAS pathway

Associated Policies

- There are no associated policies with this ERAS pathway

Education Materials

- ERAS overview handout
 - Intended to be a general handout encompassing the key concepts and plan for an ERAS pathway
 - Found on the CM external website for each ERAS pathway
 - Available in English and Spanish

ERAS Pathway Preparation

This ERAS pathway was prepared by the Department of Evidence Based Practice (EBP) in collaboration with the Neuromuscular Spinal Fusion ERAS committee composed of content experts at Children’s Mercy Kansas City. If a conflict of interest is identified, the conflict will be disclosed next to the committee member’s name.

Neuromuscular Spine ERAS Committee Members and Representation

- Aaron Shaw, DO, FAAOS | Orthopaedic Surgery | Committee Co-Chair
- Trent Sims, DO, MS | Anesthesiology | Committee Co-Chair
- Michael Benvenuti, MD | Orthopaedic Surgery | Committee Member
- John Anderson, MD | Orthopaedic Surgery | Committee Member

** These pathways do not establish a standard of care to be followed in every case. It is recognized that each case is different, and those individuals involved in providing health care are expected to use their judgment in determining what is in the best interests of the patient based on the circumstances existing at the time. It is impossible to anticipate all possible situations that may exist and to prepare a pathway for each. Accordingly, these pathways should guide care with the understanding that departures from them may be required at times.*

- Nichole Doyle, MD | Anesthesiology | Committee Member
- Emily Weisberg, MD | Anesthesiology | Committee Member
- Tara Benton, MD, MSCI | Pediatric Critical Care Medicine | Committee Member
- Cara Holton, MD | Pediatric Critical Care Medicine | Committee Member
- Leah Jones, MD | Hospital Medicine | Committee Member
- Emily Goodwin, MD, FAAP | Beacon Program | Committee Member
- Samira Naime, MD | Pulmonology | Committee Member
- Aileen Frances Har, MD | Gastroenterology | Committee Member
- Heather Sambol, RN, APRN | Anesthesiology | Committee Member
- Anne Stuedemann, MSN, RN, CPNP | Orthopaedic Surgery | Committee Member
- Katie Shedd, MSPAS, PA-C | Orthopaedic Surgery | Committee Member
- Jamie Wilkins, MS, RD, LD, CNSC | Nutrition | Committee Member

EBP Committee Members

- Todd Glenski, MD, MSHA, FASA | Anesthesiology, Evidence Based Practice
- Andrea Melanson, OTD, OTR/L | Evidence Based Practice

ERAS Development Funding

The Departments of Evidence-Based Practice, Anesthesiology, Orthopedics, Pediatric Critical Care, Hospital Medicine, Pulmonology, Gastroenterology, Nutrition, and the Beacon Program underwrote the development of this ERAS pathway.

Conflict of Interest

The contributors to the Neuromuscular Spinal Fusion ERAS pathway have no conflicts of interest to disclose related to the subject matter or materials discussed in this care process.

Approval Process

- This product was reviewed and approved by the Neuromuscular Spinal Fusion ERAS Committee, Content Expert Departments/Divisions, and the EBP Department.
- ERAS pathways are reviewed and updated as necessary every three years within the EBP Department at CMKC. Content expert teams are involved with every review and update.

Review Requested

Department/Unit	Date Obtained
Anesthesiology	January 2025
Orthopedics	January 2025
Pulmonology	January 2025
Pediatric Critical Care	January 2025
Hospital Medicine	January 2025
Gastroenterology	January 2025
Beacon Clinic	January 2025
Nutrition	January 2025
Evidence Based Practice	January 2025

Version History

Date	Comments
February 2025	Version one – (algorithms, synopsis, and patient/caregiver education)

Date for Next Review:

- February 2028

Implementation & Follow-Up

- Once approved, this ERAS pathway was presented to appropriate care teams and implemented.

** These pathways do not establish a standard of care to be followed in every case. It is recognized that each case is different, and those individuals involved in providing health care are expected to use their judgment in determining what is in the best interests of the patient based on the circumstances existing at the time. It is impossible to anticipate all possible situations that may exist and to prepare a pathway for each. Accordingly, these pathways should guide care with the understanding that departures from them may be required at times.*

- Key metrics will be assessed and shared with the appropriate care teams to determine whether changes are needed.
- Education tools for patients and families were created for pre-surgery visits to provide an overview of the ERAS pathway. Health literacy reviewed the tool.
- Education was provided to all stakeholders:
 - Nursing units where the Neuromuscular Spinal Fusion ERAS pathway is used
 - Departments of Anesthesiology, Orthopedic Surgery, Pulmonology, Gastroenterology, Critical Care, and Hospital Medicine
 - Providers from Beacon Clinic and Nutrition
 - Resident physicians

Disclaimer

When evidence is lacking or inconclusive, care options are provided in the supporting documents and the power plan(s) that accompany the ERAS pathway.

These ERAS pathways do not establish a standard of care to be followed in every case. It is recognized that each case is different, and those individuals involved in providing health care are expected to use their judgment in determining what is in the best interests of the patient based on the circumstances existing at the time.

It is impossible to anticipate all possible situations that may exist and to prepare ERAS pathways for each. Accordingly, these ERAS pathways should guide care with the understanding that departures from them may be required at times.

** These pathways do not establish a standard of care to be followed in every case. It is recognized that each case is different, and those individuals involved in providing health care are expected to use their judgment in determining what is in the best interests of the patient based on the circumstances existing at the time. It is impossible to anticipate all possible situations that may exist and to prepare a pathway for each. Accordingly, these pathways should guide care with the understanding that departures from them may be required at times.*

References

- Liu, V.X., Rosas, E., Hwang, J., Cain, E., Foss-Durant, A., Clopp, M., et al. (2017). Enhanced recovery after surgery program implementation in 2 surgical populations in an integrated health care delivery system. *JAMA Surg*, *152*, e171032. <https://doi.org/10.1001/jamasurg.2017.1032>
- Antolovich, G. C., Cooper, M. S., Johnson, M. B., Lundine, K., Yang, Y., Frayman, K., Vandeleur, M., Sutherland, I., Peachey, D., Gadish, T., Turner, B., & Harvey, A. (2022). Perioperative care of children with severe neurological impairment and neuromuscular scoliosis: A practical pathway to optimize perioperative health and guide decision making. *Journal of Clinical Medicine*, *11*(22), 6769. <https://doi.org/10.3390/jcm11226769>
- Berry, J. G., Glaspy, T., Eagan, B., Singer, S., Glader, L., Emara, N., Cox, J., Glotzbecker, M., Crofton, C., Ward, E., Leahy, I., Salem, J., Troy, M., O'Neill, M., Johnson, C., & Ferrari, L. (2020). Pediatric complex care and surgery co-management: Preparation for spinal fusion. *Journal of Child Health Care: for Professionals Working with Children in the Hospital and Community*, *24*(3), 402–410. <https://doi.org/10.1177/1367493519864741>
- Miller, N. H., Benefield, E., Hasting, L., Carry, P., Pan, Z. & Erickson, M. A. (2010). Evaluation of high-risk patients undergoing spinal surgery: A matched case series. *Journal of Pediatric Orthopaedics*, *30*(5), 496-502. doi: 10.1097/BPO.0b013e3181df16ac.
- Rafeeqi, T. & Pearson, E.G. (2021, July). Enhanced recovery after surgery in children. *Translational Gastroenterology and Hepatology*, *6*, 1-9. doi: 10.21037/tgh-20-188
- Roberts, K., Brindle, M., & McLuckie, D. (2020, July). Enhanced recovery after surgery in pediatrics: A review of the literature. *British Journal of Anaesthesia*, *20*(7), 235–241. doi.org/10.1016/j.bjae.2020.03.004.
- Simpson, B.E., Kara, S., Wilson, A., Wolf, D., Bailey, K., MacBriar, J., Mayes, T., Russell, J., Chundi, P., & Sturm, P. (2022, March). Reducing patient length of stay after surgical correction for neuromuscular scoliosis. *Hospital Pediatrics*, *12*(3), 293–302. doi:10.1542/hpeds.2021-006196
- Zhang, H., Liu, H., Zhang, X., Zhao, M., Guo, D., Bai, Y., Qi, X., Shi, H. & Li, D. (2024). Short-term outcomes of an enhanced recovery after surgery pathway for children with congenital scoliosis undergoing posterior spinal fusion: a case-control study of 70 patients. *Journal of Pediatric Orthopaedics B*, *33*(3), 258-264. doi: 10.1097/BPB.0000000000001105.

* These pathways do not establish a standard of care to be followed in every case. It is recognized that each case is different, and those individuals involved in providing health care are expected to use their judgment in determining what is in the best interests of the patient based on the circumstances existing at the time. It is impossible to anticipate all possible situations that may exist and to prepare a pathway for each. Accordingly, these pathways should guide care with the understanding that departures from them may be required at times.