Residual Neuromuscular Blockade - An Opportunity to Provide Patient Care Following Surgery
Alyson Wilder, PharmD, BCPS

Home Study Webcast
2 Slides Per Page
Residual Neuromuscular Blockade –
An Opportunity to Provide Patient Care Following Surgery

ACTIVITY DESCRIPTION
Residual neuromuscular blockade has been a long standing problem for post-surgical patients. Residual blockade is one of the many factors that may delay recovery and cause additional complications post-surgery. Implementation of Enhanced Recovery After Surgery (ERAS) protocols has been shown to improve peri- and post-operative care of the surgical patient. This program will provide an overview of the risks associated with residual neuromuscular blockade and discuss pharmaceutical options for reversal. In addition, components of an ERAS protocol will be described and the potential role of reversal agents in ERAS protocols will be identified.

TARGET AUDIENCE
The target audience for this activity is pharmacists and nurses in hospital, community, and retail pharmacy settings.

LEARNING OBJECTIVES
After completing this activity, the pharmacist will be able to:
- Identify risk factors for residual neuromuscular blockade
- List adverse events that stem from residual neuromuscular blockade
- Describe elements of an Enhanced Recovery After Surgery (ERAS) protocol
- Identify role of reversal agents in enhanced recovery protocols

ACCREDITATION
Pharmacy
PharmCon, Inc. is accredited by the Accreditation Council for Pharmacy Education as a provider of continuing pharmacy education.

Nursing
PharmCon, Inc. is approved by the California Board of Registered Nursing (Provider Number CEP 13649) and the Florida Board of Nursing (Provider Number 50-3515). Activities approved by the CA BRN and the FL BN are accepted by most State Boards of Nursing.

CE hours provided by PharmCon, Inc. meet the ANCC criteria for formally approved continuing education hours. The ACPE is listed by the AANP as an acceptable, accredited continuing education organization for applicants seeking renewal through continuing education credit. For additional information, please visit: http://www.nursecredentialing.org/RenewalRequirements.aspx

Universal Activity No.: 0798-0000-16-121-H01
Credits: 1.0 contact hour (0.1 CEU)

Release Date: 12/31/2017
freeCE Expiration Date: 6/30/2018
ACPE Expiration Date: 11/21/2020

ACTIVITY TYPE
Knowledge-Based Home Study Webcast

FINANCIAL SUPPORT BY
Merck & Co., Inc.
ABOUT THE AUTHOR
Dr. Wilder is currently working as an Assistant Professor of Pharmacy Practice at the Presbyterian College School of Pharmacy. She is practicing as a Critical Care Clinical Pharmacist at SELF Memorial Hospital in Greenwood, SC. Dr. Wilder earned her Doctorate of Pharmacy from the University of South Carolina College of Pharmacy in 2007. She then went on to complete a PGY1 residency at Vanderbilt University Medical Center (VUMC) in Nashville, TN followed by a PGY2 residency in Critical Care/Nutrition. After her PGY2 residency, Dr. Wilder worked as a Clinical Pharmacy Specialist in the Neuro ICU at University of Maryland Medical Center. She has also held Clinical Pharmacy Specialist positions at The Regional Medical Center in Orangeburg, SC and at Naval Hospital Jacksonville in Jacksonville, FL. Dr. Wilder is a Board Certified Pharmacotherapy Specialist.

FACULTY DISCLOSURE
It is the policy of PharmCon, Inc. to require the disclosure of the existence of any significant financial interest or any other relationship a faculty member or a sponsor has with the manufacturer of any commercial product(s) and/or service(s) discussed in an educational activity. Alyson Wilder reports no actual or potential conflict of interest in relation to this activity.

Peer review of the material in this CE activity was conducted to assess and resolve potential conflict of interest. Reviewers unanimously found that the activity is fair balanced and lacks commercial bias.

Please Note: PharmCon, Inc. does not view the existence of relationships as an implication of bias or that the value of the material is decreased. The content of the activity was planned to be balanced and objective. Occasionally, faculty may express opinions that represent their own viewpoint. Participants have an implied responsibility to use the newly acquired information to enhance patient outcomes and their own professional development. The information presented in this activity is not intended as a substitute for the participant’s own research, or for the participant’s own professional judgement or advice for a specific problem or situation. Conclusions drawn by participants should be derived from objective analysis of scientific data presented from this activity and other unrelated sources.

Neither freeCE/PharmCon nor any content provider intends to or should be considered to be rendering medical, pharmaceutical, or other professional advice. While freeCE/PharmCon and its content providers have exercised care in providing information, no guarantee of it’s accuracy, timeliness or applicability can be or is made. You assume all risks and responsibilities with respect to any decisions or advice made or given as a result of the use of the content of this activity.
Objectives

• Identify risk factors for residual neuromuscular blockade

• List adverse events that stem from residual neuromuscular blockade

• Describe elements of an Enhanced Recovery After Surgery (ERAS) protocol

• Identify the role of reversal agents in enhanced recovery protocols
Common Uses of Neuromuscular Blockers

- Facilitate emergency intubation
- Enhance mechanical ventilation for ARDS
- Prevent patient-ventilator dyssynchrony
- Manage elevated intracranial and intraabdominal pressure
- Maintain induced hypothermia after cardiac arrest

Neuromuscular Blockers (NMB)

<table>
<thead>
<tr>
<th>Depolarizing</th>
<th>Non-Depolarizing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Succinylcholine</td>
<td>Aminosteroidal</td>
</tr>
<tr>
<td></td>
<td>Pancuronium</td>
</tr>
<tr>
<td></td>
<td>Rocuronium</td>
</tr>
<tr>
<td></td>
<td>Vecuronium</td>
</tr>
</tbody>
</table>
Acetylcholine Mechanism of Action

NMB Mechanism of Action
### NMB Monitoring: Train of Four (TOF)

- Peripheral nerve stimulation
- Stimuli delivered every 0.5 sec
  - Total of 4 stimuli
- Twitches → level of block

<table>
<thead>
<tr>
<th>Number of twitches</th>
<th>Receptors blocked</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>100%</td>
</tr>
<tr>
<td>1</td>
<td>90%</td>
</tr>
<tr>
<td>2</td>
<td>75-80%</td>
</tr>
<tr>
<td>3</td>
<td>75%</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>


### NMB Recovery Monitoring: TOF Ratio

Train-of-Four (TOF) illustrates twitch responses to stimuli over time. The ratio of the fourth twitch to the first twitch (T4/T1) is used to determine the level of neuromuscular blockade.

- **100%** (No Block)
- **75%** (Partial Block)
- **40%** (Complete Block)

### Residual Neuromuscular Blockade

- Incomplete recovery from NMB  
  - Presence of signs or symptoms of muscle weakness in the postoperative period after the intraoperative administration of an NMB
- Common complication in the post-anesthesia care unit (PACU)
- TOF ratio <0.9
- Patient safety issue

### Complications of Residual NMB

<table>
<thead>
<tr>
<th>Healthy Volunteers</th>
<th>Surgical Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Swallowing dysfunction</td>
<td>• ↑ risk of post-op hypoxemia</td>
</tr>
<tr>
<td>• Decreased inspiration</td>
<td>• ↑ risk of re-intubation</td>
</tr>
<tr>
<td>• Profound muscle weakness</td>
<td>• Prolonged post-op ventilatory weaning</td>
</tr>
<tr>
<td></td>
<td>• Prolonged PACU stay</td>
</tr>
</tbody>
</table>
Risk Factors for RNMB

- Type and dose of NMB administered intraoperatively
- Degree of blockade maintained intraoperatively
- Use of interacting medications
- Patient specific factors
  - Electrolyte imbalances
  - Neurological and muscular diseases
  - Renal and hepatic function

Reversal Agents

- Neostigmine
- Sugammadex
NMB Reversal Agents

<table>
<thead>
<tr>
<th>Depolarizing</th>
<th>Non-Depolarizing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Succinylcholine</td>
<td>Aminosteroidal</td>
</tr>
<tr>
<td></td>
<td>Pancuronium</td>
</tr>
<tr>
<td></td>
<td>Rocuronium</td>
</tr>
<tr>
<td></td>
<td>Vecuronium</td>
</tr>
</tbody>
</table>

Sugammadex

Neostigmine

Neostigmine (Bloxiverz™)

- Approved* May 2013
- Reversal of non-depolarizing NMB after surgery
- Single bolus injection over at least a minute
- Must be given with anticholinergic agent

<table>
<thead>
<tr>
<th>Dose</th>
<th>Indication</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.03mg/kg</td>
<td>NMB with shorter half-lives; 1st twitch &gt;10% of baseline or 2nd twitch present</td>
</tr>
<tr>
<td>0.07mg/kg</td>
<td>NMB with longer half-lives; weak first twitch response; rapid recovery</td>
</tr>
<tr>
<td>Max dose:</td>
<td>0.07mg/kg or 5mg (whichever is less)</td>
</tr>
</tbody>
</table>

Mechanism of Action

- Inhibits destruction of acetylcholine

![Diagram showing mechanisms of action](image)

Neostigmine (Bloxiverz™)

**Contraindications**
- Peritonitis
- Mechanical obstruction of GI/GU tract

**Warnings**
- Bradycardia
- Neuromuscular dysfunction with overdose

Neostigmine (Bloxiverz™)

Adverse Effects
- Hypotension
- Nausea/vomiting
- Dizziness

Special Populations
- Approved for pediatric use
- Adjust dose in renal impairment
- Not studied in hepatic impairment

Neostigmine and PACU Complications

- Retrospective cohort
- April 2005 – December 2013
- Adults having non-cardiac surgery + received NMB
- Incidence of major and minor PACU complications
  - Reversal agent vs. without

## Major PACU Complications

<table>
<thead>
<tr>
<th>Major complication</th>
<th>Absolute numbers of complications</th>
<th>Incidence per 10,000 surgeries (95%CI)&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any major</td>
<td>2701</td>
<td>210 (202, 218)</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>61</td>
<td>4.73 (3.68, 6.09)</td>
</tr>
<tr>
<td>Cardiac arrest</td>
<td>83</td>
<td>6 (5, 8)</td>
</tr>
<tr>
<td>Pulmonary aspiration</td>
<td>11</td>
<td>0.85 (0.46, 1.55)</td>
</tr>
<tr>
<td>Stroke</td>
<td>4</td>
<td>0.31 (0.09, 0.83)</td>
</tr>
<tr>
<td>Unplanned admission to ICU</td>
<td>1357</td>
<td>105 (100, 111)</td>
</tr>
<tr>
<td>Return to OR</td>
<td>211</td>
<td>16 (14, 19)</td>
</tr>
<tr>
<td>Re-intubation</td>
<td>1522</td>
<td>118 (112, 124)</td>
</tr>
</tbody>
</table>

<sup>a</sup> Exact binomial method for confidence intervals.

## Minor PACU Complications

<table>
<thead>
<tr>
<th>Minor complication</th>
<th>Absolute number of complications</th>
<th>Incidence per 10,000 surgeries (95%CI)&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any minor</td>
<td>45,375</td>
<td>3521 (3495, 3547)</td>
</tr>
<tr>
<td>Hypotension</td>
<td>5498</td>
<td>427 (416, 438)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>18,677</td>
<td>1449 (1430, 1468)</td>
</tr>
<tr>
<td>Hypoxemia</td>
<td>9857</td>
<td>765 (750, 779)</td>
</tr>
<tr>
<td>Bronchospasm</td>
<td>3254</td>
<td>252 (244, 261)</td>
</tr>
<tr>
<td>Prolonged NMB</td>
<td>89</td>
<td>7 (6, 9)</td>
</tr>
<tr>
<td>Nausea &amp; vomiting</td>
<td>18,604</td>
<td>1443 (1424, 1463)</td>
</tr>
<tr>
<td>Hypo/hyperglycemia</td>
<td>3010</td>
<td>234 (225, 242)</td>
</tr>
<tr>
<td>Hypo/hyperkalemia</td>
<td>293</td>
<td>23 (20, 25)</td>
</tr>
<tr>
<td>Hyponatremia</td>
<td>6</td>
<td>0.5 (0.01, 3.4)</td>
</tr>
<tr>
<td>Bradycardia</td>
<td>271</td>
<td>21 (19, 24)</td>
</tr>
</tbody>
</table>

<sup>a</sup> Exact binomial method for confidence intervals.
### Major Complications: Incidence/10,000 surgeries

<table>
<thead>
<tr>
<th>Major Event</th>
<th>Neostigmine</th>
<th>No reversal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any major</td>
<td>170</td>
<td>605</td>
</tr>
<tr>
<td>MI</td>
<td>4.5</td>
<td>6.9</td>
</tr>
<tr>
<td>Cardiac arrest</td>
<td>5.6</td>
<td>14.6</td>
</tr>
<tr>
<td>Pulmonary aspiration</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>Stroke</td>
<td>0.3</td>
<td>0</td>
</tr>
<tr>
<td><strong>Unplanned ICU admission</strong></td>
<td>84</td>
<td>319</td>
</tr>
<tr>
<td>Return to the OR</td>
<td>16.4</td>
<td>16.3</td>
</tr>
<tr>
<td><strong>Reintubation</strong></td>
<td>83.5</td>
<td>465</td>
</tr>
</tbody>
</table>


### Minor Complications: Incidence/10,000 surgeries

<table>
<thead>
<tr>
<th>Minor Event</th>
<th>Neostigmine</th>
<th>No reversal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any minor</td>
<td>3523</td>
<td>3497</td>
</tr>
<tr>
<td>Hypotension</td>
<td>423</td>
<td>462</td>
</tr>
<tr>
<td>Hypertension</td>
<td>1450</td>
<td>1438</td>
</tr>
<tr>
<td>Hypoxemia</td>
<td>747</td>
<td>945</td>
</tr>
<tr>
<td>Bronchospasm</td>
<td>253</td>
<td>246</td>
</tr>
<tr>
<td><strong>Prolonged NMB</strong></td>
<td>2.4</td>
<td>52.3</td>
</tr>
<tr>
<td>Nausea/Vomiting</td>
<td>1445</td>
<td>1429</td>
</tr>
<tr>
<td>Hypo/Hyperglycemia</td>
<td>236</td>
<td>211</td>
</tr>
<tr>
<td>Hypo/Hyperkalemia</td>
<td>23</td>
<td>19.7</td>
</tr>
<tr>
<td>Hyponatremia</td>
<td>0.5</td>
<td>0</td>
</tr>
<tr>
<td><strong>Bradycardia</strong></td>
<td>16.6</td>
<td>65.2</td>
</tr>
</tbody>
</table>

Sugammadex (Bridion®)

- Approved December 2015
- Reversal of rocuronium and vecuronium in adults surgical pts
- Single bolus injection over 10 seconds

### Indication

<table>
<thead>
<tr>
<th>Indication</th>
<th>Rocuronium</th>
<th>Vecuronium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderate block</td>
<td>2mg/kg</td>
<td>2mg/kg</td>
</tr>
<tr>
<td>Deep block</td>
<td>4mg/kg</td>
<td>4mg/kg</td>
</tr>
<tr>
<td>Immediate reversal</td>
<td>16mg/kg</td>
<td>Not studied</td>
</tr>
</tbody>
</table>

### Mechanism of Action

- Forms a complex with the NMB in the plasma
- Amount of available NMB to bind to nicotinic receptors is reduced

Bridion (sugammadex) [prescribing information]. June 2017.
Sugammadex (Bridion®)

**Warnings**
- Increased aPTT and PT/INR
- Marked bradycardia

**Adverse Effects**
- Nausea/vomiting
- Hypotension and headache

**Special Populations**
- Contraindicated in CrCl <30 and dialysis
- Caution in hepatic impairment

Sugammadex and Residual NMB

- Randomized, parallel group, assessor-blinded
- December 2011 – November 2012
- Elective laparoscopic or open abdominal surgery + rocuronium
- Sugammadex vs. usual care (neostigmine/glycopyrrolate)
- Reduction in incidence of residual blockade

**Sugammadex and Reversal Efficacy**

**Impact on Extubation and Discharge**

<table>
<thead>
<tr>
<th></th>
<th>Sugammadex (n=74)</th>
<th>Usual Care (n=77)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Last NMB dose to last stitch</td>
<td>39 min</td>
<td>49 min</td>
<td>0.063</td>
</tr>
<tr>
<td>Reversal administration to extubation</td>
<td>11 min</td>
<td>15.2 min</td>
<td>0.014</td>
</tr>
<tr>
<td>Reversal administration to OR discharge ready</td>
<td>14.7 min</td>
<td>18.6 min</td>
<td>0.021</td>
</tr>
<tr>
<td>Reversal administration to OR discharge</td>
<td>19.9 min</td>
<td>24.1 min</td>
<td>0.020</td>
</tr>
<tr>
<td>PACU admission to PACU discharge ready</td>
<td>135 min</td>
<td>132 min</td>
<td>0.63</td>
</tr>
<tr>
<td>PACU admission to PACU discharge</td>
<td>209 min</td>
<td>235 min</td>
<td>0.22</td>
</tr>
</tbody>
</table>
### The Surgical Patient

<table>
<thead>
<tr>
<th>Goals for discharge</th>
<th>Challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Sufficient oral intake</td>
<td>• Stress of surgery</td>
</tr>
<tr>
<td>• Return of bowel function</td>
<td>• Delayed gut function</td>
</tr>
<tr>
<td>• Oral pain control</td>
<td>• Multiple transitions of care</td>
</tr>
<tr>
<td>• Sufficient mobility</td>
<td></td>
</tr>
<tr>
<td>• No complications requiring hospital care</td>
<td></td>
</tr>
</tbody>
</table>

### Enhanced Recovery After Surgery (ERAS)

- Multimodal, multidisciplinary approach to care of the surgical patient
  - Multidisciplinary team
  - Multimodal approach to complications that delay recovery
  - Evidence-based care protocols
- Key surgical endpoint is quality of recovery
- Consists of 24 core elements
  - Supported by scientific evidence

ERAS Society Guidelines

- Began as published protocol for colonic resections
- ERAS Society formed in 2010
- Guidelines incorporate core elements in for specific procedures
- www.erassociety.org

<table>
<thead>
<tr>
<th>Procedure and Topic</th>
<th>Year of Publication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colonic resection</td>
<td>2012</td>
</tr>
<tr>
<td>Rectal resection</td>
<td>2012</td>
</tr>
<tr>
<td>Pancreatoduodenectomy</td>
<td>2012</td>
</tr>
<tr>
<td>Cystectomy</td>
<td>2013</td>
</tr>
<tr>
<td>Gastric resection</td>
<td>2014</td>
</tr>
<tr>
<td>Anesthesia protocols</td>
<td>2015</td>
</tr>
<tr>
<td>Anesthesia pathophysiology</td>
<td>2015</td>
</tr>
<tr>
<td>Major gynecology (parts 1 and 2)</td>
<td>2015</td>
</tr>
<tr>
<td>Bariatric surgery</td>
<td>2016</td>
</tr>
<tr>
<td>Liver resection</td>
<td>2016</td>
</tr>
<tr>
<td>Head and neck cancer surgery</td>
<td>2016</td>
</tr>
<tr>
<td>Breast reconstruction</td>
<td>2017</td>
</tr>
<tr>
<td>Hip and knee replacement</td>
<td>Under production</td>
</tr>
<tr>
<td>Thoracic noncardiac surgery</td>
<td>Under production</td>
</tr>
<tr>
<td>Esophageal resection</td>
<td>Under production</td>
</tr>
</tbody>
</table>

ERAS Protocol Implementation

- Decreased length of stay
  - Consistent results
  - Multiple surgery types and complex patients

- Reduction in rates of complications
  - Up to 50% demonstrated in colorectal surgery
  - Decrease in severe complications and mortality in colorectal cancer

- Compliance with protocol produced better outcomes
  - Complications, length of primary and total stay, and readmissions
ERAS Flowchart Example

Impact of Surgical Insult

Catabolism
- Loss of protein
- Loss of muscle strength

Bowel dysfunction
- Delayed return to normal function
- Post-op ileus

Fluid shifts
- Reduced perfusion
- Salt and fluid overload

Metabolic stress
- Increased insulin resistance
Achieving Goals of ERAS

- Minimize stress & improve response to stress
- Avoid factors known to worsen outcomes
- Maximize nutrition
- Promote early return of bowel function

↓ insulin resistance

Patient Case

- SR is a 43 yo M scheduled for bariatric surgery
- PMH significant for HTN, DM, HLD and obesity
- Remote history of smoking and alcohol use
- Wife accompanies patient to all appointments
ERAS: Preadmission Core Elements

Smoking cessation and limit alcohol intake

Nutritional screening, assessment & support

Medical optimization of chronic disease

Patient Case: Preadmission Core Elements

• Remind SR of importance of abstaining from smoking and alcohol
  • Use increases risk of complications

• Conduct nutritional assessment and provide nutrition support
  • Pre-op nutrition deficiency is a strong predictor poor overall survival

• Optimize medical management of his HTN, DM and HLD
  • Reduces post-operative complications

**ERAS: Preoperative Core Elements**

- Structured information and patient engagement
- Preoperative carbohydrate treatment
- Thrombosis prophylaxis
- Infection prophylaxis
- Nausea & vomiting prophylaxis

---

**Patient Case: Preoperative Core Elements**

- Thoroughly explain what to expect during hospital stay to SR and his wife
  - Patient must understand their role in the process
  - Reduce patient anxiety & improve compliance with protocol

- Provide clear carbohydrate drinks up to 2hr before surgery
  - Decreases protein losses & post-op insulin resistance
  - Facilitates early return of bowel function
  - 6hr fast of solids before surgery

**Patient Case: Preoperative Core Elements**

- SR will be started on mechanical and/or pharmacological thrombosis prophylaxis
  - Significant cause of morbidity and mortality in bariatric patients
- Pre-operative antibiotics likely not needed for bariatric surgery
- Orders will be written for anti-nausea medications
  - PONV delays gut function and can cause metabolic derangements

---

**ERAS: Intraoperative Core Elements**

1. Minimize invasive techniques and surgical drains
2. Avoid long-acting opioids
3. Maintain fluid balance
4. Use epidural anesthesia for open surgery
5. Remove NG tubes before anesthesia reversal
6. Control body temperature
Patient Case: Intraoperative Core Elements

- Invasive techniques and surgical drains will be minimized
  - Known to cause significant complications
  - Promote faster recovery and reduce pain
- Epidural anesthesia will be used
  - Reduces stress response
  - Decreases risk of post-op ileus
- Long-acting opioids will be avoided
  - Decreases risk of post-op ileus
  - Long-acting opioids known to prolong recovery


Patient Case: Intraoperative Core Elements

- Fluid balance will be maintained and may use vasopressors for BP control
  - Fluid overload associated with delayed gut function and increased post-operative complications
- Nasogastric (NG) tube will be removed intraoperatively
  - Impair gut function
  - Increase incidence of post-op fever, atelectasis and pneumonia
- Hypothermia will be avoided
  - Increased risk of infection and bleeding
  - Affects pharmacokinetics of NMBs

ERAS: Postoperative Core Elements

- Early mobilization and prepare for early discharge
- Early intake of oral fluids and solids
- Early removal of IV fluids and urinary catheters
- Use of protein and energy-rich supplements
- Opioid sparing pain control and use of laxatives
- Multimodal approach to N/V control
- Regular audit of process and outcomes

Patient Case: Postoperative Core Elements

- Goal for SR to be up to chair and walking the day of surgery
  - Bed rest increases insulin resistance, muscle loss and risk of thrombosis
- Will offer oral fluids and solids day of surgery
  - Facilitates early return of bowel function and decreases post-op morbidity
- Will give protein rich supplements in addition to oral diet
  - Decrease protein loss
  - Promote wound healing

Patient Case: Postoperative Core Elements

- IV fluids and urinary catheters will be removed as soon as possible
  - Removal of fluids promotes mobilization and supports oral intake
  - Removal of catheter supports mobilization and decreases infection risk
- Continue use of medications to avoid nausea and vomiting
- Pain will be managed with oral, non-opioid agents if possible
  - Pain control reduces insulin resistance
  - Opioids delay gut motility
  - Oral medications facilitate discharge


Role of NMB Reversal in ERAS Protocol

- Incorporate appropriate use of NMB and reversal agents into intraoperative core elements
  - Could also consider screening for risk factors during preadmission
- Risk of residual blockade and benefits of reversal agents well documented
- Verbiage in ERAS Society Guidelines for GI and bariatric surgery
  - Do not recommend one NMB or reversal agent over another

ERAS in GI Surgery

• Avoid long-acting NMB
• Use minimum necessary NMB dose and level of block
• Maintain normothermia
• Use appropriate NMB monitoring techniques
• Avoid residual NMB with use of reversal agent


ERAS in Bariatric Surgery

• Consider deep neuromuscular block
• Ensure full reversal of neuromuscular blockade
• Use appropriate monitoring of neuromuscular blockade

Benefits of Inclusion in ERAS Protocols

- Early identification and correction of modifiable risk factors
- Reduced incidence of residual neuromuscular blockade
- Decrease in post-operative complications
- Improved patient outcomes

Summary

- Residual neuromuscular blockade causes significant post-surgical complications
- Many risk factors of residual blockade are modifiable
- Available reversal agents shown to reduce complications of residual blockade
- Enhanced Recovery After Surgery (ERAS) protocols improve patient care
- Appropriate use of neuromuscular blockers and reversal agents play a role in ERAS protocols
1. Choose the CORRECT statement regarding Train of Four (TOF) below:
A. TOF of 0 is full, deep blockade
B. TOF of 0 is full movement
C. TOF of 5 is full, deep blockade
D. TOF of 5 is full movement

2. The current definition of residual neuromuscular blockade is defined as:
A. TOF ratio <0.3
B. TOF ratio <0.5
C. TOF ratio <0.7
D. TOF ratio <0.9

Use the case below to answer questions 3 and 4.
LM is a 61yo F who underwent bariatric surgery. Her PMH includes HTN, DM and CKD. During surgery, LM received propofol, sevoflurane and pancuronium. She was maintained at a TOF of 0 during surgery. She arrived to the PACU with a TOF of 0.5 despite use of a reversal agent. Post-surgery, she became hypoxemic requiring re-intubation and was admitted to the ICU.

3. Which of the following is NOT a risk factor for LM’s residual neuromuscular blockade?
A. A female undergoing bariatric surgery
B. Use of pancuronium, a long acting neuromuscular blocker
C. Use of deep blockade requiring large doses of pancuronium during surgery
D. Use of sevoflurane, an inhaled anesthetic

4. LM arrived to the PACU with signs and symptoms of residual neuromuscular blockade. Which of the following is a complication of residual neuromuscular blockade?
A. Early extubation
B. Re-intubation
C. Shortened hospital stay
D. Increased inspiration

5. Sugammadex is approved for reversal of:
A. All depolarizing neuromuscular blockers
B. All non-depolarizing neuromuscular blockers
C. Rocuronium and vecuronium only
D. Atracurium and cisatracurium only
6. Choose the CORRECT statement regarding reversal agents below:
   A. Sugammadex must be given with glycopyrrolate and atropine
   B. Neostigmine is FDA approved to reverse succinylcholine only
   C. Sugammadex has an approved dosing regimen for reversal of deep blockade.
   D. Neostigmine has an approved dosing regimen for reversal of deep blockade.

7. The primary goal of Enhanced Recovery After Surgery (ERAS) is:
   A. Decreased length of surgical procedure
   B. Quality of surgical procedure
   C. Increased time to recovery
   D. Quality of recovery

8. Which of the following is NOT an ERAS preoperative core element?
   A. Infection prophylaxis
   B. Weight loss prophylaxis
   C. Nausea and vomiting prophylaxis
   D. Thrombosis prophylaxis

9. Choose the CORRECT statement regarding the role of reversal agents in ERAS protocols?
   A. Reversal agents are included in ALL published ERAS Society Guidelines
   B. Reversal agents are not addressed in ANY published ERAS Society Guidelines
   C. Reversal agents may be addressed in the preadmission and intraoperative portions of ERAS protocols
   D. Reversal agents have no role in ERAS protocols

10. Which of the following ERAS Postoperative elements helps to improve gut motility after surgery?
    A. Opioid sparing pain control and use of laxatives
    B. Early removal of IV fluids and urinary catheters
    C. Preparation for early discharge
    D. Regular audit of process and outcomes