

Neuromuscular Monitoring and Patient Safety:

“Pulmonary Complications of Residual Block”

CEEA Course

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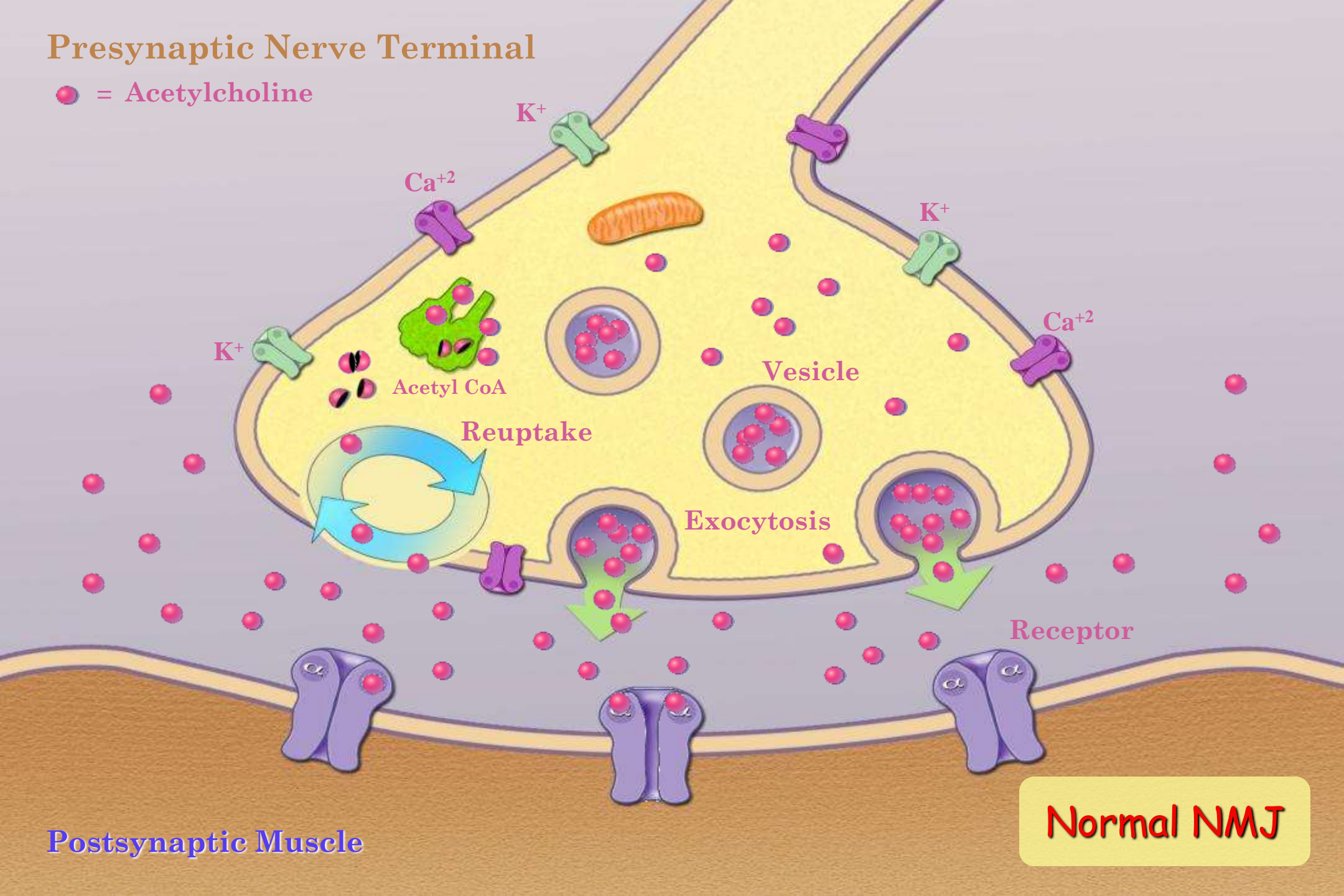


OVERVIEW

- **Residual NM Paralysis – Incidence**
 - Standards & Magnitude of the Problem
- Myths & Dogmas - Pulmonary Effects
 - Potential Solutions

Presynaptic Nerve Terminal

● = Acetylcholine



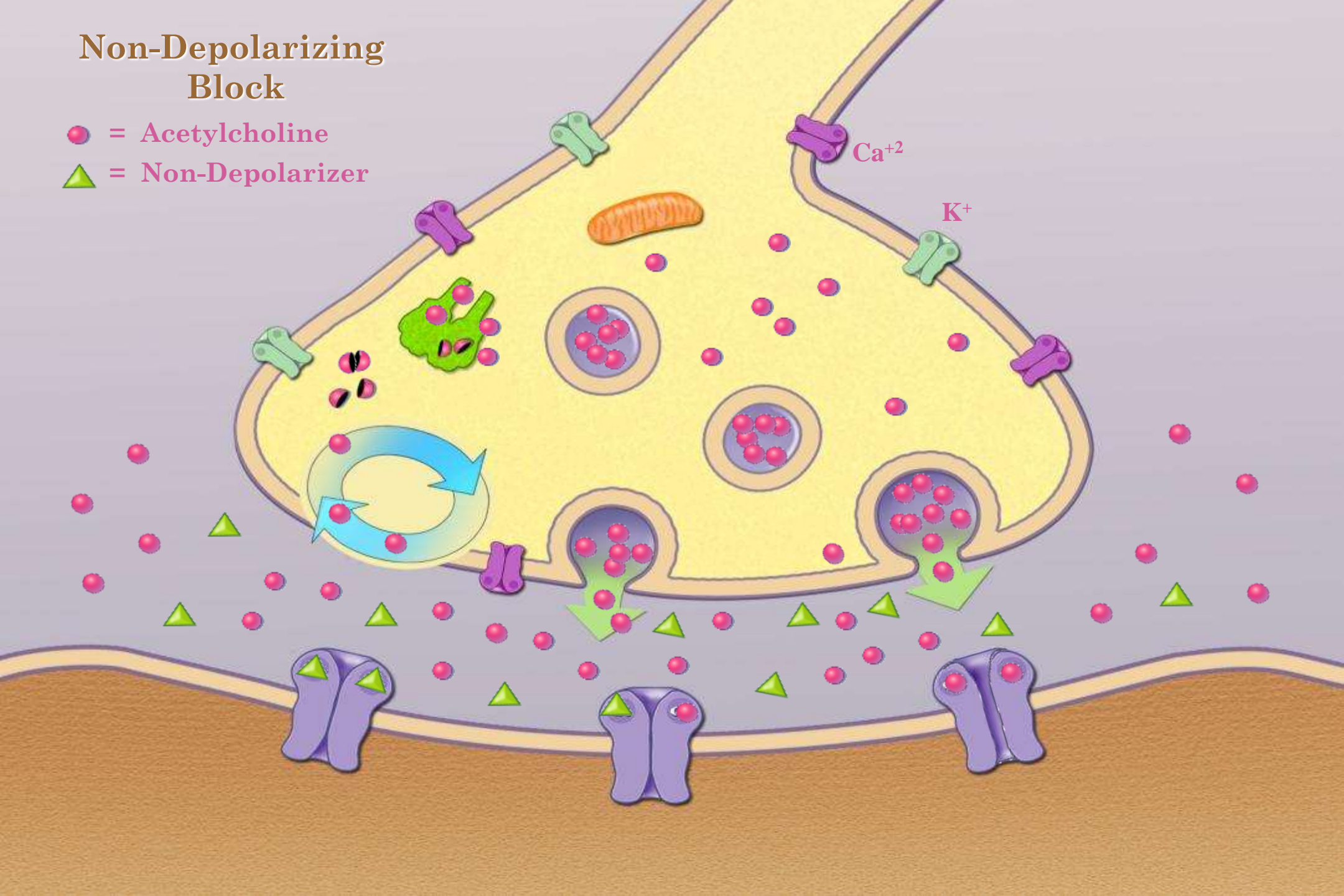
Postsynaptic Muscle

Normal NMJ

Non-Depolarizing Block

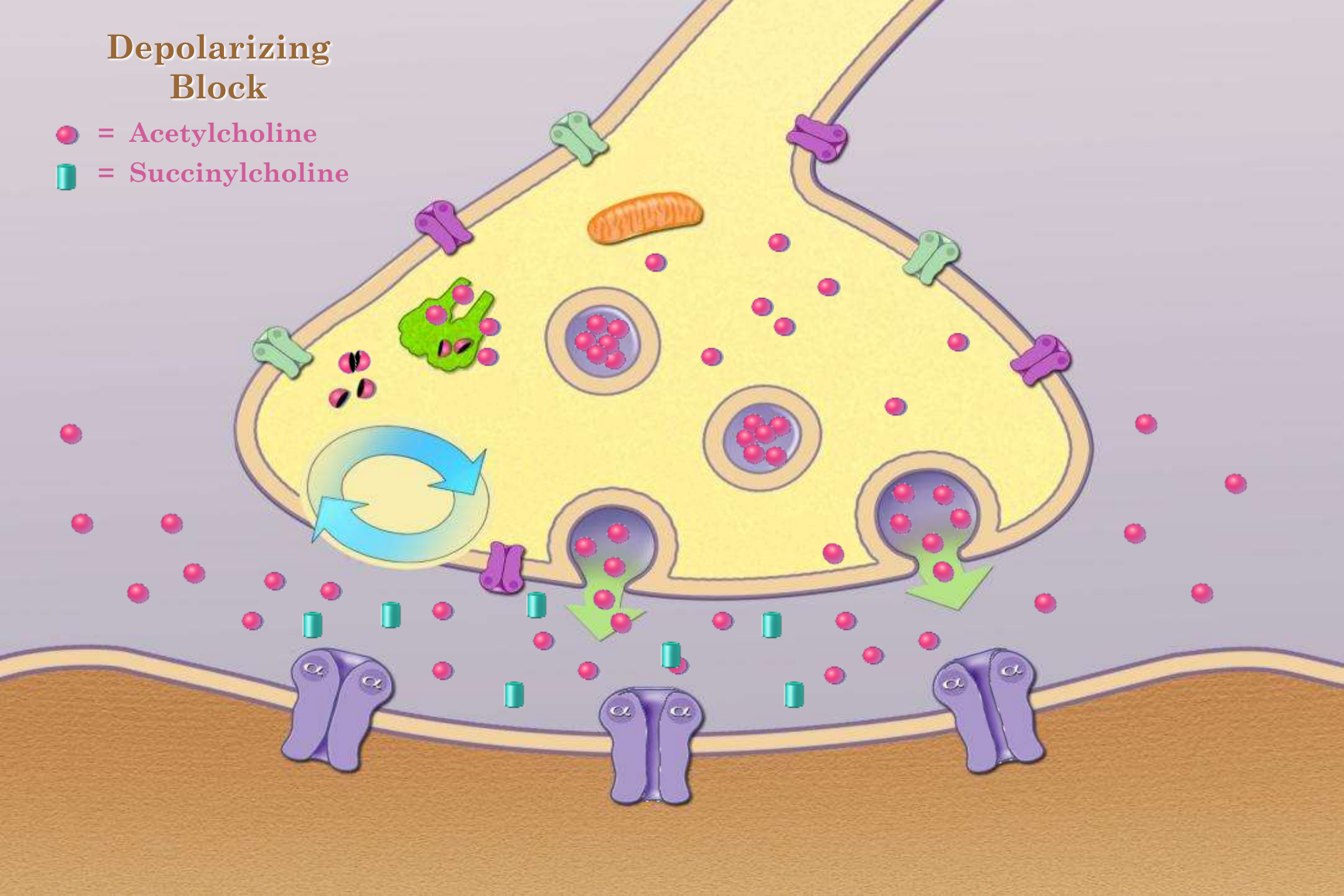
● = Acetylcholine

▲ = Non-Depolarizer



Depolarizing Block

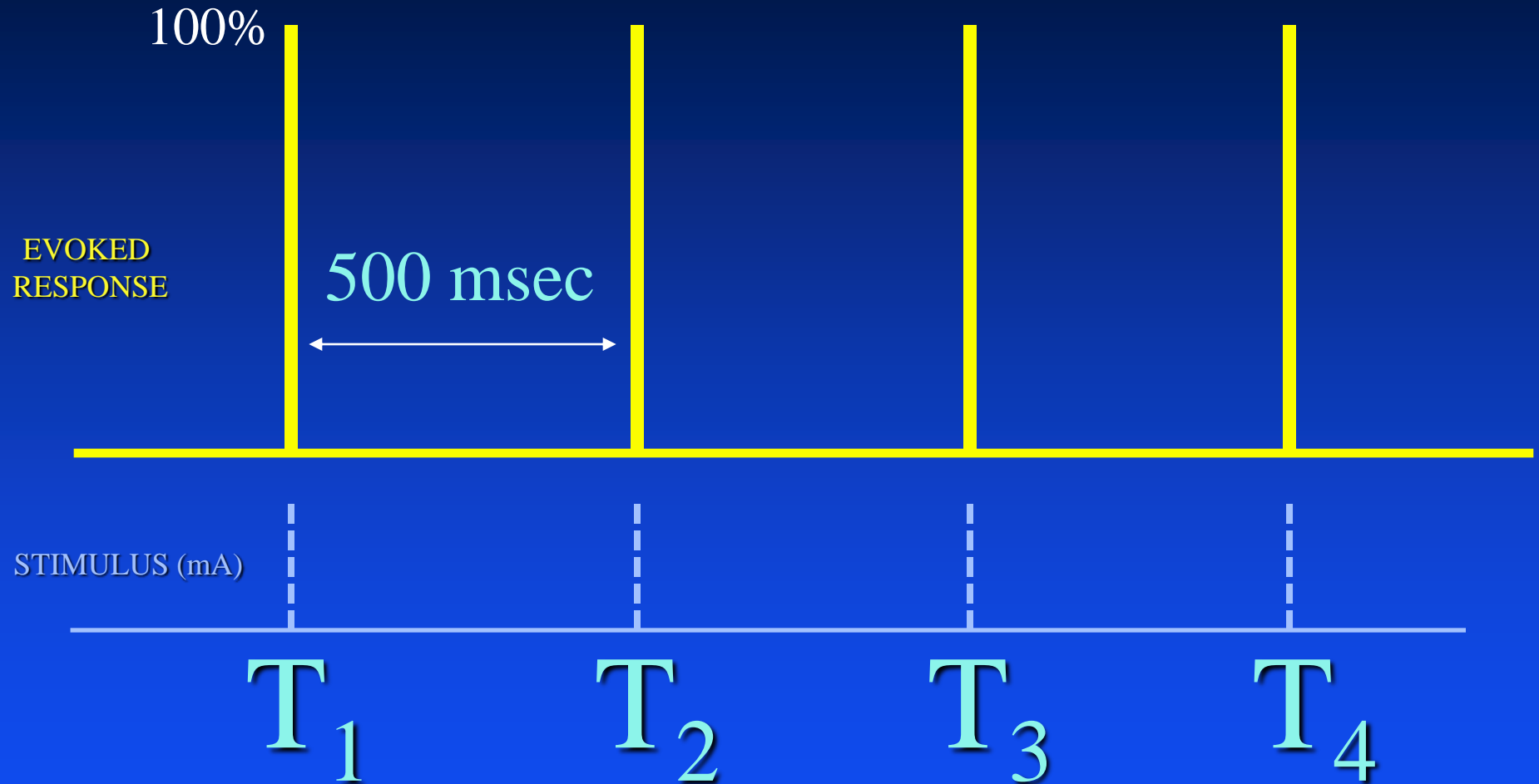
- = Acetylcholine
- = Succinylcholine



PATTERNS OF STIMULATION

- Single Twitch
- Train-of-Four (TOF)
- Double Burst Stimulation (DBS)
- Tetanic Stimulation
- Post-Tetanic Count

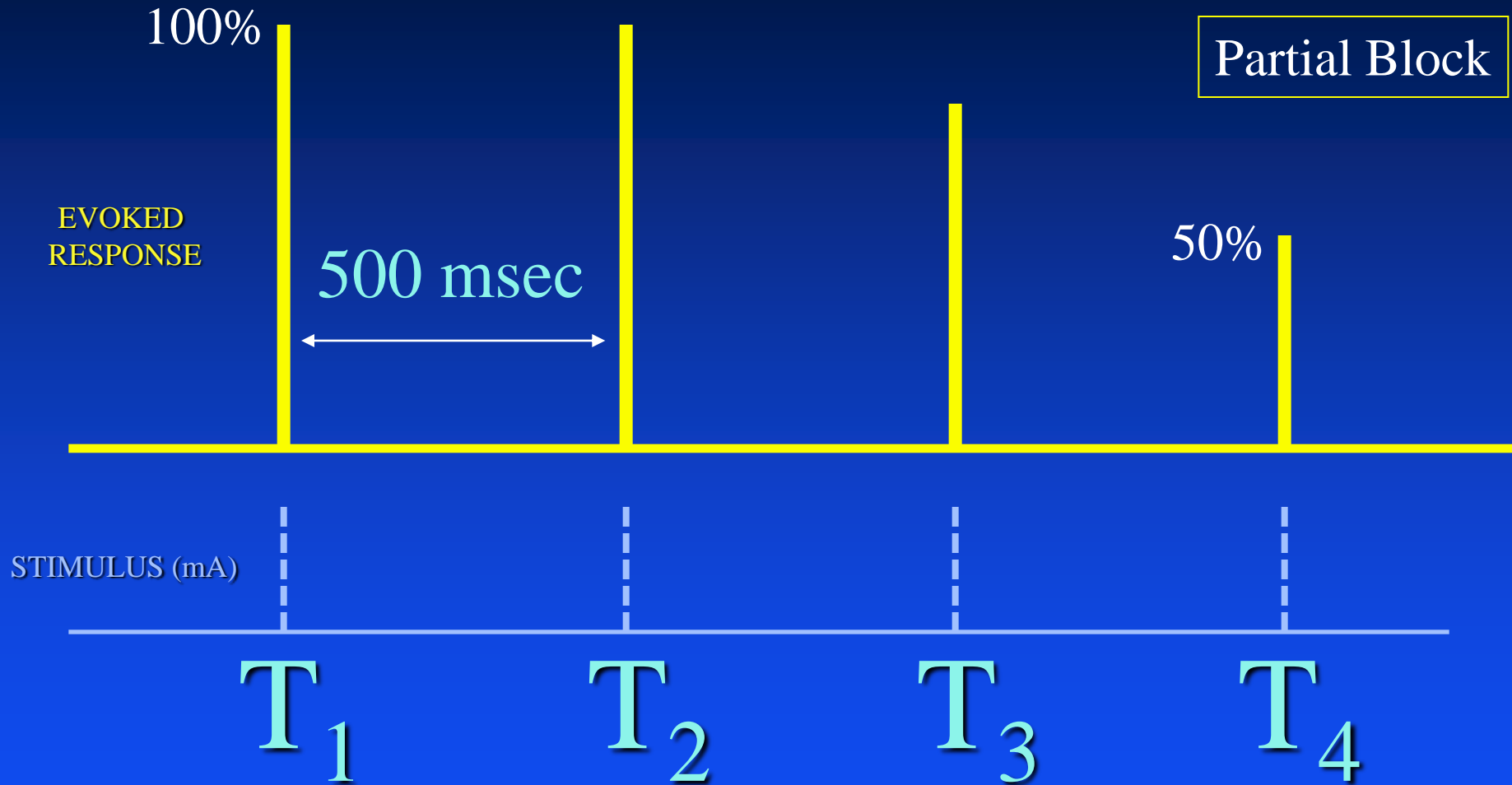
TRAIN-OF-FOUR (TOF)



$$T_4/T_1 \text{ RATIO} = 1.0$$



TRAIN-OF-FOUR (TOF)



$$T_4/T_1 \text{ RATIO} = 0.5$$



Definition of “Adequate Recovery”

Volunteer Data – healthy, no premedication

- **TOF > 0.70**
 - Open eyes, protrude tongue, 5-sec head lift
 - Cough, VC = 15-20 mL/kg (Ali & Kitz 1973; Brand 1977)
- **TOF < 0.80**
 - Impaired inspiratory flow/respiratory reserve (Ali 1975)
 - Decreased ventilatory response to hypoxia (Eriksson 1996)
 - Partial upper AW obstruction (Eikermann 2003)
- **TOF < 0.90**
 - Pharyngeal dysfunction (Isono 1991)
 - Increased risk of aspiration (Eriksson 1997, 2000)
- **TOF > 0.90**
 - Diplopia, fatigue
 - Not “street ready” (Kopman 1997)

Incidence of Residual Paralysis

- **Long-acting NMB:**

- d-TC, pancuronium - **42%** (Neostigmine reversal)

(Viby-Mogensen 1979; Beemer 1986; Brull 1989)

- **Intermediate-acting NMB:**

- Incidence of residual weakness (TOF < 0.70):

- Vecuronium - **7-64%**

(Brull 1989; Bissinger 2000; Debaene 2003)

- Atracurium - **4-65%**

(McCaul 2002; Hayes 2001; Baillard 2005)

- Rocuronium - **9-88%**

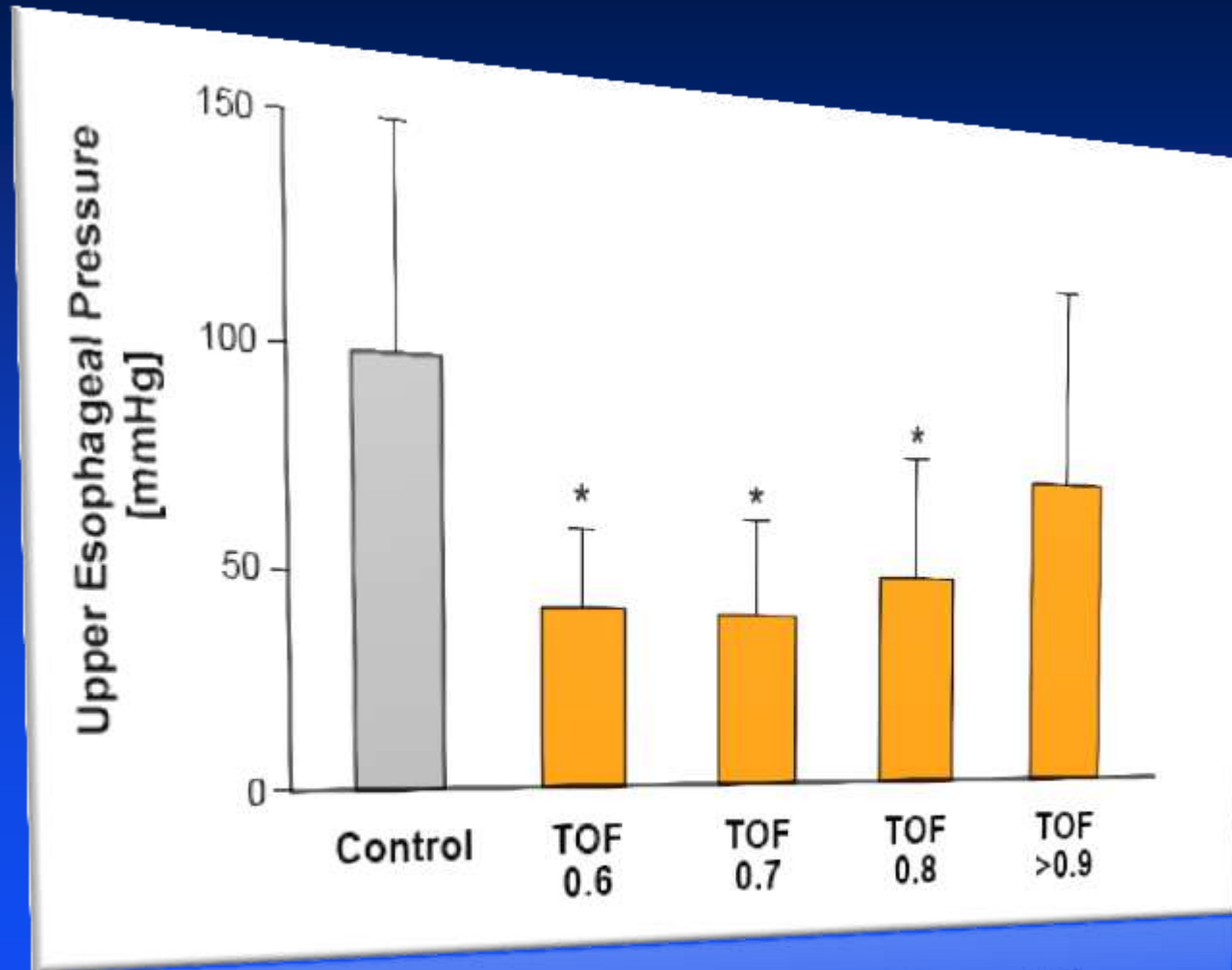
(Kim 2002; Baillard 2005; Murphy 2005)

- **Short-acting NMB:**

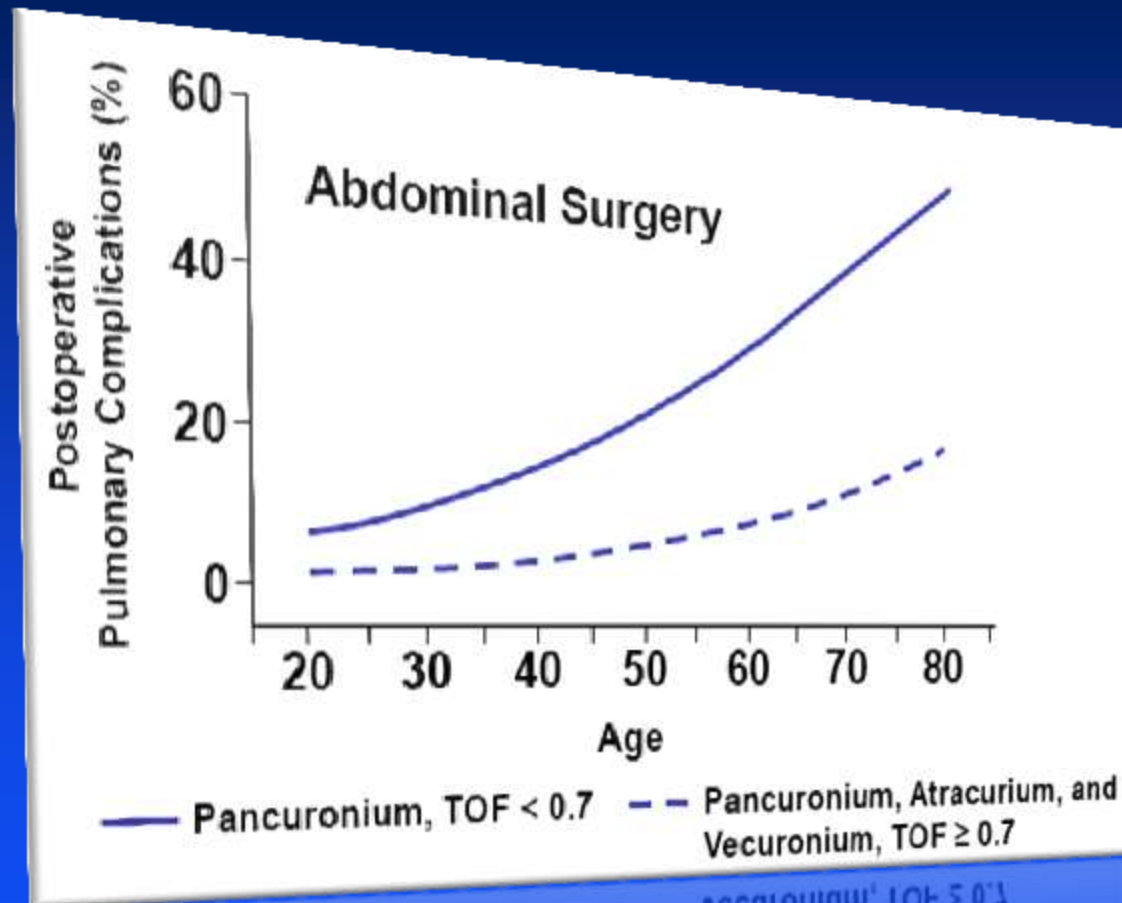
- Mivacurium - **23-35%**

(Cammu, 2006)

Residual Block and Swallowing Ability



Probability of Developing Postoperative Pulmonary Complications



Incidence of Residual Paralysis

- Meta-analysis – 24 studies; 3,375 patients
 - Antagonism in 62.1% of patients
 - Monitoring (qual. or quant.) – 24.4% patients
 - Intermediate-acting NMB:
 - **Incidence TOF < 0.90 = 41%**
- “Thus, four decades after the first nerve stimulators were described, **unacceptable levels of residual paresis in the PACU continue to be reported.**”

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Are There Standards?

- **ASA: no Standards, Guidelines or Statements**
- **“Standards for Basic Anesthesia Monitoring”**
(Effective July 2011)
 - **Standard I – Presence of qualified anesthesia personnel**
 - **Standard II – Oxygenation**
 - **Standard III – Ventilation**
 - **Standard IV – Circulation**
 - **Standard V – Body Temperature**
- **“Statement on Documentation of Anesthesia Care”**
(Last amended October 22, 2008)
 - **Silent**



Houston, We Have a Problem

- Postoperative pulmonary complications

(Moller 1990; Pedersen 1992; Berg 1997)

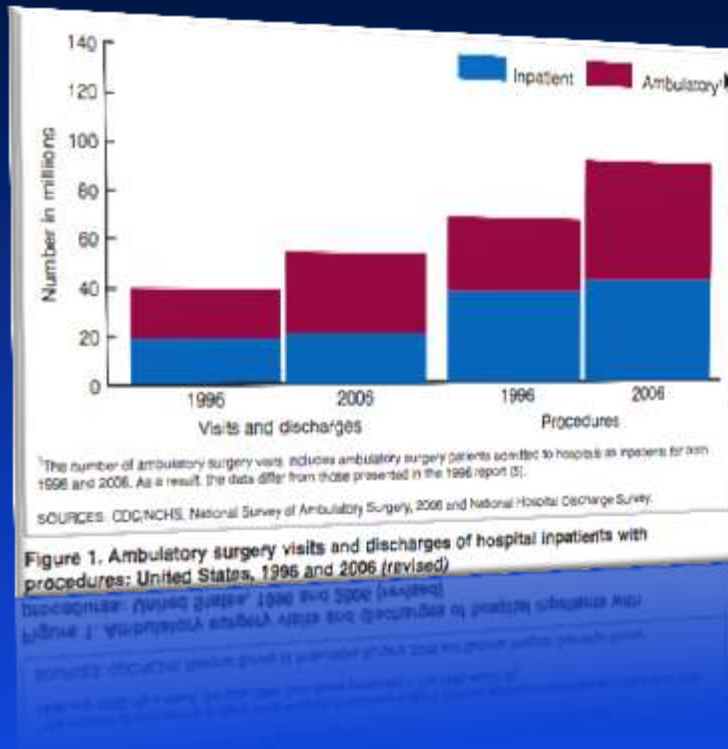
- Significant delays in meeting PACU and hospital discharge criteria (M&M, \$\$)

(Murphy 2004)

- Appropriate reversal of NMB decreases 24-hr mortality and coma

(Arbous 2005)

Houston, How Big Is the Problem?



- Approximately 40M inpatient surgical cases/year (2006) in the United States
 - Nat Health Statistics Reports 11; 2009 (www.cdc.gov/nchs/data/nhsr)
- 60% receive GA = 24M (million) patients
- PORP = 41% then 10M patients at risk

- Incidence of Critical Respiratory Events = 0.8%
 - CRE = AW obstruction; O₂ sat 90-93% on O₂; O₂ sat <90% on O₂; Respiratory distress; Reintubation; Pulmonary aspiration. (Murphy 2008)
- Potential Risk: 0.8% of 10M = 80-100,000 patients/year with CRE

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- Residual NM Paralysis – Incidence
 - Standards & Magnitude of the Problem
- **Myths & Dogmas – Pulmonary Effects**
 - Potential Solutions

Most anesthesiologists in the U.S. and Europe
believe that **clinically significant** residual
postoperative weakness is RARE

Truth of Fiction?

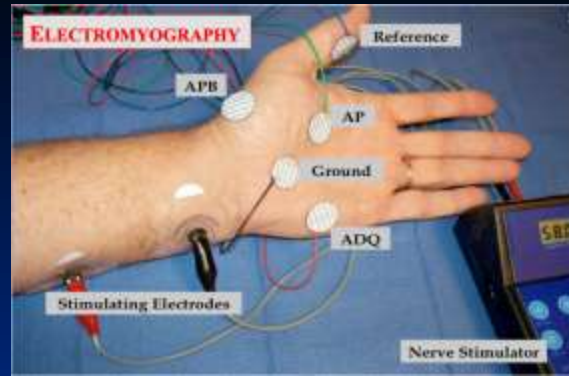
“Most anesthesiologists in the U.S. and Europe believe clinically significant residual postoperative weakness is **RARE**”

- In 2,636 completed surveys:
 - 64.1% of US anesthesiologists
 - 52.2% of European anesthesiologists
 - Believe postoperative residual weakness **rate is <1%**

TRUE!
And they are
WRONG!

Incidence of Residual Paralysis

- Meta-analysis – 24 studies; 3,375 patients
 - Antagonism in 62.1% of patients
 - Monitoring (qual. or quant.) – 24.4% patients
 - Intermediate-acting NMB:
 - **Incidence TOF < 0.90 = 41%**



“Objective monitoring has a good applicability, but demands frequent use. **There are many myths and excuses for not using a nerve stimulator.** The truth is, however, that **there are no good reasons for not monitoring** neuromuscular block, whenever a neuromuscular blocking agent is given.”

Claudius C, Karacan H, Viby-Mogensen J: Prolonged residual paralysis after a single intubating dose of rocuronium. Br J Anaesth 2007; 99 :514-7

OVERVIEW

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- Myths & Dogmas
- **Potential Solutions**

How Can We Improve Our Practice?

- Do not rely on **clinical tests** alone
 - Sensitivity (0.18-0.35) and Positive Predictive Value (0.47-0.52)
- Many clinical tests (leg- or head-lift, hand grip):
 - **Not specific for respiratory function: 5-sec head-lift**
 - 11 of 12 volunteers had sustained 5-sec lift, TOF ratio = 0.50
(Eikermann M. Anesthesiology 2003)
 - 16 of 19 patients had 5-sec head-lift in PACU, TOF < 0.5
(Pedersen T. Anesthesiology 1990)

How Can We Improve Our Practice?



- **Do not rely on subjective** (qualitative) tests

- At TOF = 0.41-0.50:
 - Visual vs. Tactile detection of fade: $p = \text{NS}$

(Viby-Mogensen J. Anesthesiology 1985)

- **Usefulness of Nerve Stimulators (PNS) is LIMITED**

- Tactile evaluation vs. clinical assessment: $p = \text{NS}$ (deep block)
- Meta-analysis: not able to demonstrate difference

(Naguib M. Br J Anaesth 2007)

How Can We Improve Our Practice?

- Use **QUANTITATIVE** means of testing:
 - MMG, EMG, AMG, KMG or PMG
- Do NOT rely on time since last administration:
 - Single dose **vecuronium** 0.1 mg/kg
 - TOF < 0.75 at 3 hrs in 3 of 10 patients) – 30%
 - TOF < 0.75 at 4 hrs in 1 of 20 patients) – 5%

(Caldwell JE. Anesth Analg 1995)

- Do NOT reverse **ALL** patients – may induce block

- Neo induces weakness without NMB

(Payne JP. Br J Anaesth 1980)

- Neo impairs genioglossus & diaphragm

(Eikermann M. Anesthesiology 2007)



How Can We Improve Our Practice?

- Timely ANTAGONISM (REVERSAL) - until TOF > 0.90
 - Neo 0.07 mg/kg after rocuronium:
 - From TOF count 1 - to recovery: 29 (9-76 min)
 - From TOF count 2 - to recovery: 23 (8-57 min)
 - From TOF count 3 - to recovery: 16 (7-44 min)
 - From TOF count 4 - to recovery: 10 (5-26 min)
- “A TOF count of 4 is needed to achieve reversal of rocuronium within 15 min!!”

(Kim KS. Anesth Analg 2004)

How Can We Improve Our Practice?

- Reversal Dosing
 - If TOF count = 0-1: DELAY reversal
 - If TOF count = 2-3: full reversal
 - If TOF < 0.40: full reversal
 - If TOF = 0.40-0.90: low-dose neo (0.02 mg/kg)
 - If TOF > 0.90 (quantitative): NO reversal

(Brull SJ, Murphy GS. Anesth Analg 2010)

In Summary:

- Postoperative Neuromuscular Weakness is a **Continuing Clinical Problem**
- **Objective Monitoring** Will Ensure Pulmonary Recovery and Safety
- **Standards Are Needed**

“Quality is not an act. It is a habit.”



Aristotle, 384-322 BCE.
Philosopher, student of Plato,
and teacher of Alexander the
Great.

Thank You – Multumesc!