Perioperative Medicine Summit

Evidence Based Perioperative Medical Care

Perioperative Pulmonary Risk Assessment & Management

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No financial or other conflicts of interest

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Perioperative & Consultative Medicine

MEDICAL COLLEGE OF WISCONSIN

Objectives

- Review established risk factors and risk reduction methods for postoperative pulmonary complications (PPCs)
- Explore developments in perioperative pulmonary risk assessment and management in several areas

ARS Question #1

You are seeing a 76-year-old woman in preop clinic prior to sigmoidectomy for recurrent diverticulitis. She has been feeling fine with no symptoms and a good functional capacity. Her history is otherwise significant only for HTN and smoking (quit 2 months ago).

Exam: HR 80, BP 130/72, RR 18, Pox 96% (RA); otherwise normal

Labs: BMP normal, Hgb 12.8 g/dl

Which of the following is this patient's strongest patient-specific predictor for postoperative pulmonary complications?

A) Smoking history

B) ASA classification

C) Planned surgical site

D) Age

Pulmonary Risk Factors

- Postoperative pulmonary complications (PPCs), including respiratory failure and pneumonia, are common yet underappreciated
  - **5.8%** in modern major abdominal surgery cohorts[1]
  - Account for >50% of negative perioperative outcomes[2]
  - Carry higher cost, morbidity and mortality than cardiac complications[3,4]
  - Cause 4% of postoperative hospital readmissions[5]
- Multiple studies over the last several years have identified similar risk factors for PPCs[6-9]

[1] Yang CK et al. *J Surg Res*. 198(2):441-9
[2] Fleischmann KE et al. *Am J Med*. 2003;115:515-20.
[3] Johnson RG et al. *J Am Coll Surg*. 2007;204:1188-98.
[4] Dimick JB et al. *J Am Coll Surg*. 2004;199:531-7.
[5] Merkow RP et al. *JAMA*. 2015;313(5):483-95.
[6] Smetana GW et al. *Ann Intern Med*. 2006;144:581-95.
[7] Gupta H et al. *Chest*. 2011;140:1207-15.
[8] Gupta H et al. *Mayo Clin Proc*. 2013;88(11):1241-9.
[9] Memtsoudis SG et al. *Anesth Analg*. 2014;118:407–18.

Pulmonary Risk Factors

PATIENT Risk Factor		Adjusted OR
ADL functional dependence	Total	4.07-4.33[2,3]
	Partial	1.93-2.16[2,3]
Age	60-69	2.09[1]
	≥70	3.04[1]
CHF (NYHA ≥II)		2.20[4]
OSA		1.86-2.46[5,6]
COPD		1.79[1]
ASA class (≥4)		1.28[2]
Smoking		1.26[1]
Pulmonary hypertension		---

PROCEDURAL Risk Factor		Adjusted OR
Surgical site	Aortic	2.94[2]
	Foregut/hepatobiliary	2.64[2]
	Brain	2.08[2]
	Other abdominal	1.27-1.78[2]
	ENT	1.11[2]
Prolonged surgery (>2 hours)		2.21[1]
Emergency surgery		2.21[1]
General anesthesia		1.83[1]

1 Smetana GW et al. *Ann Intern Med.* 2006;144:581-95.
2 Gupta H et al. *Chest.* 2011;140:1207-15.
3 Gupta H et al. *Mayo Clin Proc.* 2013;88(11):1241-9.
4 Canet J et al. *Eur J Anaesthesiol.* 2015;32(7):458-70.
5 Memtsoudis SG et al. *Anesth Analg.* 2014;118:407–18.
6 Hai F et al. *J Clin Anesth.* 2014;26(8):591-600.

Pulmonary Risk Prediction

- Multiple risk indices have been developed
  - Many are highly specific to either population (eg, abdominal surgery) or unique complication (eg, acute lung injury)
  - Most have not been externally validated
  - Most created from databases in which OSA was not recorded
- A few have been more inclusive in terms of population and outcomes…

Pulmonary Risk Indices

Index	PPCs	C-stat	Population	Unique risk factors
Arozullah et al – 2000[1]	Resp failure	0.843	VA	↑BUN, transfusion, prior CVA, wt loss, impaired sensorium, EtOH use, steroid use
Arozullah et al – 2001[2]	Pneumonia	0.779		
ARISCAT (Canet et al) – 2010/2014[3,4]	Resp failure, resp infection, ATX, pneumonitis, pleural effusion, bronchospasm	0.76-0.87	European (performance best in Western Europe)	Anemia, resp infection in last month, preop SpO_2<95%
Gupta et al – 2011[5]	Resp failure	0.894	NSQIP	Sepsis
Gupta et al – 2013[6]	Pneumonia	0.860		
ACS Surgical Risk Calculator – 2013[7]	Pneumonia	0.870	NSQIP	***
PERISCOPE (Canet et al)[8]	Resp failure (hypoxia requiring intervention)	0.82	European	Resp symptoms (cough, dyspnea, wheezing), chronic liver disease, CHF

[1] Arozullah AM et al. *Ann Surg.* 2000;232(2): 242-53.
[2] Arozullah AM et al. *Ann Intern Med.* 2001;135(10):847-57.
[3] Canet J et al. *Anesthesiology*. 2010;113(6):1338-5.
[4] Mazo V et al. *Anesthesiology*. 2014;121(2):219-31.
[5] Gupta H et al. *Chest*. 2011;140:1207-15.
[6] Gupta H et al. *Mayo Clin Proc*. 2013;88(11):1241-9.
[7] Bilimoria KY et al. *J Am Coll Surg*. 2013;217(5):833-42.
[8] Canet J et al. *Eur J Anaesthesiol*. 2015;32(7):458-70.

Do the Math…

Arozullah Indices

RISK FACTOR	Pneumonia Risk Score	Resp. Failure Risk Score
Type of Surgery		
AAA Repair	15	27
Thoracic	14	21
Upper abdominal	10	14
Neck	8	11
Neurosurgery	8	14
Vascular surgery	3	14
Age		
≥80 years	17	6
70-79 years	13	
60-69 years	9	4
50-59 years	4	-
Functional Status		
Totally dependent	10	7
Partially dependent	6	
BUN		
<8 mg/dL	4	-
22-30 mg/dL	2	-
>30 mg/dL	3	8
Albumin < 3 g/dL	-	9
Weight loss >10% within 6 months	7	-
Chronic steroid use	3	-
Emergency surgery	3	11
General anesthesia	4	-
Alcohol use (> 2 drinks/day within 2 weeks)	2	-
COPD history	5	6
Smoker within 1 year	3	-
Impaired sensorium	4	-
CVA history	4	-
Preoperative transfusion (>4 units)	3	-

Risk Class	Pneumonia Risk Score	Probability of Pneumonia	Respiratory Failure Risk Score	Probability of Respiratory Failure
1	0-15	0.2%	0-10	0.5%
2	16-25	1.2%	11-19	2.2%
3	26-40	4.0%	20-27	5.0%
4	41-55	9.4%	28-40	11.6%
5	>55	15.3%	>40	30.5%

ARISCAT INDEX (all PPCs)

Risk Factor		Score
Age (yrs)	51-80	3
	>80	16
Preop S_{pO2} (%)	91-95	8
	<91	24
Respiratory infection in past month		17
Location of surgery	Upper abdominal	15
	Thoracic	24
Duration of surgery (hrs)	>2 to 3	16
	>3	23
Emergency surgery		8
Preop Hgb ≤10 g/dl		11

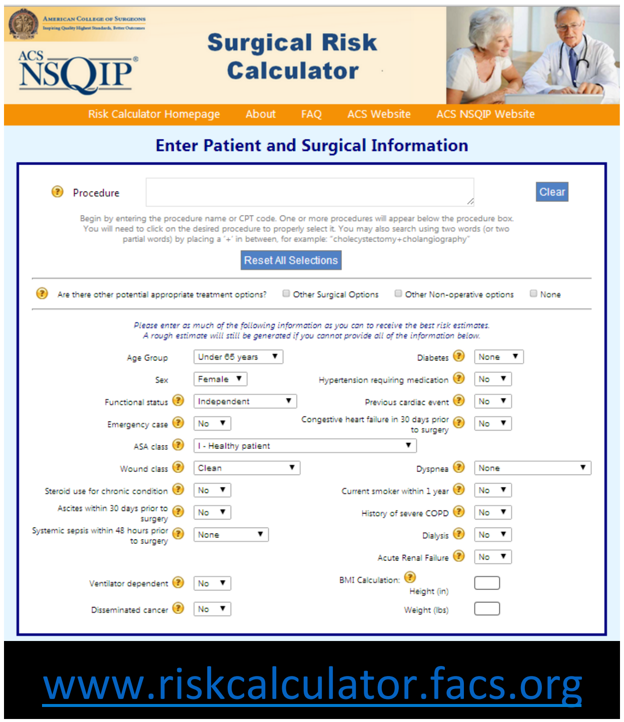
RISK CLASS	Risk Score	PPCs (%)
Low	<26	1.6-3.4
Intermediate	26-44	13-13.3
High	>44	38-42.1

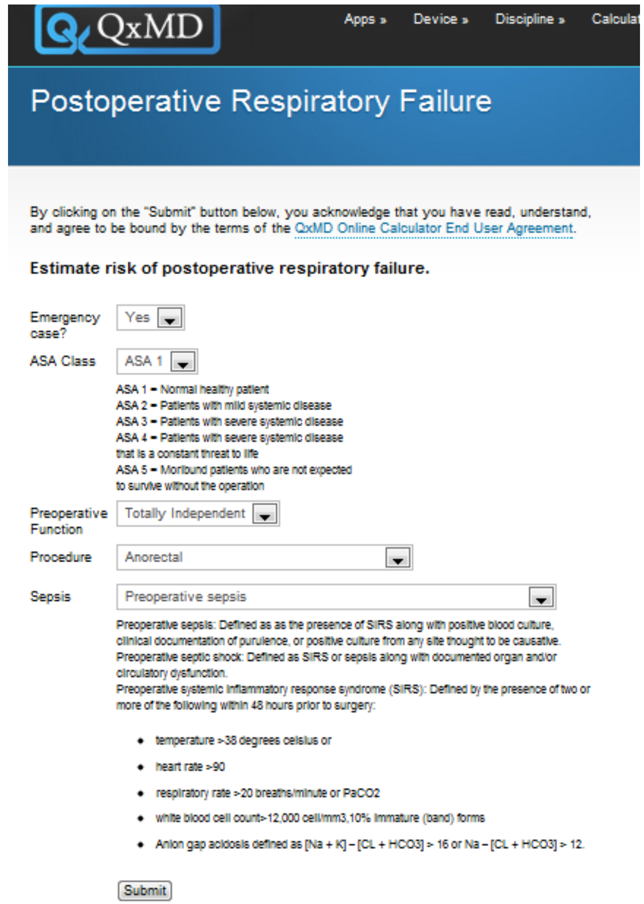
PERISCOPE INDEX (Resp Failure)

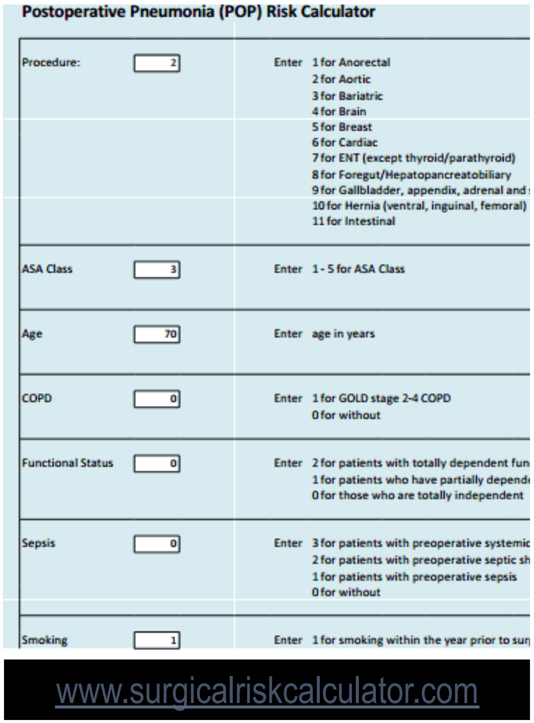
Risk Factor		Score
CHF	NYHA I	3
	NYHA ≥II	8
Preop S_{pO2} (%)	91-95	7
	<91	10
Respiratory symptoms		10
Location of surgery	Closed upper abdominal/ thoracic	3
	Open upper abdominal	7
	Open thoracic	12
Surgery duration (hrs)	>2 to 3	5
	>3	10
Emergency surgery		12
Chronic liver disease		7

RISK CLASS	Risk Score
Low	<12
Intermediate	12-22
High	>22

...Or Use a Calculator







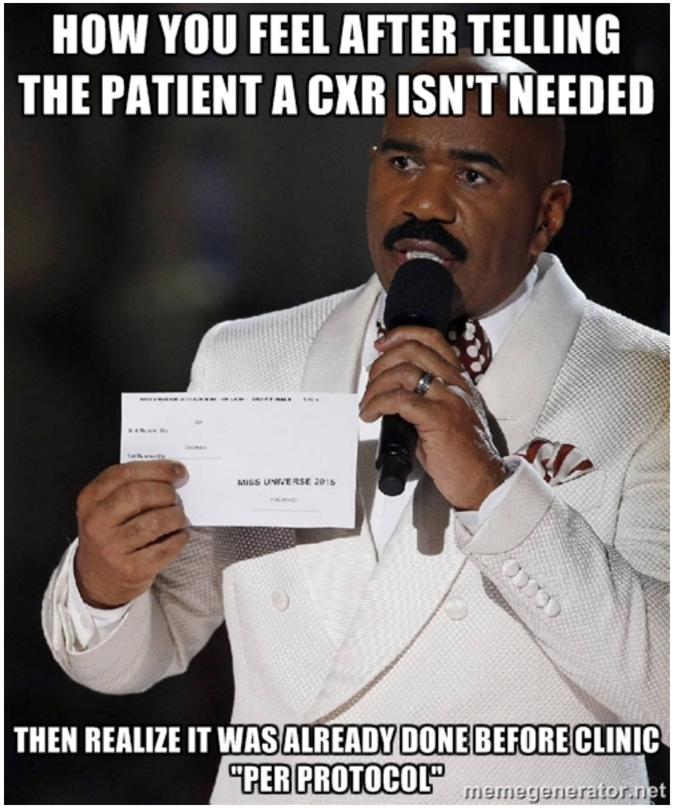
Summary – Risk Assessment

- All available risk indices provide reliable estimation of PPC risk
- Calculation of risk may be less important than recognition of risk factors so that available risk reduction measures can be implemented
  - Specific percentiles of risk and specific risk factors do not trigger specific risk reduction measures
- **Available risk indices largely confirm same risk factors for PPCs:**
  - **Poor functional status (ADLs)**
  - **Procedure**
    - **Proximity to respiratory tree**
    - **Long duration**
    - **Emergent**
  - **Multiple comorbidities (i.e., higher ASA class)**
  - **COPD**
  - **Smoking**
  - **Advanced age**
  - ***Liver disease***
  - ***Recent respiratory illness/symptoms***
  - ***Hypoxia***
  - ***Anemia/transfusion***
  - ***CHF***
- Major weakness of all remains the lack of incorporation of OSA

Diagnostic Testing

- Several pulmonary diagnostic tests can be considered for preoperative risk stratification
  - Chest radiography
  - Spirometry
  - Arterial blood gas analysis
- Value of these tests in cardiothoracic surgery has been established, but their utility in other surgeries is questionable

Chest Radiography



- Screening CXR in asymptomatic patients is problematic
  - Relatively low yield (5-20%)[1]
  - Poor correlation with pulmonary risk[1]
  - Rarely changes management (<5%)[1]
- ABIM Foundation's Choosing Wisely Campaign:
  - 3 different societies recommend against CXR in patients without signs or symptoms of disease[2]

[1] Qaseem A et al. *Ann Int Med* 2006;144:575-580.\
[2] www.choosingwisely.org

Arterial Blood Gas Analysis

- Data for preoperative ABG is also weak
- May identify hypercapnia or hypercarbia, but does not clearly correlate with risk, especially compared to clinical assessment

Smetana GW, Macpherson DS. *Med Clin N Am.* 2003;87:7-40.

Spirometry

- Some studies have shown that less favorable spirometry results (low FEV1) correlate with PPCs
- Comparisons of spirometry to clinical data do not clearly demonstrate an additional predictive value from spirometry[1]
- No prohibitive FEV1 has been determined for non-cardiothoracic surgery[1]
- Encouragingly, a recent Canadian study showed decreases in preoperative spirometry ordering[2]

[1] Smetana GW et al. *Ann Int Med* 2006;144:581-95.
[2] Sun LY et al. *JAMA Intern Med.* 2015;175(8):1410-2.

Evaluation of spirometric testing as a routine preoperative assessment in patients undergoing bariatric surgery

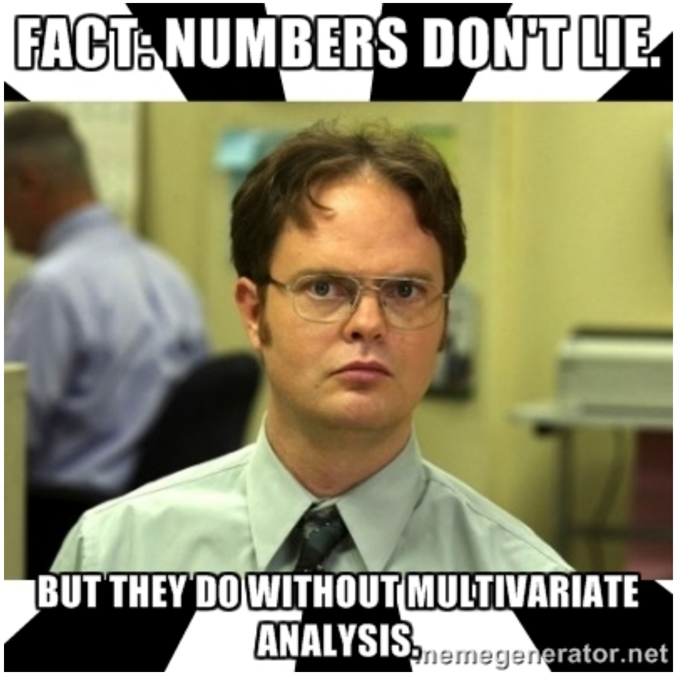
Clavellina-Gaytán D et al. *Obes Surg*. 2015;25(3):530-6.

- American Society for Metabolic and Bariatric Surgery and American College of Physicians do not recommend routine preoperative spirometry
- 2013 study found 3-fold increased rate of PPCs in bariatric surgery patients with abnormal spirometry[1]
- Retrospective study of 600 bariatric surgery patients who had undergone preoperative spirometry
    - Mean BMI 42.1 kg/m^2
    - 68% smokers
    - 55% with preop respiratory symptoms (snoring, dyspnea, bronchospasm, chronic cough)
    - 21% with OSA (only 16% of these "requiring" CPAP)

[1] Van Huisstede A et al. *Obes Surg*. 2013;23:1596–603.

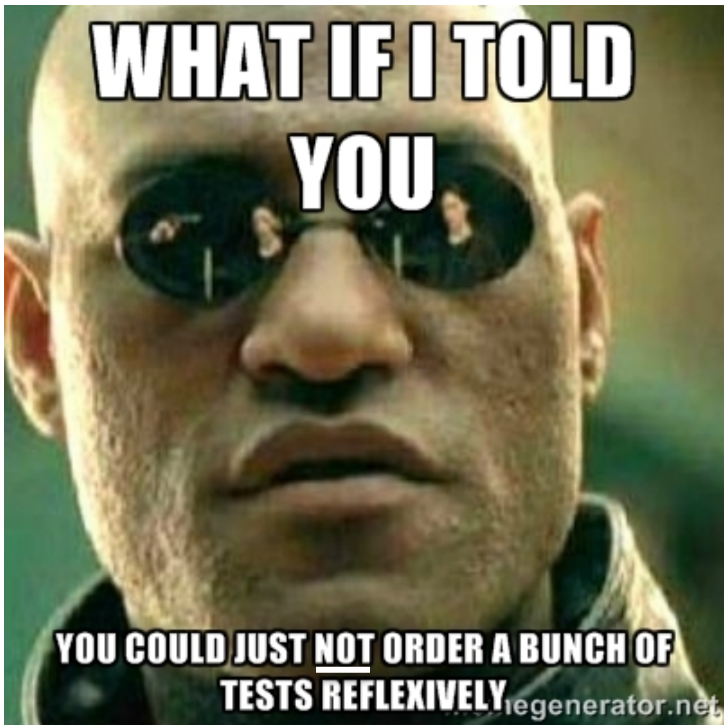
Spirometry & Bariatric Surgery

- Yield of spirometry was low – 6.2% were abnormal
    - 83.7% of these revealed a restrictive pattern
- Abnormal spirometry associated with increased risk of PPCs (OR 2.6 [95% CI, 1.0-3.72])
- Multivariate analysis found no association when OSA and respiratory symptoms were removed
- Conclusion: order spirometry when you would anyway – history or exam suggestive of underlying disease



Clavellina-Gaytán D et al. *Obes Surg*. 2015;25(3):

Summary – Diagnostic Studies



- Nothing routine or reflexive for non-thoracic procedures
- Obtain these studies only when they would otherwise be indicated
  - Signs/symptoms of active pulmonary disease
  - Would alter decision regarding treatment approach (i.e., lung resection)

ARS Question #2

You are seeing a 76-year-old woman in preop clinic prior to sigmoidectomy for recurrent diverticulitis. She has been feeling fine with no symptoms and a good functional capacity. Her history is otherwise significant only for HTN and smoking (quit 2 months ago).

Exam: HR 80, BP 130/72, RR 18, Pox 96% (RA); otherwise normal

Labs: BMP normal, Hgb 12.8 g/dl

Which of the following interventions has the strongest evidence for efficacy in reducing PPCs?

A) Incentive spirometry

B) Laparoscopic surgical approach

C) Continuous positive airway pressure (CPAP)

D) Mechanical ventilation with high tidal volume & low PEEP

Pulmonary Risk Management

- Optimization of chronic lung disease
- Avoidance of prophylactic NG intubation
- OSA-specific interventions
- Epidural and PCA-based opioid administration

Guay J, Kopp S. *Cochrane Database Syst Rev*. 2016 Jan 5;1:CD005059.

- Reaffirmed the benefit of epidural vs systemic opioid analgesia
- Epidural analgesia associated with reduced postoperative respiratory failure (RR 0.69 [95% CI, 0.56-0.85])

Pulmonary Risk Management

- Optimization of chronic lung disease
- Avoidance of prophylactic NG intubation
- OSA-specific interventions
- Epidural and PCA-based opioid administration
- Preoperative inspiratory muscle training & cardiopulmonary physiotherapy

Katsura M et al. *Cochrane Database Syst Rev.* 2015 Oct 5;10:CD010356.

- IMT significantly reduces risk of pneumonia in cardiac & abdominal surgery patients (RR 0.45 [95% CI, 0.26-0.77])
- Studies utilized IMT under supervision of trained professional

Pulmonary Risk Management

- Optimization of chronic lung disease
- Avoidance of prophylactic NG intubation
- OSA-specific interventions
- Epidural and PCA-based opioid administration
- Preoperative inspiratory muscle training & cardiopulmonary physiotherapy
- Smoking cessation

Lee SM et al. *Anesth Analg.* 2015;120(3):582-7.

- Follow up of previous study showing efficacy of preop clinic smoking cessation intervention
  - Brief counseling RN
  - Smoking cessation brochure
  - Referral to telephone quitline
  - Free 6-week supply of nicotine patch
- Demonstrated efficacy of intervention up to 1 year after surgery (RR 3.0 [95% CI, 1.2-7.8])

Pulmonary Risk Management

- Optimization of chronic lung disease
- Avoidance of prophylactic NG intubation
- OSA-specific interventions
- Epidural and PCA-based opioid administration
- Preoperative inspiratory muscle training & cardiopulmonary physiotherapy
- Smoking cessation
- **Lung expansion maneuvers (eg, incentive spirometry)**
- **Lung-protective mechanical ventilation**
- **Regional/neuraxial anesthesia**
- **Use of shorter-acting intraoperative neuromuscular blockade agents**

Lung Expansion Maneuvers

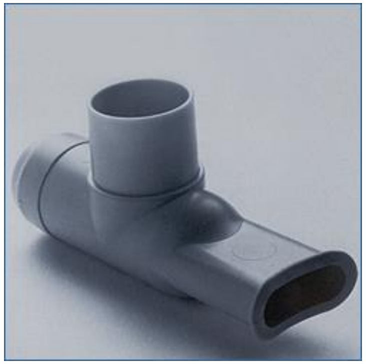
- Show moderate reduction in PPCs <u>with perfect use</u>[1]
  - Preoperative education helpful[2]
- Deep breathing, IPPB, incentive spirometry (IS) & positive airway pressure (PAP) all shown to be helpful[1]
  - CPAP definitely beneficial after abdominal surgery[3]
  - Recent Cochrane review found no benefit from IS[4]

[1] Qaseem A et al. *Ann Int Med* 2006;144:575-580.
[2] Cassidy MR et al. *JAMA Surgery.* 2013;148(8):740-5.
[3] Ireland CJ et al. *Cochrane Database Syst Rev.* 2014 Aug 1.
[4] De Nascimento JP et al. *Cochrane Database Syst Rev.* 2014 Feb 8.

The effect of incentive spirometry on postoperative pulmonary function following laparotomy: a randomized clinical trial

Tyson AF et al. *JAMA Surgery*. 2015;150(3):229-36.

- Single institution (in Malawi) RCT
- 150 patients undergoing laparotomy (elective or emergent)
- Excluded ICU patients
- All patients received instructions for deep breathing and cough
- Intervention patients instructed to use DISPIRO™ spirometer but use not monitored thereafter
- Primary outcome: change in FVC
- Secondary outcomes: mortality, LOS



Incentive Spirometry

- >70% patients male
- **Median age: 33-35 yrs**
- **Average surgical duration: 70 minutes**
- **~40% of surgeries were for bowel obstruction (including sigmoid volvulus)**
- **No difference in FVC or LOS between intervention & control groups**
- **No difference in PPCs but not a primary or secondary outcome**

Summary – Lung Expansion

- Incentive spirometers cost ~$10
- No significant documented risks from use of lung expansion maneuvers
- Work best with preoperative education
- Deep breathing/coughing instructions may be sufficient for low-risk patients
- For higher risk patients, benefits likely still outweigh costs

Lung-Protective Ventilation

- Some studies have suggested benefits of low tidal volume (V_T <10 cc/kg) and higher positive end-expiratory pressure (PEEP) ventilation
- Others have suggested no benefits and increased risks with high PEEP or low PEEP with low V_T ventilation
- Variability in study design and specific ventilator settings has confused picture

New In 2015/2016

Intraoperative use of low volume ventilation to decrease postoperative mortality, mechanical ventilation, lengths of stay and lung injury in patients without acute lung injury

Guay J, Ochroch EA. *Cochrane Database Syst Rev*. 2015 Dec 7; 12:CD011151

- Reviewed data for intraoperative **low V_T (<10 cc/kg) ventilation**
- Lower risk of pneumonia (RR 0.44 [95% CI, 0.20-0.99])
- Decreased need for ventilator support
  - Noninvasive (RR 0.31 [95% CI, 0.15-0.64])
  - Invasive (RR 0.33 [95% CI, 0.14-0.80])
- No difference in mortality
- Among patients receiving V_T ≥10 cc/kg, higher plateau pressures associated with increased PPC risk
- Overall moderate quality evidence

Intraoperative protective mechanical ventilation and risk of postoperative respiratory complications: hospital based registry study

Ladha K et al. *BMJ.* 2015;351:h3646.

- Registry study at 3 Massachusetts hospitals of ~69,000 noncardiac surgery patients
- V_T <10 cc/kg, PEEP ≥ 5 cwp & median plateau pressure <30 cwp associated with decreased PPCs (aOR 0.90 [95% CI, 0.82 to 0.98])
- Similar effect seen in propensity-matched cohorts
- **PEEP of 5 cwp, V_T 7.5-8.4 cc/kg & median plateau pressure <16 cwp associated with lowest risk**

Lung-Protective Ventilation – Evidence

		Tidal volume (cc/kg)			
		3-6	6-8	8-10	10-12
PEEP (cwp)	0-4	• ∅Δ LOS/ mortality[1]	• ↑ LOS/ mortality[1]	• ↑ Intraop hypoxia[2] • ∅Δ LOS/ mortality[1] • ∅Δ PPCs[2]	• ↑ PPCs[3,4] • ∅Δ LOS/ mortality[1]
	4-10		↓ PPCs[3,4,5]		
	>10			• ↑ Intraop hypotension[2] • ∅Δ PPCs[2]	

[1] Levin MA et al. *Br J Anaesth.* 2014;113(1):97-108.

[2] PROVE Network Investigators. *Lancet.* 2014;384:495-503.

[3] Hemmes SNT et al. *Curr Opin Anesthesiol.* 2013;26:126-33.

[4] Futier E et al. *NEJM.* 2013;369:428-37.

[5] Ladha K et al. *BMJ.* 2015;351:h3646.

Summary – Lung-Protective Ventilation

- In general, lower tidal volumes & higher (not high) PEEP while maintaining lower plateau pressures may decrease PPCs
- Need to factor in all patient characteristics:
  - Underlying lung pathology
  - Cardiovascular status
- Likely requires active management in higher risk patients

Anesthesia Type

- Studies of general versus neuraxial/regional anesthesia have been mixed in terms of PPCs
- Some suggest increased risk from general
- Others suggest neuraxial/regional is protective, even in addition to general
- Still others show no difference

New In 2015/2016

General vs Neuraxial Anesthesia

Study*	Population	Source	Comparison	PPCs	Other Outcomes
Poeran[1]	98,000 open **colectomy** pts – **avg age 64**	Admin database	GA vs GA+NA	No difference	**GA+NA:** ↓**CVAs** (OR 0.67 [0.51-0.88]) ↓**TE** (OR 0.74 [0.58-0.93]) ↑AMI (OR 2.74 [2.19-3.43]) ↑UTI (OR 1.35 [1.21-1.50])
Basques[2]	>9000 propensity-matched **hip fracture** pts **>70 yrs old**	ACS NSQIP	GA vs spinal anesthesia	No difference	**GA:** ↓LOS (HR 1.28 [1.22-1.34]) ↓UTIs (HR 0.73 [0.62-0.87]) ↑**overall adverse events** (HR 1.21 [1.10-1.32]) ↑**TE** (HR 1.90 [1.24-2.89])
Chu[3]	>100,000 propensity-matched **hip surgery pts ≥65 yrs old** (Taiwan)	Patient claims database (1997-2011)	GA vs NA	**GA:** ↑**respiratory failure** (OR 2.71 [2.38-3.01])	**GA:** ↑**mortality** (OR 1.24 [1.15-1.35]) ↑**CVAs** (OR 1.18 [1.07-1.31])
Hausman[4]	5200 propensity-matched **general surgery** patients with **COPD**	ACS NSQIP	GA vs regional (spinal, epidural or peripheral nerve block)	**GA:** ↑**pneumonia** (abs diff 1% [0.09-1.88]) ↑**prolonged ventilation** (abs diff 1.2% [0.51-1.84]) ↑**postop intubation** (abs diff 0.8% [0.04-1.62])	**GA:** ↑**composite morbidity** (abs diff 1.9% [0.21-3.72])

* All retrospective studies {red font} = favoring NA

GA = general anesthesia, NA = neuraxial (spinal, epidural) anesthesia

[1] Poeran J et al. *J Surg Res*. 2015;193(2):684-92.
[2] Basques BA et al. *Bone Joint J*. 2015;97-B(5):689-95.
[3] Chu CC et al. *Anesthesiology*. 2015;123(1):136-47.
[4] Hausman MS Jr et al. *Anesth Analg*. 2015;120(6):1405-12.

Summary – Anesthesia Type

"We tend to favour more traditional anaesthetic techniques here."

- No absolutes for determination of anesthesia type – individualize based on patient, clinical scenario and provider expertise
- Favoring use of neuraxial anesthesia – patients with:
  - Increased pulmonary risk (COPD)
  - Increased thromboembolic risk (including CVA)

Neuromuscular Blockade

- Intermediate- and long-acting neuromuscular blockade (NMB) agents are associated with increased risk of residual NMB and increased PPCs[1]
- NMB reversal is often employed to counteract these effects but may also be associated with postoperative complications, especially when not performed with quantitative NMB monitoring[2]

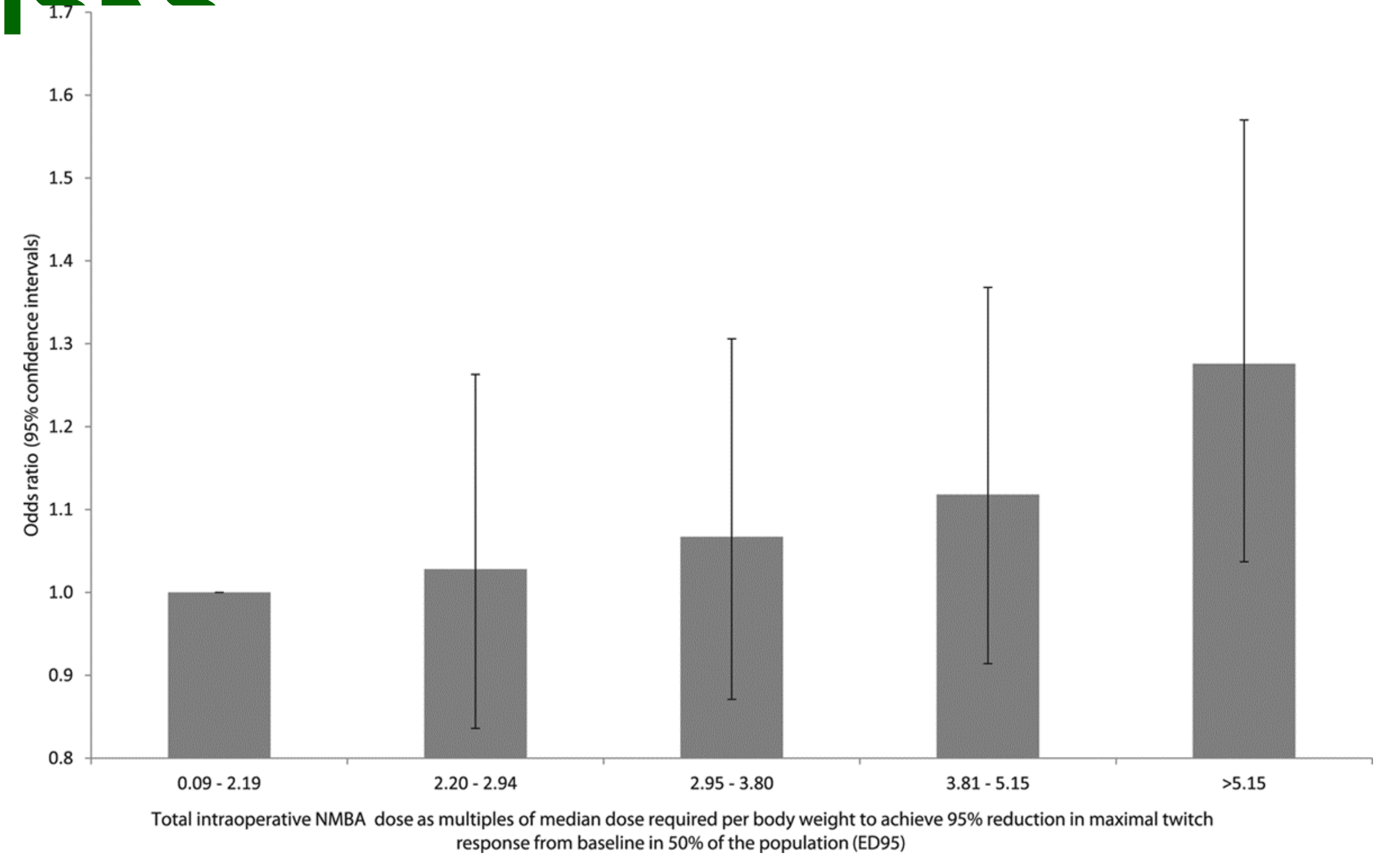
[1] Lawrence VA et al. *Ann Intern Med*. 2006;144(8)-596-608.

Dose-dependent Association between Intermediate-acting Neuromuscular-blocking Agents and Postoperative Respiratory Complications

McLean DJ et al. *Anesthesiology*. 2015;122(6):1201-13.

- Hospital registry study of ~48,000 noncardiac surgical patients from 2007-2012 at Massachusetts General Hospital
- Intermediate-acting NMB agents: atracurium, cisatracurium, rocuronium, vecuronium
- Reversal agent: neostigmine
- PPCs: respiratory failure, pulmonary edema, tracheal reintubation, pneumonia
- Appropriate reversal: minimum TOF count of 2 & use of neostigmine ≤60 μg/kg

Neuromuscular Blockade Risks



- **Lowest *vs* highest quintile NMB dose: OR 3.42 (95% CI, 1.01-11.5)**
- No difference with class of NMBA (benzylisoquinolines or aminosteroidal NMBAs)

McLean DJ et al. *Anesthesiology*. 2015;122(6):1201-13.

NMB Reversal Risks

- Neostigmine *vs* no neostigmine: OR, 1.19 (95% CI, 1.03 to 1.37)
- Post hoc analysis: appropriate neostigmine reversal eliminated association between NMB & PPCs

	Patients, No. (%)	Patients with Respiratory Complications, No. (%)	Compari-son with No Neostigmine Administration
Patients who received neostigmine	35,897 (74.0%)	1,478 (4.1%)	1.19 (1.03–1.37)
Patients who did not receive neostigmine	12,602 (26.0%)	334 (2.7%)	Not applicable
Dose–response, mg/kg			
<0.02	1,407 (3.9%)	38 (2.7%)	0.97 (0.67–1.40)
0.02–0.04	7,623 (21.2%)	233 (3.1%)	1.05 (0.87–1.27)
0.041–0.06	11,455 (31.9%)	386 (3.4%)	1.09 (0.92–1.30)
0.061–0.08	9,698 (27.0%)	482 (5.0%)	1.20 (1.01–1.42)
>0.08	5,720 (15.9%)	339 (5.9%)	1.51 (1.25–1.83)

McLean DJ et al. *Anesthesiology*. 2015;122(6):1201-13.

Summary – NMB & Reversal

Brull SJ and Prielipp RC[1]:

- NMB should not be taken lightly and should be used only when clinically necessary
- Increasing the total dose of NMB increases the total duration of action and the likelihood of residual NMB and related sequelae (including PPCs)
- Reversal based on the objective-evoked responses is associated with decreased risk of PPCs
- Reversal at either extreme of the recovery curve is associated with an increased risk of PPCs
  - Recent study of sugammadex showed no benefit with use with TOF ratio ≥0.9[2]
- Objective measurement of neuromuscular function is mandatory

[1] Brull SJ and Prielipp RC. *Anesthesiology*. 2015;122(6):1183-5.
[2] Baumüller E et al. *Br J Anaesth.* 2015;114(5):785-93.

NMB, Monitoring and Reversal

We As Patients Would Expect Better

"Blockade Monitoring," From Cover

adequacy of pharmacologic reversal have not been widely utilized by anesthesia professionals (Fig. 1).[1] Achievement of the goal of routine qualitative or quantitative monitoring using a peripheral nerve stimulator is difficult when the daily experiences of anesthesia professionals do not predictably demonstrate the existence of a problem that may occur well after the anesthesia professional has turned over care to another health care professional.[4] Universal adoption of quantitative monitoring is further impeded by the limited availability of easy-to-use, reliable monitoring technology. Many anesthesia professionals continue to rely on clinical signs (head lift, hand grip, negative inspiratory force, tidal volume) that are insensitive indicators of residual skeletal muscle weakness and applicable only to awake patients. Likewise, reliance on visual/tactile assessment of the TOF (low sensitivity to detect fade) to titrate the effects and assess the pharmacologic reversal of nondepolarizing NMBD is an insensitive and unreliable monitoring technique. Though double-burst stimulation (DBS) and fade with 100 Hz tetanic stimulation significantly improve the ability to detect residual neuromuscular

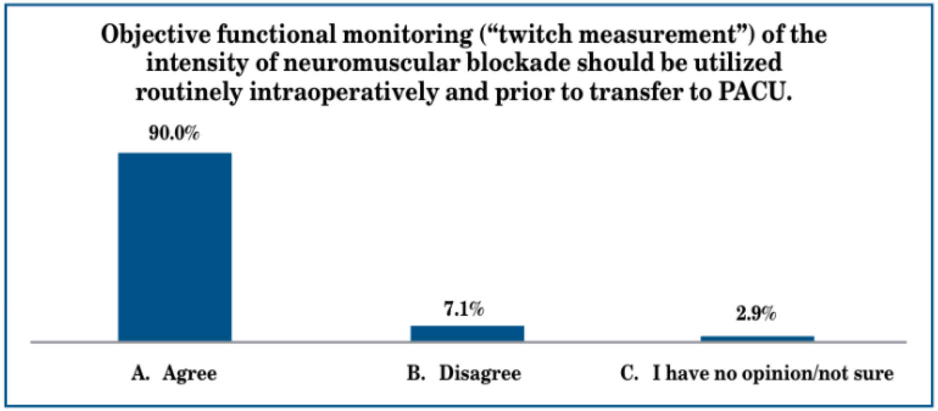


Figure 1: Stoelting RK. APSF survey results: Drug-induced muscle weakness in the postoperative period safety initiative. APSF Newsletter *Winter 2013-14:28:69-71. http://www.apsf.org/newsletters/pdf/winter2014.pdf*

gering drug-induced muscle weakness in the early postoperative period.

What will it take for "North American" anesthesia professionals to accept the reality of this patient safety risk?

2. Stoelting RK. Residual drug-induced muscle weakness in the postoperative period—a patient safety issue. *ASA Newsletter* 2015;79:64-65. Available at: http://www.asahq.org/search?q=February%202015%20ASA%20Newsletter.

3. Brull SJ, Naguib M. What we know: Precise measure-

Conclusion

- Advances in perioperative pulmonary care continue evolve
- Surgical populations continue to increase in age and comorbidities
- Clinicians will need to stay abreast of new developments and apply these thoughtfully to individual patients' care

Thank You

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