

Respiratory Depression in the Early Postoperative Period



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Conflicts of Interest

- Medtronic
 - Chair of CEC Committee for PRODIGY Trial
- Merck
 - Investigator initiated unrestricted research grant
 - Manufacturer of sugammadex
- Previous Research Support
 - Baxter Healthcare
 - Investigator initiated unrestricted research grant
 - Manufacturer of Desflurane and Scopolamine patch
 - Respiratory Motion
 - Material support of research study
 - Manufacturer of ExSpiron monitor
- SASM

Learning Objectives:

- Incidence of postoperative hypercarbic respiratory depression
- Temporal relationship between end of surgery and development of respiratory depression
- Review risk factors for respiratory depression
- Review implications and risk factors for respiratory depression in the PACU

Postoperative Respiratory Failure



Decreased defusion

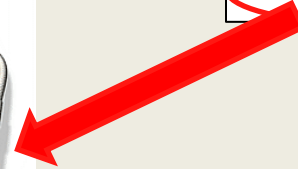
- ARDS
- Pneumonia
- Atelectasis

Decreased ventilation

- Weakness
- Drive



Failure to Rescue
Anoxic Brain Injury
Death



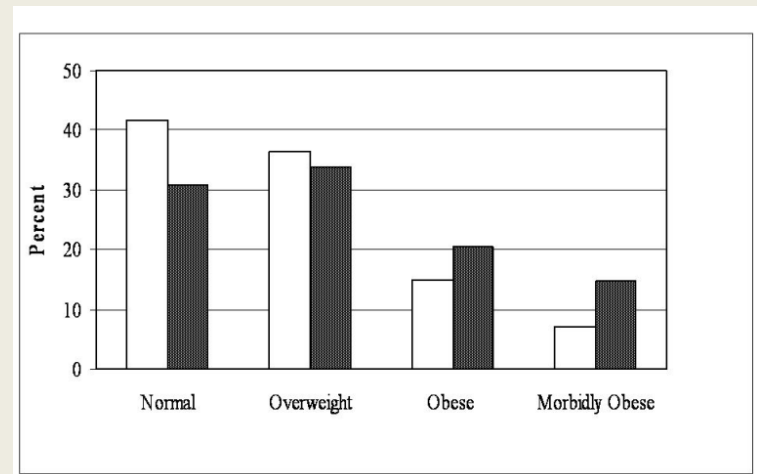
Hypercarbic Respiratory Failure

- Arrests from decreased respiratory drive
 - Multifactorial
 - Medications

63% Increase!

Analgesic Treatments	Year 2000	Year 2002	P value
Back surgery	2.5 (0-29)	2.5 (0-30)	0.94
Morphine Equivalents (mg)			
Total	40.4 ± 13.2	46.6 ± 20.4	<0.001
Intraoperative	33.9 ± 15.2	36.0 ± 16.6	0.03
PACU	6.5 ± 7.3	10.6 ± 10.4	<0.001
Ketorolac treatments (n)			

- Underlying comorbidities

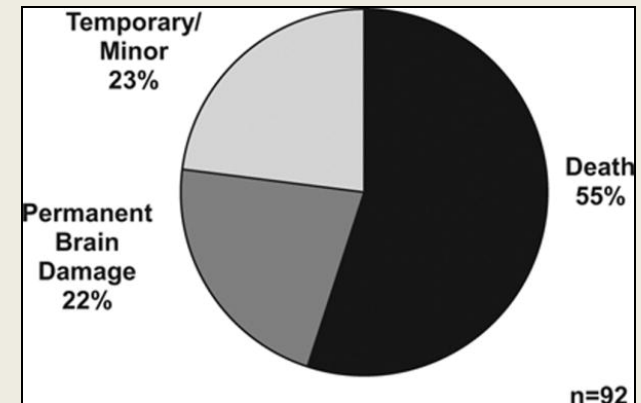


Rate of serious OIRD

Study	Measure	Number	Rate
Rosenfeld 2016	Naloxone	108/28,151	0.38%
Weingarten 2015	Naloxone	134/84,553	0.16%
Khelemsk 2015	Naloxone	433/442,699	0.10%
Ramachandran 2011	Naloxone + CPR	44/87,650	0.04%
Gordon 2005	Naloxone	56/10,511	0.50%
Total		775/653564	0.12%

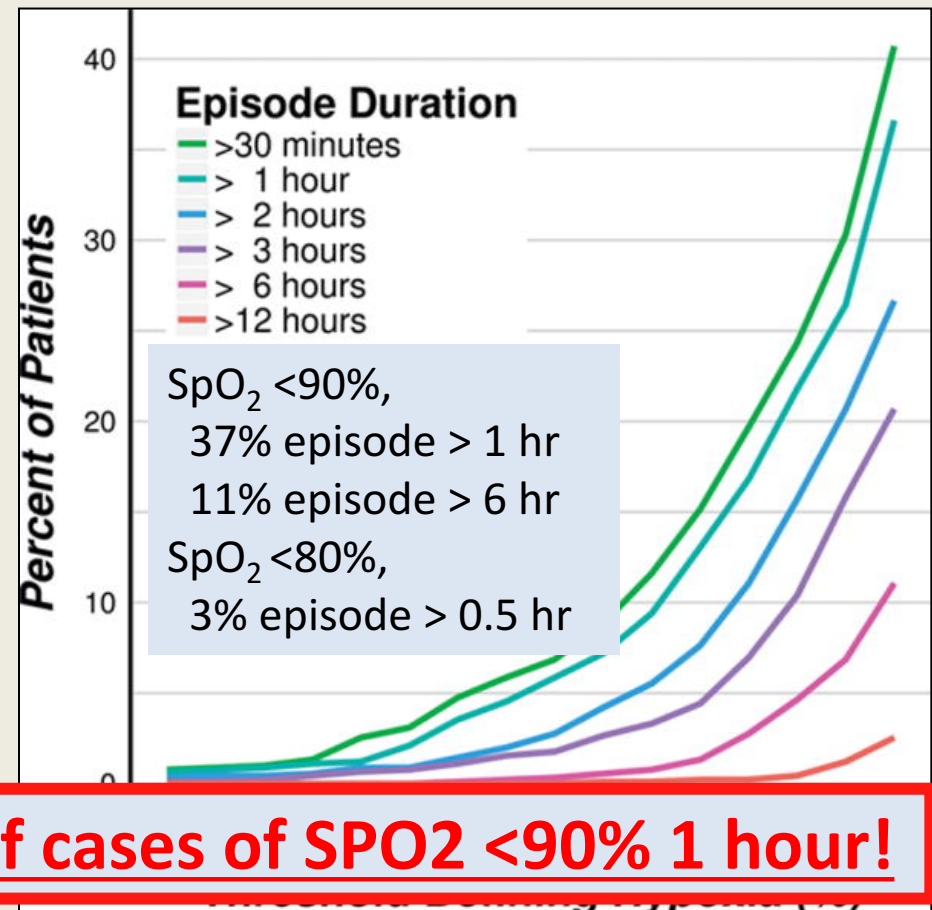
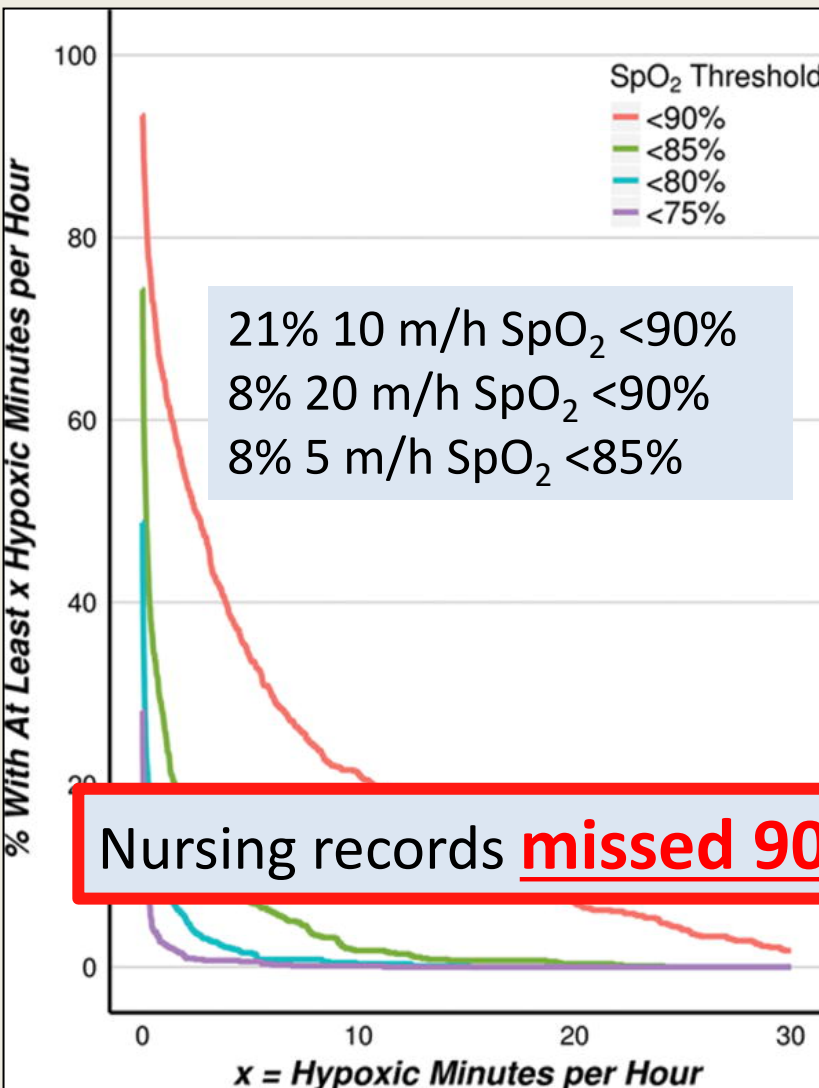
2015 ASA Closed Claim Postoperative OIRD
 Median payout of \$216,750

Gupta K, abstract SASM 2017
 Lee LA, Anesthesiology 2015



Postoperative Hypoxemia Very Common

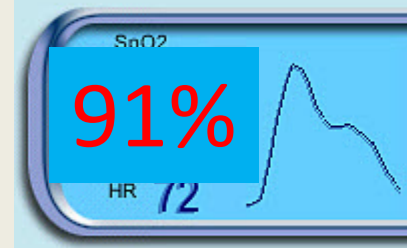
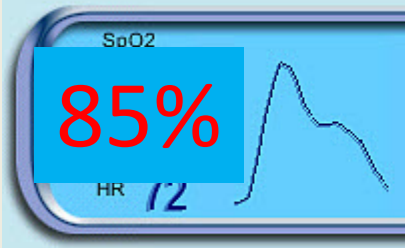
CCF 1250 non-CV patients SPO2 monitored



Nursing records missed 90% of cases of SPO2 <90% 1 hour!

Hypoxemia is underappreciated Intermittent Nursing Checks

Nursing records **missed 90% of cases!**



Manually measured SPO2 is 6.5% (4.0-9.0%) higher than automated systems.

WAKE UP EFFECT

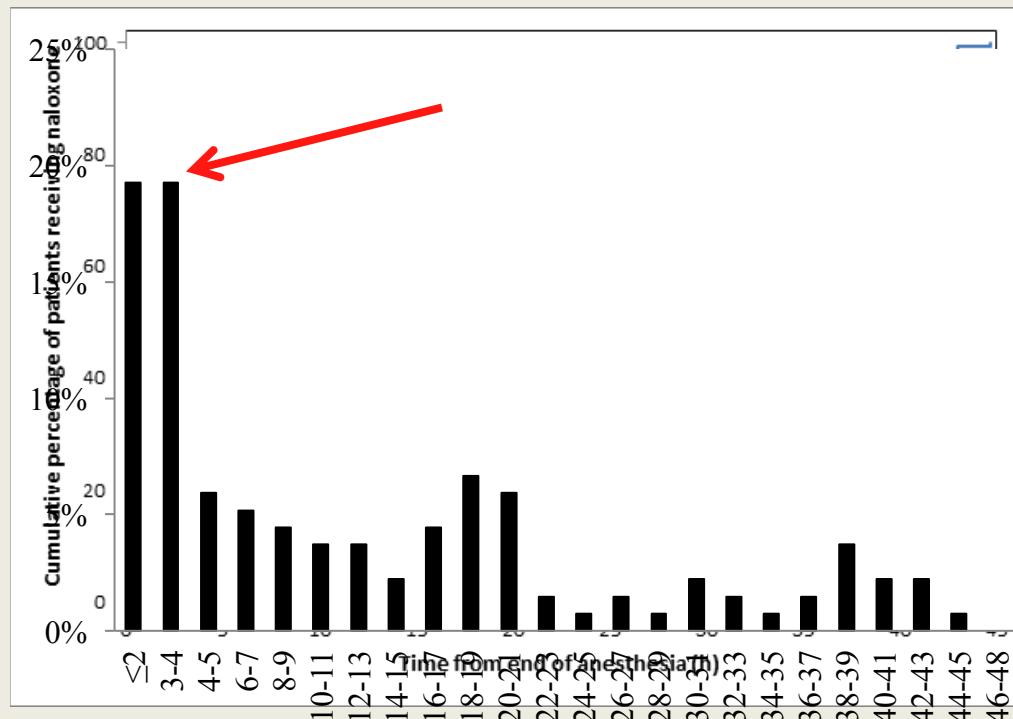
APSF rates intermittent nursing checks

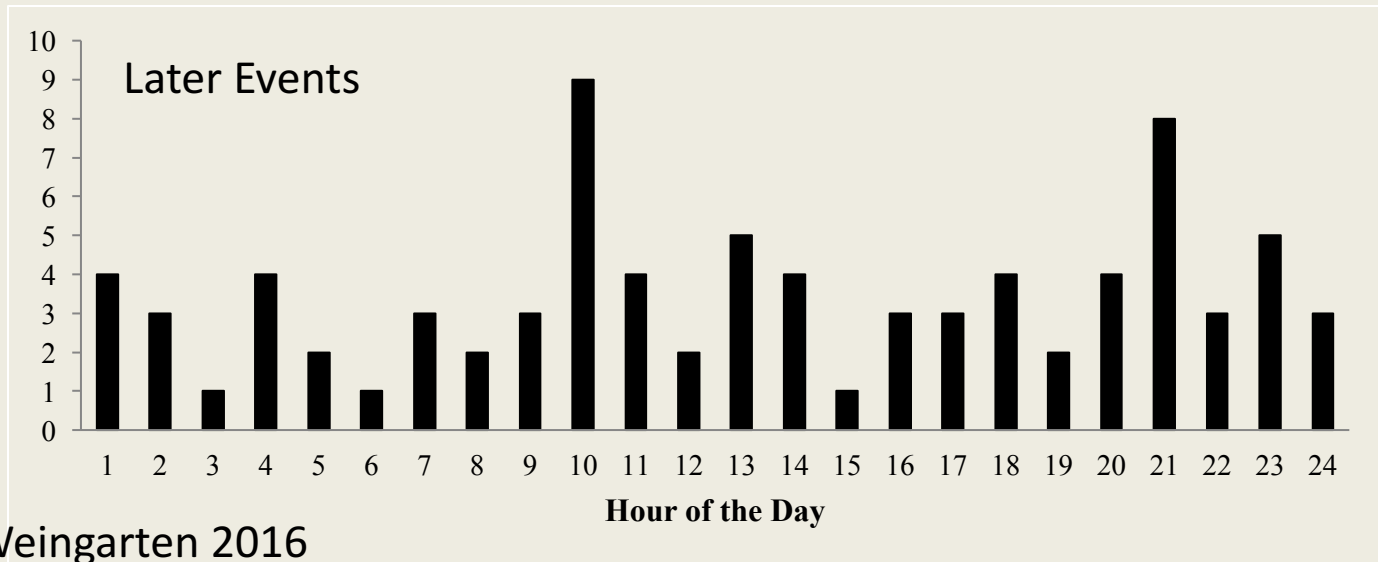
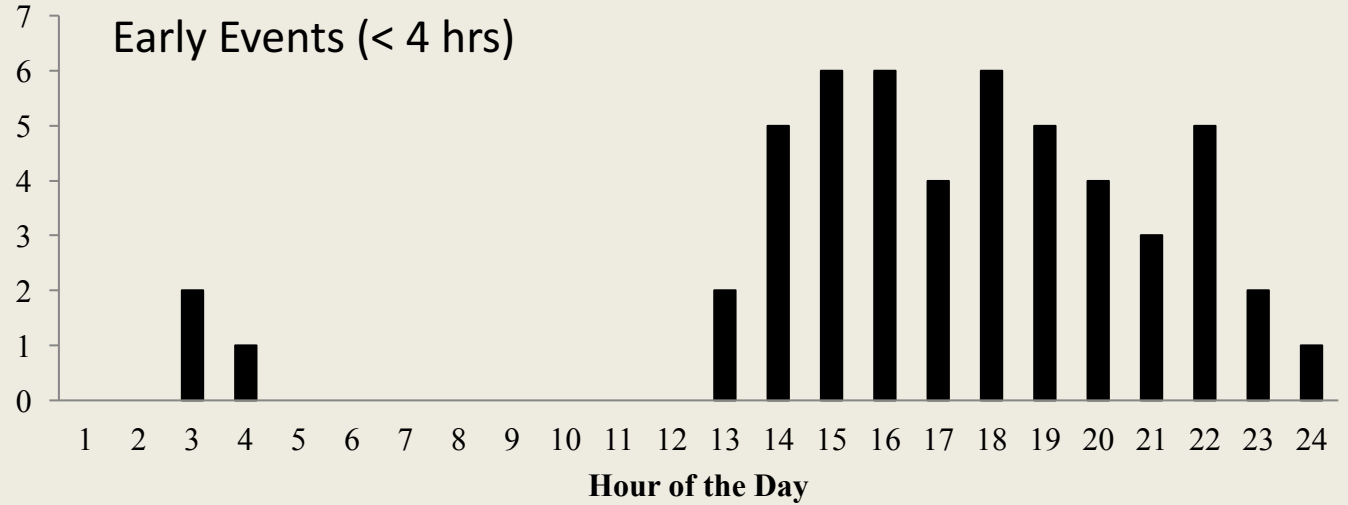
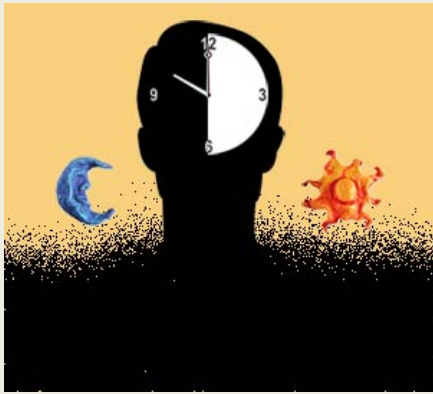
Low-moderate sensitivity, specificity and reliability,

Slow response times

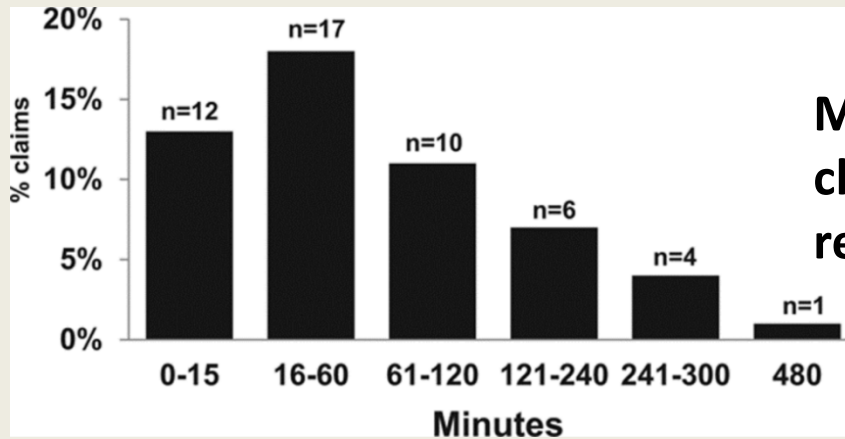
Time of greatest risk

- ASA Closed Claims of postoperative opioid-induced respiratory depression
 - 88% happened within 1st postoperative day





Following Vital Sign Checks



Many respiratory events in the closed claim analysis happened shortly after a reassuring vital sign check!

- SPO2 increases with manual vital sign checks
 - 6.5% (4.0-9.0%)
- APSF rates intermittent nursing checks
 - Low-moderate sensitivity, specificity and reliability,
 - Slow response times



Patient Factors: NARCAN ADMINISTRATION < 48 HOURS OF PACU DISCHARGE

- **OSA**

- 2.44 (1.15-5.19)

- 90% cases undiagnosed

- 20% adult surgical patients

- **CV**

- 2.56 (1.28-5.11)

- **CNS**

- 4.05 (1.61-10.17)



Three Emerging Phenotypes

Variable	Narcan N = 128	Control N = 256	OR	(95% C.I.)	p
Age, years	61.8 ± 14.7	62.0 ± 14.4			
Male	46 (35.9)	92 (35.9)			
BMI	29.0 ± 8.0	28.8 ± 6.7	1.00	(0.98, 1.04)	0.777
OSA	47 (36.7)	55 (21.5)	2.12	(1.33, 3.38)	0.002
Charlson score	5 [2, 7]	4 [2, 7]	1.03	(0.96, 1.10)	0.426
Disability	67 (52.3)	85 (33.2)	2.21	(1.43, 3.41)	<0.001
Home Use					
Opioids	42 (52.3)	57 (22.3)	1.71	(1.06, 2.73)	0.027
Benzodiazepines	25 (19.5)	21 (8.2)	2.72	(1.45, 5.01)	0.002
Gabapentinoids	39 (30.5)	27 (10.6)	3.72	(2.15, 6.43)	<0.001

*Deljou SASM abstract 2017

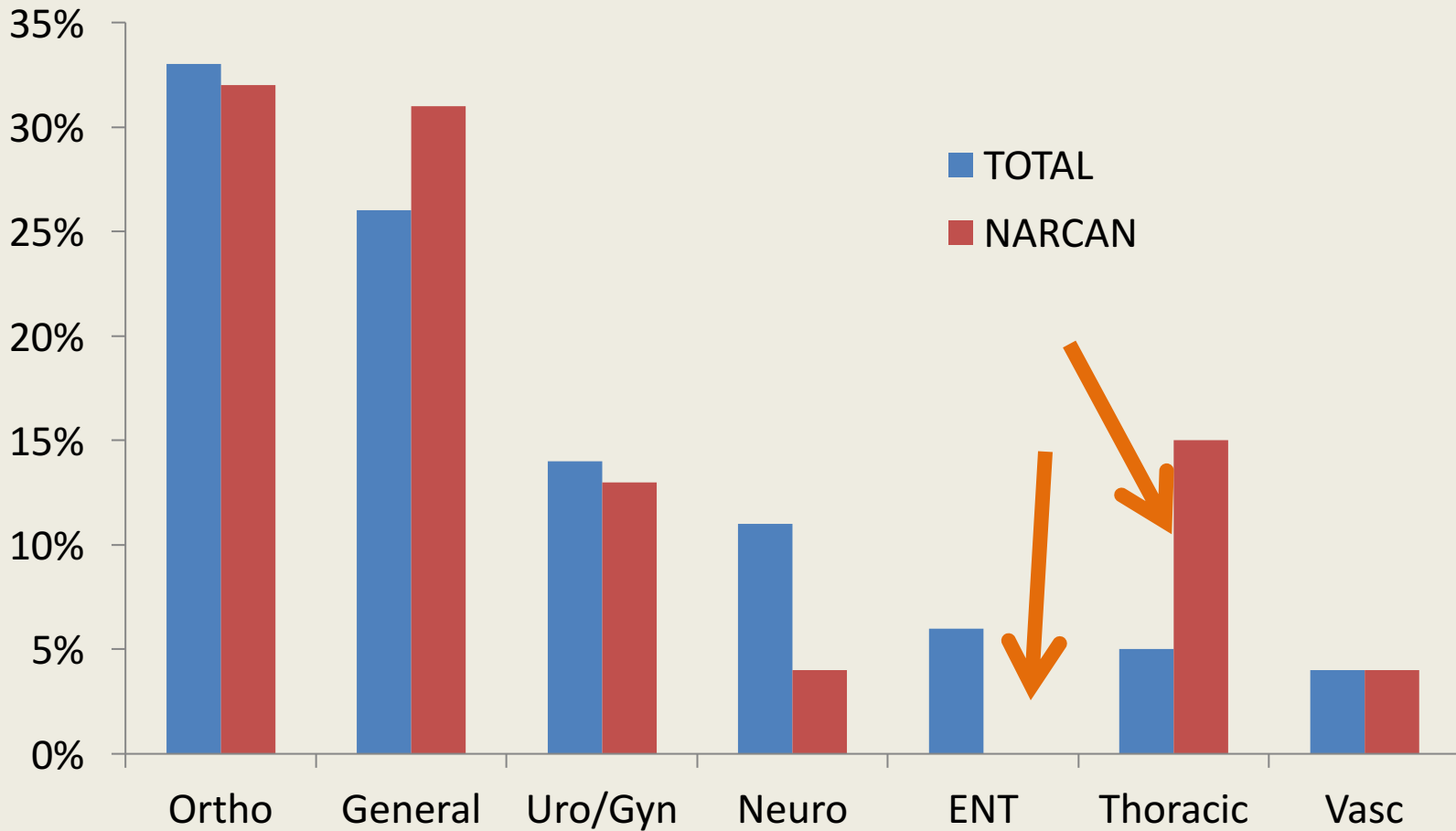
SURGICAL FACTORS

surrogates for bigger surgeries

- Longer duration
 - 7% increased odds per half hour
- Long-acting vs. short-acting opioid
 - OR 2.48 (1.05-5.88)

PERIOPERATIVE FACTORS

Type of Surgery



PACU COURSE



Mayo Clinic Discharge Criteria

a) **Motor Activity**

- 2 Active motion
- 1 Weak motion
- 0 No motion

b) **Respiration**

- 2 Coughs on command
- 1 Maintains airway without support
- 0 Requires airway maintenance

c) **Systolic**

- 2 ± 20 mmHg preanesthetic level
- 1 $\pm 20 - 50$ mmHg
- 0 ≥ 50 mmHg

d) **Consciousness**

- 2 Fully awake or easily aroused
- 1 Responds to stimulus
- 0 No response or absent protective reflexes

e) **Oxygen saturation**

- 2 Sat $\geq 93\%$ (or preop) without O₂
- 1 Sat $\geq 93\%$ (or preop) with O₂
- 0 Sat $\leq 93\%$ (or preop) with O₂

Patient can be discharged with score ≥ 8 unless there is a 0 in any category

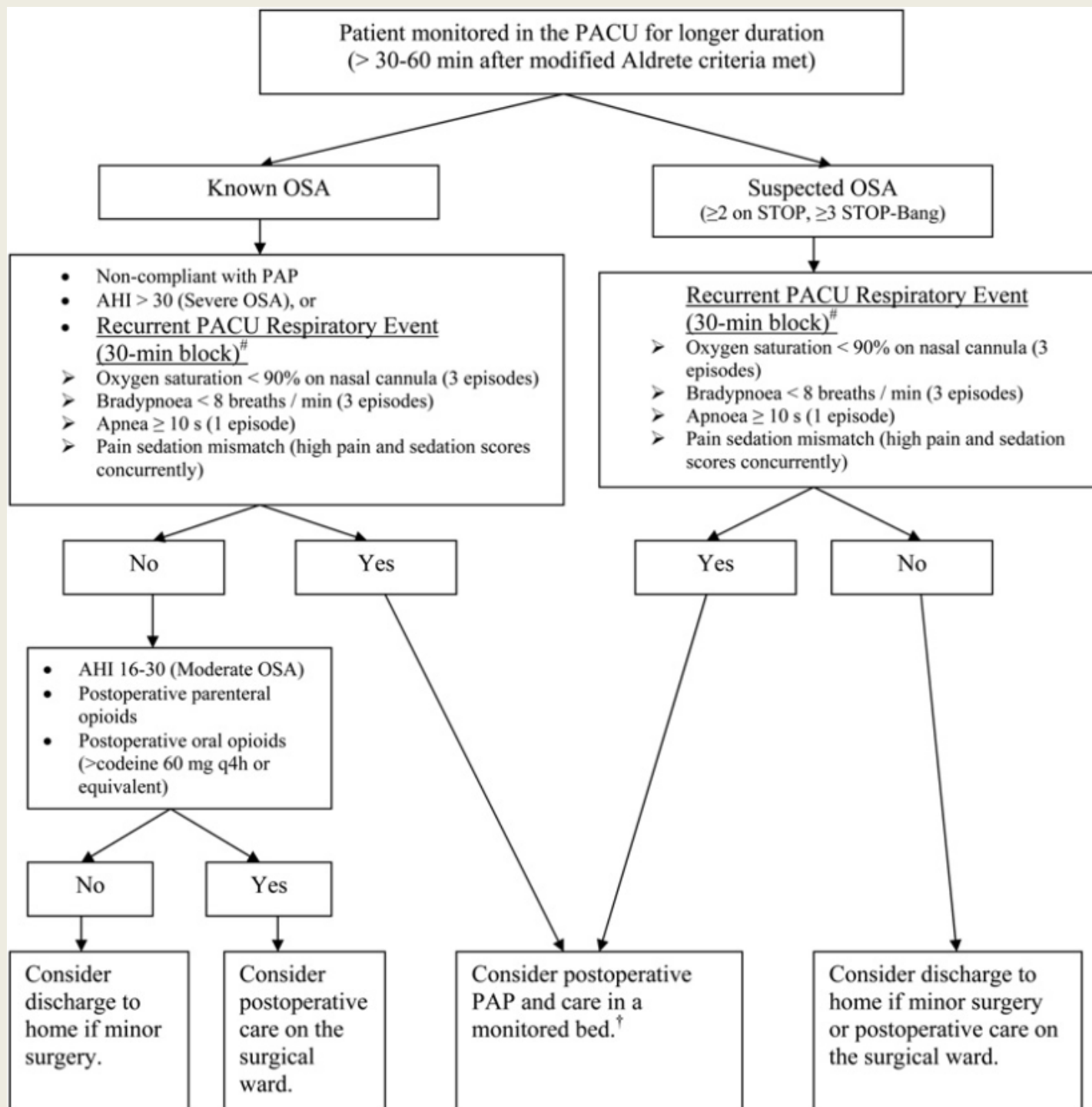
Respiratory Specific Events

- Hypoventilation
 - 3 episodes < 8 breaths per minute
- Apnea
 - 1 episode ≥ 10 seconds
- Desaturations
 - 3 episodes Pulse Ox $< 90\%$ or preop saturation with or without O₂
- Pain Sedation Mismatch
 - 1 episode RASS < -1 and Pain Score > 5

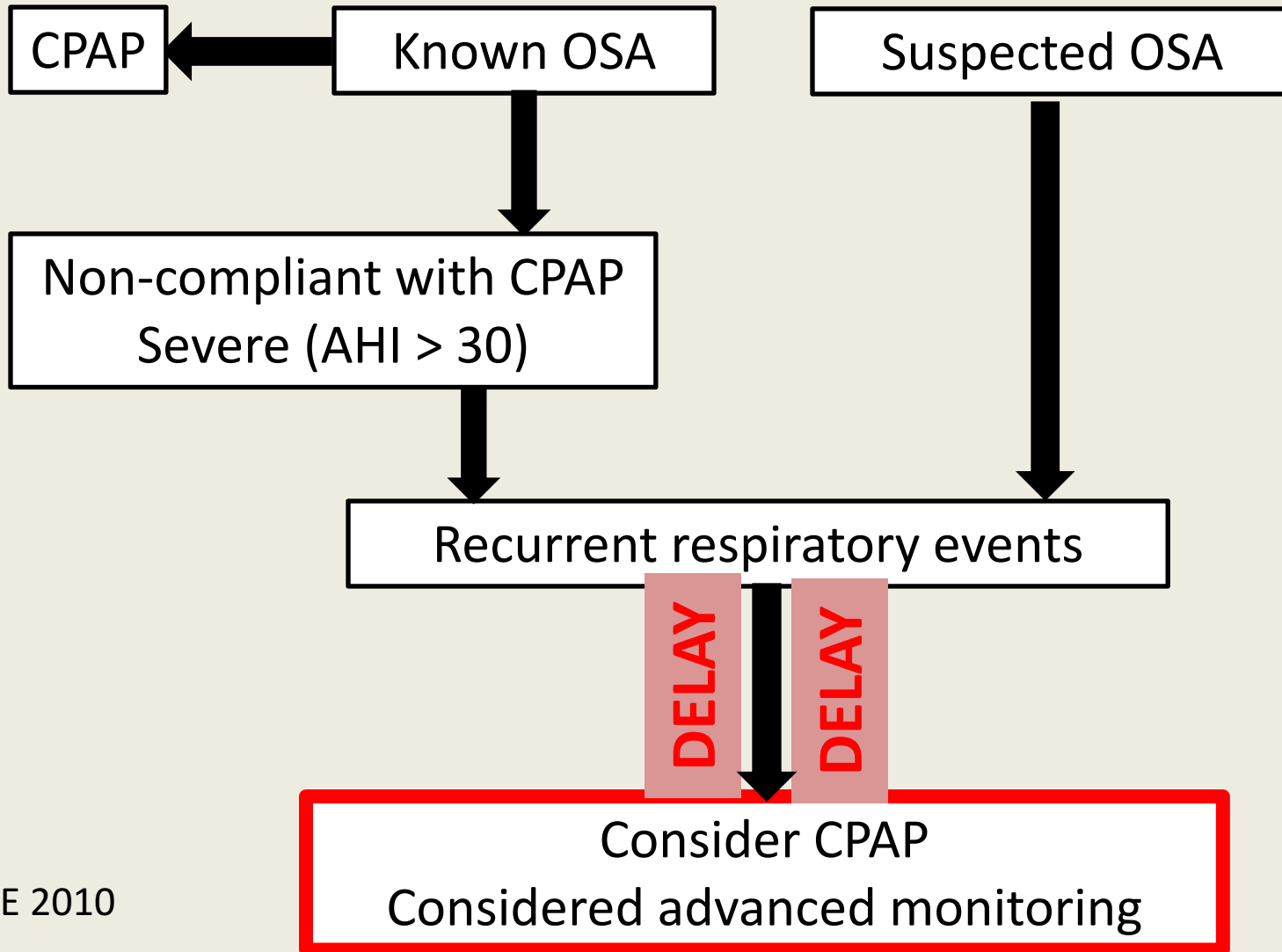
Mayo Respiratory Events

DOES NOT INCLUDE PEDIATRIC PATIENTS (<18 YEARS OF AGE)

Evaluation Period	Initial Period 30minutes	2 nd Eval Period 60 minutes	3 rd Eval Period 90 minutes
Hypoventilation < 8 respirations/minute (3 episodes needed for yes)			
No hypoventilation			
Episode of hypoventilation			
Apnea ≥10 seconds (only 1 episode needed for yes)			
No Apnea			
Episode of Apnea			
Desaturations Pulse Ox<90% or pre-op saturation with or without oxygen (3 episodes needed for a yes)			
No Desaturation			
Episode of Desaturation			
Pain/sedation mismatch RASS score -2 through -5 and pain scale score >5 (only 1 episode needed for a yes)			
No pain/sedation mismatch			
Episode of pain/sedation mismatch			



Algorithm for OSA patient triage



OSA and PACU Respiratory Depression

35

33

OR 5.11 (2.32-11.27) of receiving naloxone after PACU Discharge

ry Com
20
15

11

PACU naloxone administration had OR 3.39, 95 % CI 2.22-5.23, P < 0.001 for adverse events

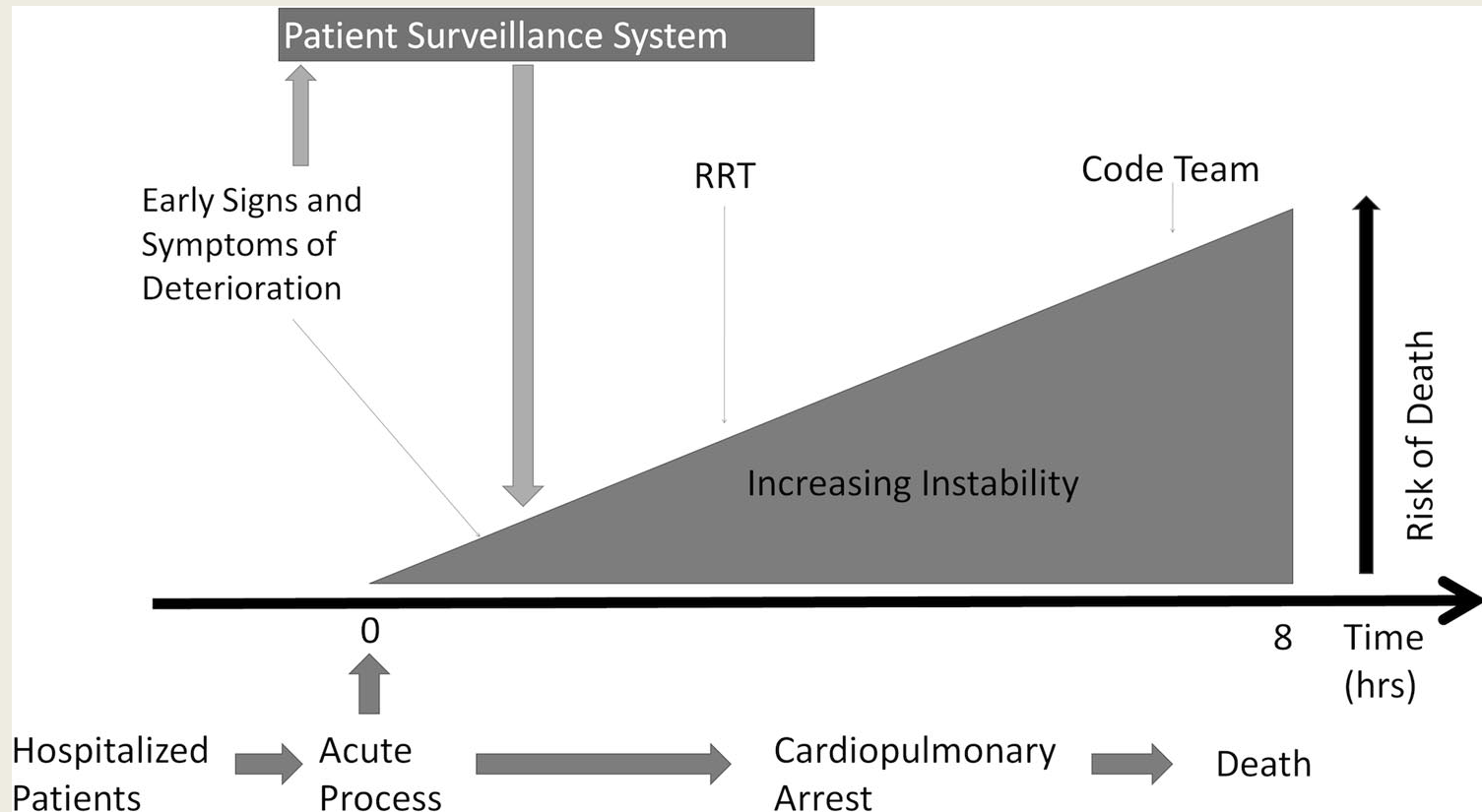
No Recurrent PACU Events

Recurrent PACU Events

ICU Admissions and PACU Respiratory Depression

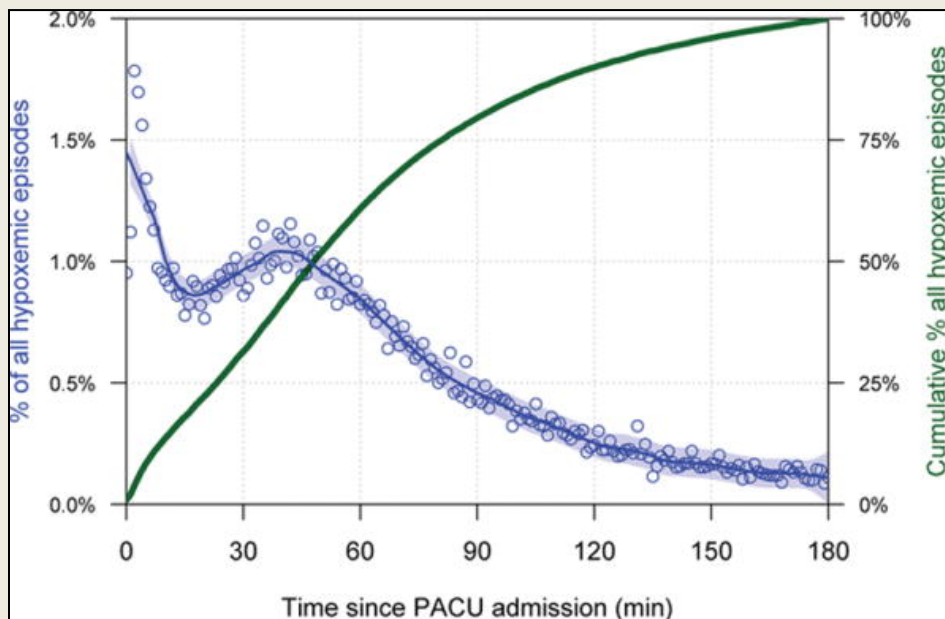
Surgery	Respiratory Events	ICU Admissions		P
		Event	Event Free	
TJA (n=11,970)	2,836 (23.4%)	189 (6.8%)	121 (1.3%)	<0.001
Laparoscopic > 90 (n=8,567)	1,311 (15.3%)	101 (7.7%)	407 (5.6%)	0.004

PACU episodes of respiratory depression fits into early warning theory



Hypoxemia in PACU

- 137,757 patients 2007 – 2013 @ Vanderbilt
 - Hypoxemia < 90% for 2 minutes
- 11% patients had a hypoxic event
 - 66% only had 1 event
 - 70% had event > 30 minutes
- 0.1% reintubated
 - 63% > 30 minutes



Rates of PACU Respiratory Depression at Mayo

Population	Hospital	Rate
Hip/Knee TJA (6,467)	A	31%
Laparoscopic >90 min (5,412)	A	19%
Laparoscopic > 90 min (3,258)	B	9%
General Surgery (3,137)	B	8%
Laparoscopic Bariatric (781)	B	4%

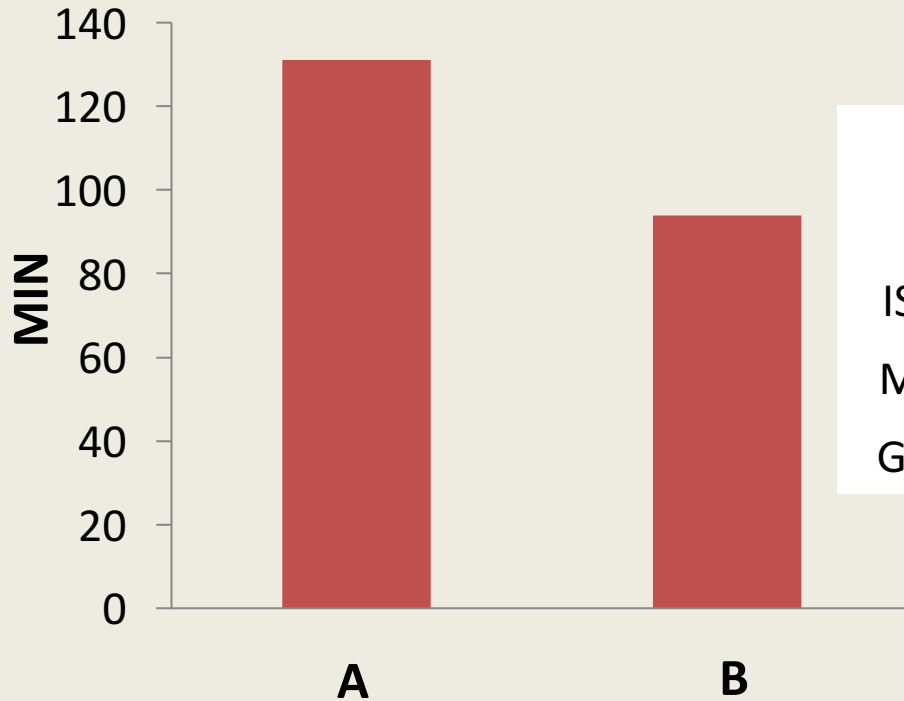
Multimodal Analgesic Therapy With Gabapentin and Its Association With Postoperative Respiratory Depression

Alexandre N. Cavalcante, MD,* Juraj Sprung, MD, PhD,* Darrell R. Schroeder, MS,† and Toby N. Weingarten, MD*

Rates of Respiratory Depression

19.2%

9.0%



Practice Differences

Hospital	A	B
ISOFLURANE	53%	29%
MIDAZOLAM	78%	37%
GABAPENTIN	26%	1%

Time to DC Criteria Met

n = 8,670

PACU Respiratory Depression Risk Factors

Patient

- **Older Age**
- **Lower BMI**
- OSA not a factor

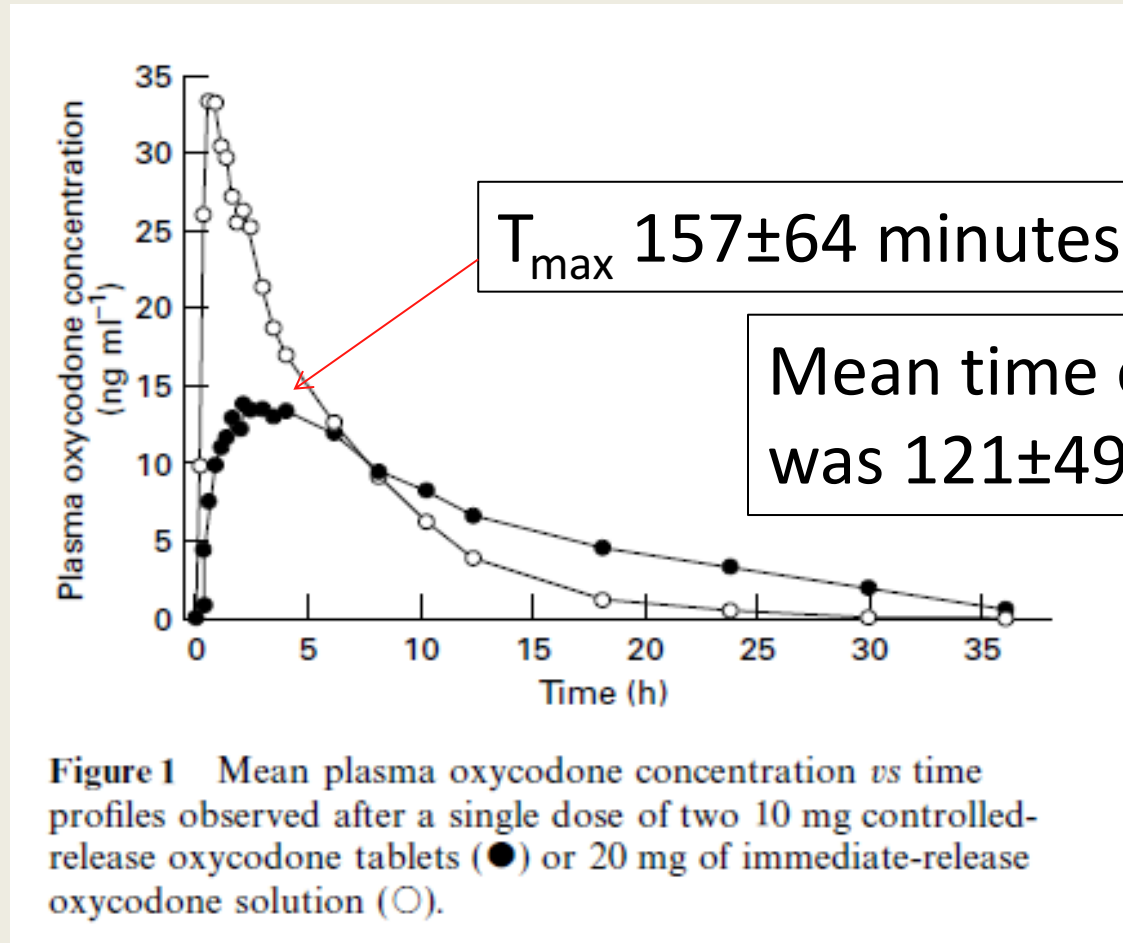
Anesthetic

- **Opioids**
- Non-opioid analgesics
 - **Gabapentinoids**
 - Ketamine
- **Volatiles**
- NMBD

Opioids

- **Higher doses = greater risk**
 - 1 - 2% increase risk per 1 IVME mg
 - Potentiated by midazolam with induction
- **Preop sustained release oxycodone for TJA**
 - 10 mg dose = OR 1.178 (1.030,1.347)
 - 20 mg dose = 1.294 (1.068, 1.566)

Sustained Release Oxycodone

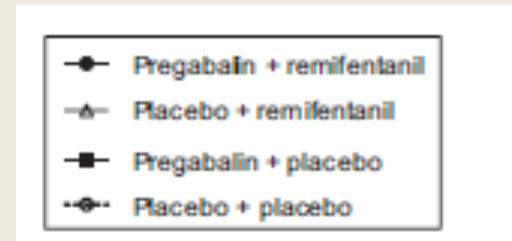
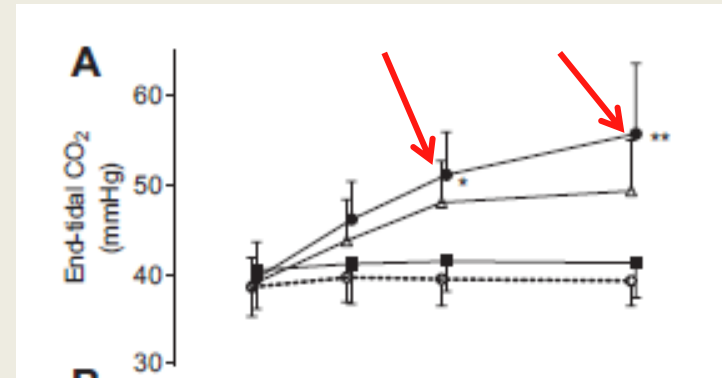
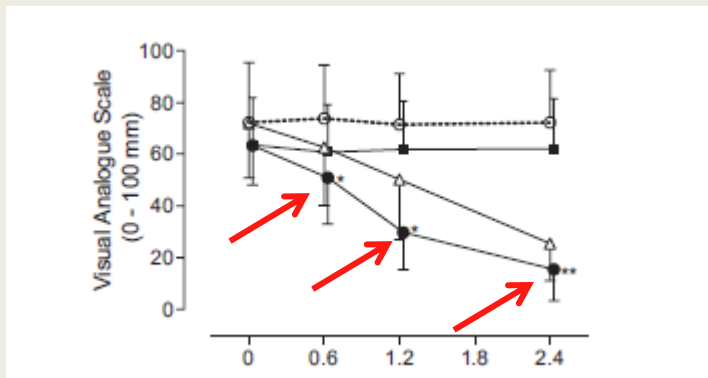


Gabapentinoids

- Knee/Hip TJA (n = 6,467)
 - 300 mg = 1.216 [0.982, 1.505]
 - 600 mg = 1.455 [1.255, 1.687]
- Laparoscopic > 90 minutes (n = 8,670)
 - 1.47 [1.22, 1.76]
- Naloxone < 48 hours of surgery*
 - Continuation of home gabapentinoids
 - **OR 6.3 (2.38, 16.66), P=0.001**

Gabapentinoids & Respiratory Depression?

- 12 ASA I 20 – 26 yo DB cross over
 - Pregabalin vs Placebo
 - 150mg 13 hr and 1 hr before study
 - Remifentanyl infusion vs Placebo

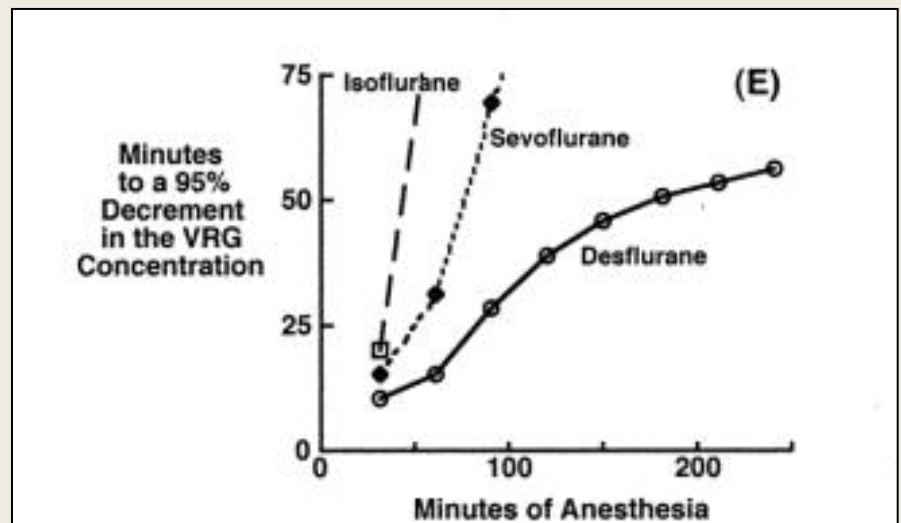
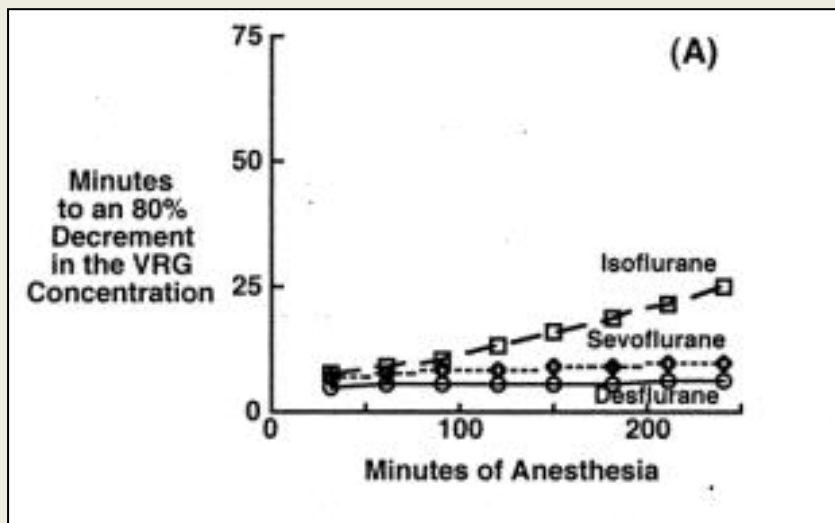


Volatiles

- Hip/Knee TJA
 - Desflurane = 0.839 [0.718, 0.979]
- Laparoscopic > 90 minutes*
 - Isoflurane = 1.31 [1.15, 1.50]

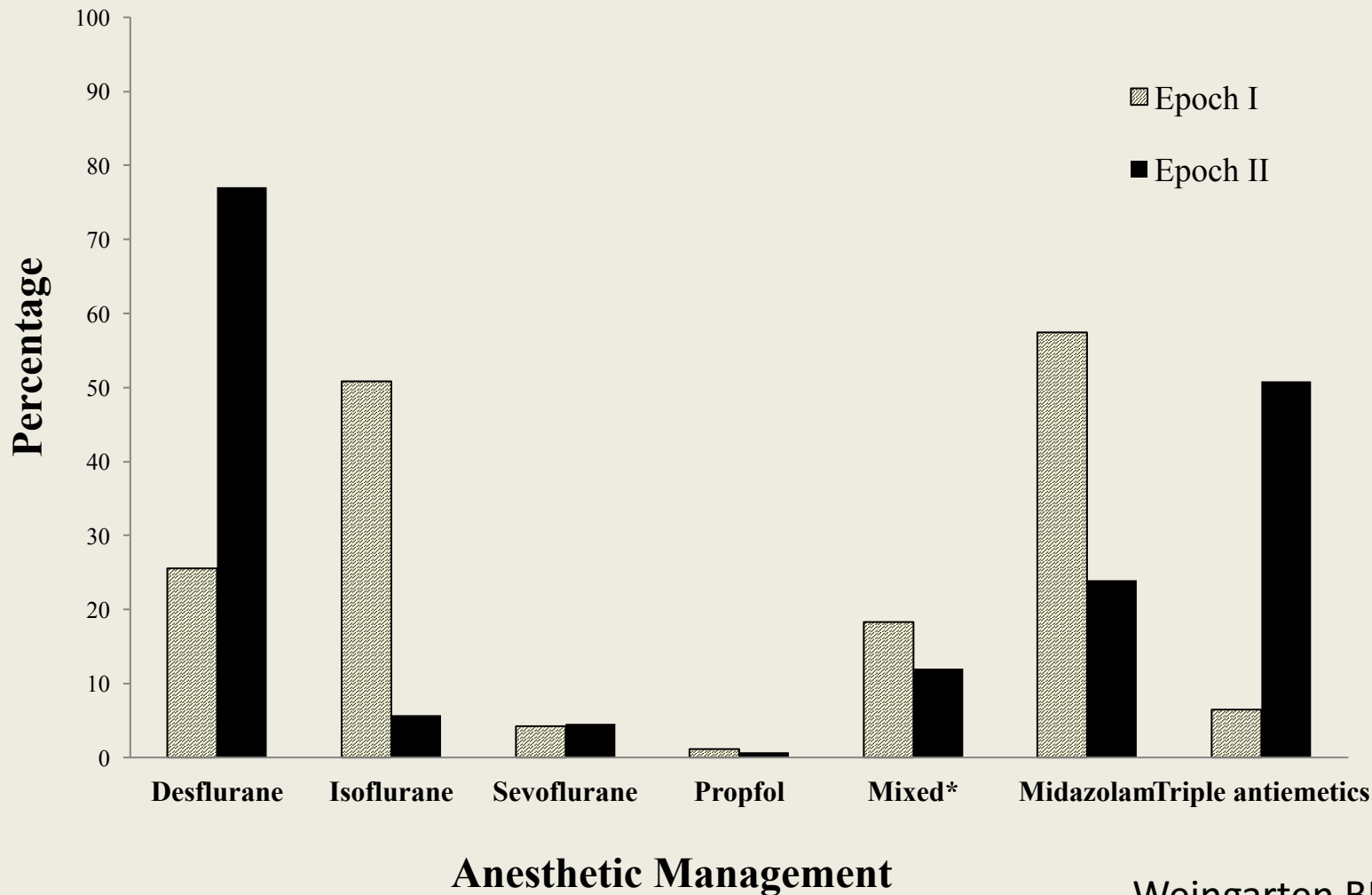
Open Eyes

Consciousness Recovered

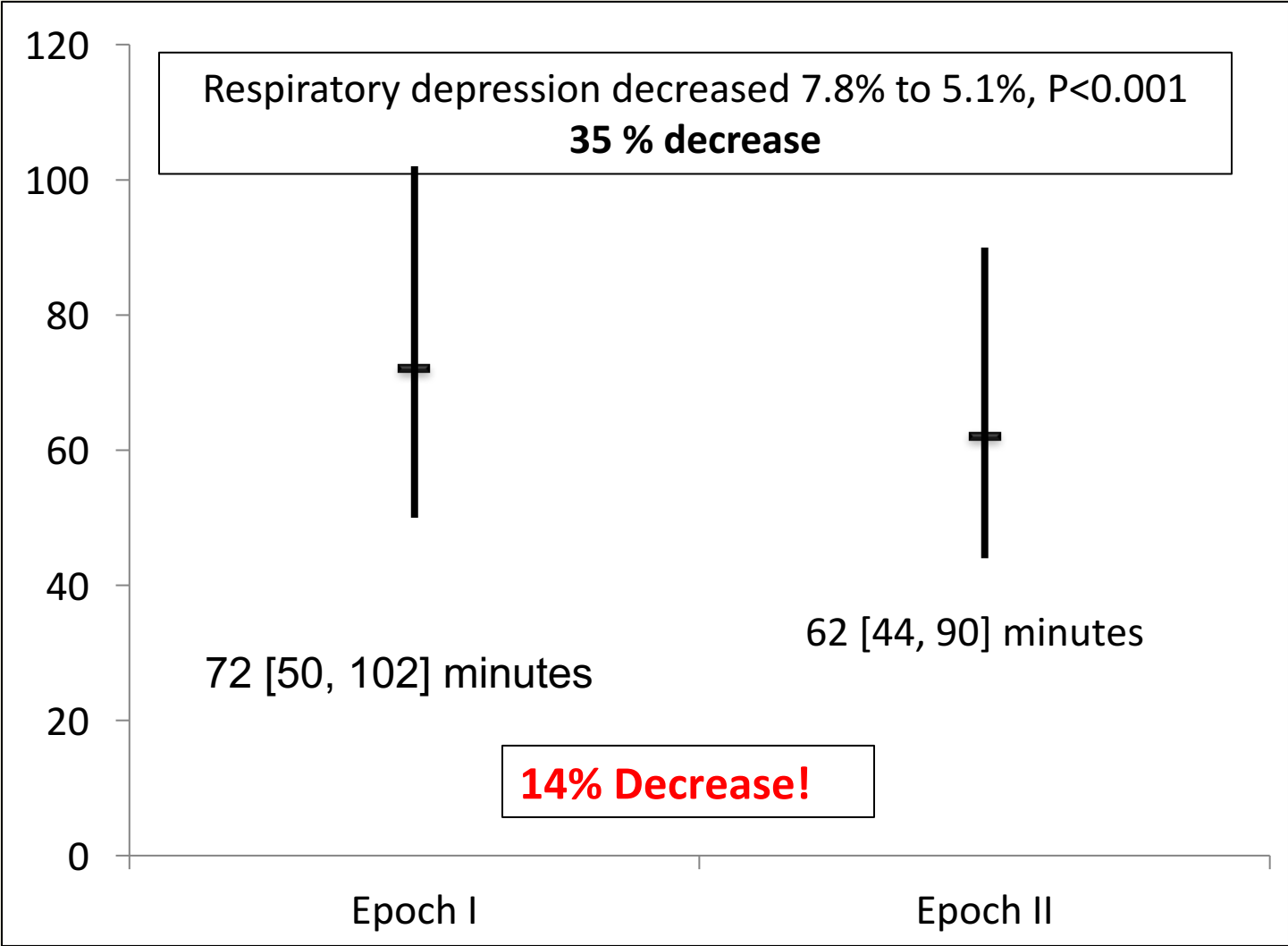


Change in anesthetic management

Comparison 2 six month epochs



Median Decrease in PACU stay



Postoperative Respiratory Depression Risks

Lessons from Inpatient Observations

- Develop early postoperative period
- Patient factors:
 - OSA,
 - CNS/CV disease or frailty
 - Tolerance
- Surgical factors
- Anesthetic factors:
 - Longer acting anesthetics
 - Sedating medications