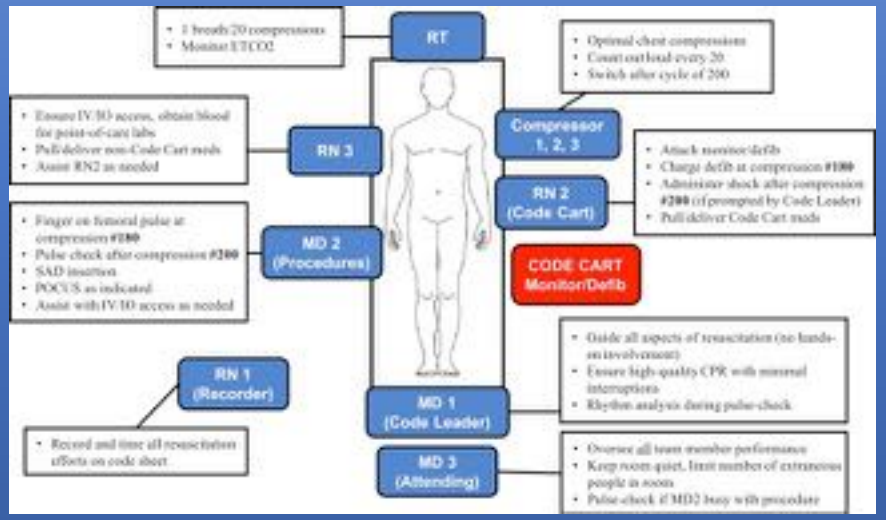
ROSC!!!!
Now What Do I Do?

Cynthia Shen, DO, FACEP, FACOEP
Fellow Emergency Critical Care Medicine
Georgetown Medstar Washington Hospital Center

EMS Radio Consult

- 65 y.o male
- From Church
- Witnessed collapse
- CPR in progress, started by bystanders
- Epi x 2
- Defibrillation x 1

Team Focused CPR



- Rehearsed and pre-assigned roles/ responsibilities
- De-emphasis on endotracheal intubation, intravenous drug administration
- 200 compression cycles
- Ventilated breath at 20th compression
- Defibrillator charged at 180th compression
- Pulse check at 200th compression

From Carolinas Medical Center (Charlotte, NC)

Mr. Jones

Your work has just begun!

- Mechanical Ventilation
- Circulatory Support
- Therapeutic Hypothermia
- Reperfusion Therapy
- Supportive care
- Prognostication

Increasing Critical Care Admissions from U.S. Emergency Departments, 2001-2009

- Analysis of National Hospital Ambulatory Medical Care Survey
  - ✓Annual critical care unit admissions increased by 79%
  - ✓Total annual hours of critical care increased by 217%
  - ✓Average daily amount of critical care provided tripled to 5.6 hours

Herring, AA et al. *Crit Care Med* 2013

Post-Cardiac Arrest Syndrome

- Post-cardiac arrest brain injury
  - ✓Coma, seizures, myoclonus, neurocognitive dysfunction, brain death
- Post-cardiac arrest myocardial dysfunction
  - ✓LV dysfunction, myocardial stunning, cardiogenic shock
- Systemic ischemia/reperfusion injury
  - ✓Inflammatory response, impaired regulation, oxygen delivery and utilization, resulting in hypotension/MSOF
- Persistent precipitating pathology
  - ✓STEMI, PE. toxic ingestion, hypoxia, hemorrhage, sepsis

Nolan JP, et al. *Resuscitation* 2015

To Do List:

- Mechanical Ventilation
  - Intubation
  - Initial Ventilator Settings
  - Ventilator associated lung injury
  - Goals of ventilation
  - Goals of oxygenation

Academic Emergency Medicine Physicians' Knowledge of Mechanical Ventilation

- Survey academic EM attendings
- 7 teaching hospitals with EM residencies
- Most receive $\leq$ 3 hours of mechanical ventilation training a year

Wilcox SR, et al. West J Emerg Med 2016

Ventilator Associated Lung Injury

- Oxygen toxicity
  - ✓Reduce FIO_2 to <60%
- Macrobarotrauma
  - ✓Overdistension that can result in pneumothorax, pneumomediastinum or subcutaneous emphysema
- Microbarotrauma/Volutrauma
  - ✓Overdistension that results in inflammatory injury

Slutsky AS and VM Ranieri, *Crit Care Med* 2013

Mechanical Ventilation

- Mode

- Respiratory rate
- Tidal volume
- PEEP

J Crit Care. 2015 Apr;30(2):341-3. doi: 10.1016/j.jcrc.2014.12.004. Epub 2014 Dec 18.

High initial tidal volumes in emergency department patients at risk for acute respiratory distress syndrome.

Allison MG[1], Scott MC[2], Hu KM[2], Witting MD[3], Winters ME[3].

- ✓Academic, tertiary care hospital
- ✓ARDS diagnosed within 48 hours
- ✓Only 5 of 34 (15%) patients received the recommended tidal volume
- ✓Initial tidal volumes that exceeded recommendations by an average of 1.5 ml/kg

Lung Protective Ventilation

- Tidal volume: 6-8 ml/kg IBW
- Permissive hypercapnia
- PEEP/F_iO_2: maintain adequate oxygenation
- Reduce F_iO_2 as soon as possible

Goals of Ventilation

- Acceptable PCO2 (40) and pH (7.4)
  - ✓Increase tidal volume or respiratory rate
    - ➢Increases minute ventilation
    - ➢Decreases PCO_2
- Plateau pressure less than 30 cm H_2O
  - ✓Varies positively with the set PEEP and Tidal volume
  - ✓Varies negatively with the compliance of the respiratory system
- Avoid Autopeep
  - ✓The buildup of additional positive pressure due to breath stacking
  - ✓Persistent end expiratory flow

Goals of Oxygenation

- Oxygen saturation >90%
  - Oxygen-ICU trial

✓Higher O_2 Sat target of 97-100% was associated with a higher rate of ICU mortality compared to lower O_2 Sat target of 94-98%

- F_iO_2 <60%

Girardis M et al. *Jama* 2016

Lung-Protective Ventilation Initiated in the Emergency Department (LOV-ED): A Quasi-Experimental, Before-After Trial

- ED / ICU of academic, tertiary center
- Evaluate the effectiveness of an ED-based lung-protective mechanical ventilation protocol on pulmonary complications

Fuller, et al. Ann Emerg Med 2017

Lung-Protective Ventilation Initiated in the Emergency Department (LOV-ED): A Quasi-Experimental, Before-After Trial

- Intervention
  - ✓ Tape measure for accurate height
  - ✓ Tidal volume: 6ml/kg PBW
  - ✓ Limit plateau pressure < 30 cm H_2O
  - ✓ Titrate F_iO_2 / SpO_2 90– 95%
  - ✓ Elevate HOB

Fuller, et al. Ann Emerg Med 2017

Lung-Protective Ventilation Initiated in the Emergency Department (LOV-ED): A Quasi-Experimental, Before-After Trial

- Results – ED

✓ LPV increased by 48.4%

✓ Tidal volume decreased by 1.8 ml/kg PBW

Fuller, et al. Ann Emerg Med 2017

Lung-Protective Ventilation Initiated in the Emergency Department (LOV-ED): A Quasi-Experimental, Before-After Trial

- Results – ICU

✓ LPV increased by 30.7%

✓ Tidal volume decreased by 1.1 ml/kg PBW

Fuller, et al. Ann Emerg Med 2017

Lung-Protective Ventilation Initiated in the Emergency Department (LOV-ED): A Quasi-Experimental, Before-After Trial

- Results

✓ Decreased ICU and hospital LOS

✓ Mortality : 14.5% absolute risk reduction

Fuller, et al. Ann Emerg Med 2017

ED Ventilator Settings Matter!

- ✓Tape measure for accurate height
- ✓Tidal volume: 6ml/kg PBW
- ✓Limit plateau pressure < 30 cm H_2O
- ✓Titrate F_iO_2 / SpO_2 90– 95%
- ✓Elevate HOB

Fuller, et al. Ann Emerg Med 2017

Implementation of a Goal-Directed Mechanical Ventilation Order Set Driven by Respiratory Therapists Improves Compliance With Best Practices for Mechanical Ventilation.

Radosevich MA[1], Wanta BT[1], Meyer TJ[2], Weber VW[2], Brown DR[1], Smischney NJ[1], Diedrich DA[1].

- Electronic order set that included specified oxygenation and ventilation goals
- Implemented by RTs
- Improved compliance to 88.2%

To Do List:

- Circulatory Support
  - ✓Central Venous Access
  - ✓Invasive Blood Pressure Monitoring
  - ✓Laboratory diagnostic testing
  - ✓Foley catheter
  - ✓Sedation
  - ✓Pain Control

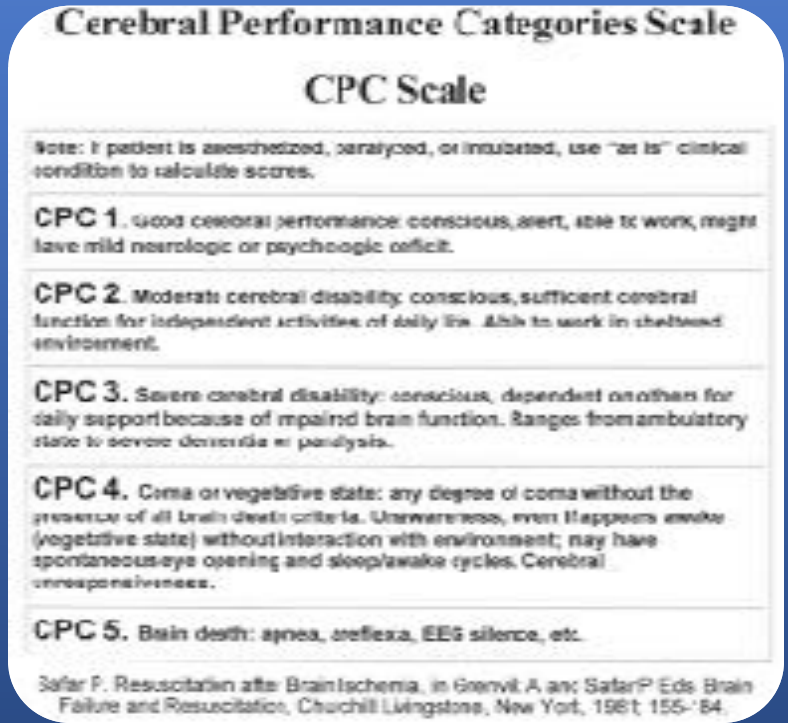
Early Vasopressors

- Topijan, et al., *Crit Care Med* 2014
  - ✓15 Childrens Hospitals
  - ✓Hypotension was associated with higher in-hospital mortality and worse neurologic outcome
- Kilgannon, et al., *Resuscitation* 2008
  - ✓Hypotension after ROSC is an independent predictor of death
  - ✓83% higher mortality
- Trzeciak, et al., *Crit Care Med* 2009
  - ✓Odds ration for death 2.7

Early Vasopressors

Impact of Early Vasopressor Administration on Neurological Outcomes after Prolonged Out-of-Hospital Cardiac Arrest

- ✓ 2100 Patients
- ✓ 43.5% ROSC
- ✓ Cerebral performance1,2 decreased by 10% for every minute delay in vasopressor administration



Circulation

- Loss of Cerebral autoregulation
  - Cerebral blood flow is highly pressure dependent
- Myocardial dysfunction and inability to maintain adequate cardiac output
- Need to maintain a high mean arterial blood pressure (MAP)
  - Goal between 65 - 100 mm of Hg

Vasoactive Drugs

Drug	Typical Starting Dose (Then Titrate to Effect)
Epinephrine	0.1–0.5 mcg/kg/min (in 70-kg adult, 7–35 mcg/min) • Useful for symptomatic bradycardia if atropine and transcutaneous pacing fail or if pacing is not available • Used to treat severe hypotension (eg, systolic blood pressure <70 mm Hg) • Useful for anaphylaxis associated with hemodynamic instability or respiratory distress[1]
Norepinephrine	0.1–0.5 mcg/kg/min (in 70-kg adult, 7–35 mcg/min) • Used to treat severe hypotension (eg, systolic blood pressure <70 mm Hg) and a low total peripheral resistance • Relatively contraindicated in patients with hypovolemia. It may increase myocardial oxygen requirements, mandating caution in patients with ischemic heart disease • Usually induces renal and mesenteric vasoconstriction; in sepsis, however, norepinephrine improves renal blood flow and urine output[2,3]
Phenylephrine	0.5–2.0 mcg/kg/min (in 70-kg adult, 35–140 mcg/min) • Used to treat severe hypotension (eg, systolic blood pressure <70 mm Hg) and a low total peripheral resistance
Dopamine	5–10 mcg/kg/min • Used to treat hypotension, especially if it is associated with symptomatic bradycardia • Although low-dose dopamine infusion has frequently been recommended to maintain renal blood flow or improve renal function, more recent data have failed to show a beneficial effect from such therapy[4,5]
Dobutamine	5–10 mcg/kg/min • The (+) isomer is a potent beta-adrenergic agonist, whereas the (–) isomer is a potent alpha-1 agonist[6] • The vasodilating beta^2-adrenergic effects of the (–) isomer counterbalance the vasoconstricting alpha-adrenergic effects, often leading to little change or a reduction in systemic vascular resistance
Milrinone	Load 50 mcg/kg over 10 minutes then infuse at 0.375 mcg/kg/min • Used to treat low cardiac output • May cause less tachycardia than dobutamine

Early Vasopressors

Bolus dose of epinephrine for refractory post-arrest hypotension

Michael Gottlieb, MD, RDMS*

- ✓ Case report of 3 patients
- ✓ Bolus dose of epinephrine as a bridge to vasopressor therapy

Early Vasopressors

Bolus dose of epinephrine for refractory post-arrest hypotension

Michael Gottlieb, MD, RDMS*

1. Obtain a 10-mL syringe of 0.9% normal saline.
2. Remove 1 mL of 0.9% normal saline from the syringe.
3. Inject 1 mL of cardiac epinephrine (100 micrograms/mL) into the syringe.
4. Shake the syringe well. The new solution will contain 10 micrograms of epinephrine per mL.
5. Give 0.5 – 2.0 mL (5 – 20 micrograms) every minute, titrating to the desired blood pressure.

Pain & Anxiety

- Patients experience pain
  - ✓CPR
  - ✓Mechanical ventilation
  - ✓Invasive procedures
  - ✓Surgical procedures
  - ✓Nursing care (repositioning, suctioning)

Pain & Anxiety

- Critically ill patients are unable to report pain
  - ✓Mechanical ventilation
  - ✓Altered mental status
  - ✓Medications

Pain & Anxiety

- Short-term consequences
  - ✓Increase catecholamines
  - ✓Arteriolar vasoconstriction
  - ✓Impair tissue perfusion
  - ✓Increase myocardial oxygen consumption

Pain & Anxiety

- Long-term consequences
  - ✓PTSD
  - ✓Post-ICU Syndrome
  - ✓Depression
  - ✓Impact on family / caregivers

Pain Assessment

- Difficult to evaluate
  - ✓Decreased consciousness level
  - ✓Delirium
  - ✓Effect of medications


1mV
Resp 2x
SpO2
NIBP Review Table
TIME NIBP NIBPm HR SpO2 RR T1
17:46:36 134/95 105 80 95 19 --.-
ECG
bpm
80
PR (79)
ST HIGHER
II:0.05mV
NIBP mmHg Auto
Adult Sys / Dia
PR (70)
137/93
Mean (104)
Min
SpO2
%
98
RR
rpm
16

Pain & Anxiety

Crit Care Med. 2002 Apr;30(4):746-52.

Patients' recollections of stressful experiences while receiving prolonged mechanical ventilation in an intensive care unit.

Rotondi AJ[1], Chelluri L, Sirio C, Mendelsohn A, Schulz R, Belle S, Im K, Donahoe M, Pinsky MR.

- ✓ 150 Patients
- ✓ 4 ICU within a tertiary care hospital
- ✓ 82% recalled pain with ETT

Pain Assessment

- Using specific guidelines for assessment and management
  - ✓Decreased ventilator days
  - ✓Shorter length of hospitalization
  - ✓Reduced cost of care

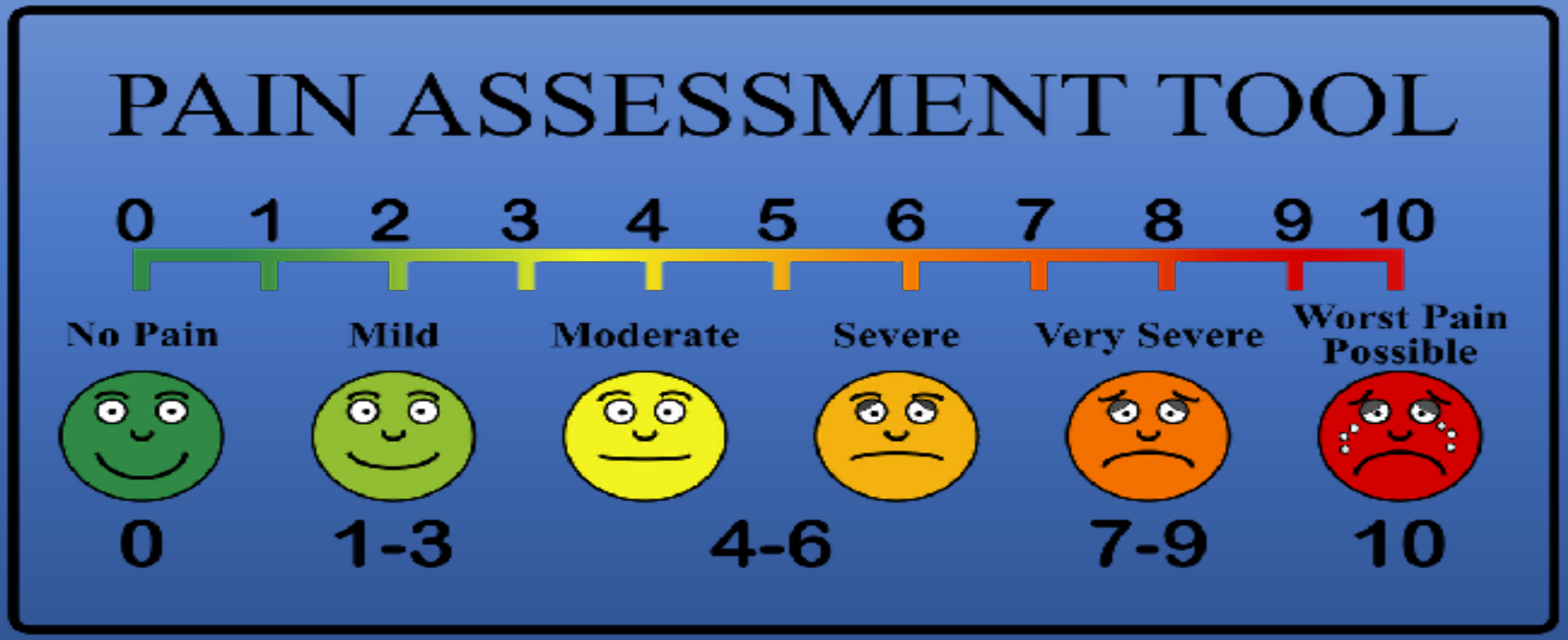
Crit Care Med. 2013 Jan;41(1):263-306. doi: 10.1097/CCM.0b013e3182783b72.

Clinical practice guidelines for the management of pain, agitation, and delirium in adult patients in the intensive care unit.

Barr J[1], Fraser GL, Puntillo K, Ely EW, Gélinas C, Dasta JF, Davidson JE, Devlin JW, Kress JP, Joffe AM, Coursin DB, Herr DL, Tung A, Robinson BR, Fontaine DK, Ramsay MA, Riker RR, Sessler CN, Pun B, Skrobik Y, Jaeschke R; American College of Critical Care Medicine.

- ✓ Behavioral Pain Scale (BPS)
- ✓ Critical-Care Pain Observation Tool (CPOT)
- ✓ Non-verbal Pain Scale (NVPS)
- ✓ Numerical Rating Scale (NRS)
- ✓ Visual Analog Scale (VAS)
- ✓ Defense and Veterans Pain Rating Scale (DVPRS)

Visual Analog Scale



Behavioral Pain Scale (BPS)

Item	Description	Score
Facial expression	Relaxed	1
	Partially tightened (e.g., brow lowering)	2
	Fully tightened (e.g., eyelid closing)	3
	Grimacing	4
Upper limb movements	No movement	1
	Partially bent	2
	Fully bent with finger flexion	3
	Permanently retracted	4
Compliance with mechanical ventilation	Tolerating movement	1
	Coughing but tolerating ventilation for the most of time	2
	Fighting ventilator	3
	Unable to control ventilation	4

BPS score ranges from 3 (no pain) to 12 (maximum pain).

Medscape® www.medscape.com

Indicator	Description	Score	
Facial expression	No muscular tension observed	Relaxed, neutral	0
	Presence of frowning, brow lowering, orbit tightening, and levator contraction	Tense	1
	All of the above facial movements plus eyelid tightly closed	Grimacing	2
Body movements	Does not move at all (does not necessarily mean absence of pain)	Absence of movements	0
	Slow, cautious movements, touching or rubbing the pain site, seeking attention through movements	Protection	1
	Pulling tube, attempting to sit up, moving limbs/ thrashing, not following commands, striking at staff, trying to climb out of bed	Restlessness	2
Muscle tension Evaluation by passive flexion and extension of upper extremities	No resistance to passive movements	Relaxed	0
	Resistance to passive movements	Tense, rigid	1
	Strong resistance to passive movements, inability to complete them	Very tense or rigid	2
Compliance with the ventilator (intubated patients)	Alarms not activated, easy ventilation	Tolerating ventilator or movement	0
	Alarms stop spontaneously	Coughing but tolerating	1
	Asynchrony: blocking ventilation, alarms frequently activated	Fighting ventilator	2
OR			
Vocalization (extubated patients)	Talking in normal tone or no sound	Talking in normal tone or no sound	0
	Sighing, moaning	Sighing, moaning	1
	Crying out, sobbing	Crying out, sobbing	2
Total, range			0-8

Agitation

- Associated with adverse outcomes
- Underlying causes

✓Pain

✓Delirium
✓Hypoxemia
✓Hypotension
✓Hypoglycemia
✓Withdrawal from alcohol or other drugs

Agitation Assessment

- Sedation scales
- Sedation protocols
- Improved ICU outcomes
- Shortened duration of mechanical ventilation
- Shortened ICU and hospital LOS
- Decreased delirium and long term cognitative dysfunction

Agitation Assessment

- Richmond Agitation-Sedation Scale
- Sedation-Agitation Scale
- Ramsay Sedation Scale
- Sedation Intensive Care Score
- New Sheffield Sedation Score

Richmond Agitation and Sedation Scale

Score	Descriptor	Characteristics
+4	Combative	Combative, violent, immediate danger to staff
+3	Very agitated	Pulls or removes tube(s) or catheter(s); aggressive
+2	Agitated	Frequent nonpurposeful movement, fights ventilator
+1	Restless	Anxious, apprehensive but movements not aggressive or vigorous
0	Alert and calm	
-1	Drowsy	Not fully alert, but has sustained awakening to voice (eye opening and contact >10 seconds)
-2	Light sedation	Briefly awakens to voice (eye opening and contact <10 seconds)
-3		
-4	Moderate sedation	Movement or eye opening to voice (but no eye contact)
	Deep sedation	No response to voice, but movement or eye opening to physical stimulation
-5	Unarousable	No response to voice or physical stimulation

Pain & Anxiety

Am J Emerg Med. 2013 Jan;31(1):222-6. doi: 10.1016/j.ajem.2012.05.015. Epub 2012 Jul 4.

Estimates of sedation in patients undergoing endotracheal intubation in US EDs.

Weingart GS[1], Carlson JN, Callaway CW, Frank R, Wang HE.

- ✓ Retrospective review
- ✓ National Hospital Ambulatory Medical Care Survey
- ✓ Only 46.4% received sedation

Pain & Anxiety

Am J Emerg Med. 2008 May;26(4):469-72. doi: 10.1016/j.ajem.2007.05.024.

Inadequate provision of postintubation anxiolysis and analgesia in the ED.

Bonomo JB[1], Butler AS, Lindsell CJ, Venkat A.

- 117 Patients

✓ 33% received no anxiolytic
✓ 53% received no analgesic
✓ 20% received neither anxiolytic nor analgesic

Pain & Anxiety

Am J Emerg Med. 2014 May;32(5):452-6. doi: 10.1016/j.ajem.2014.01.002. Epub 2014 Jan 15.

Long-acting neuromuscular paralysis without concurrent sedation in emergency care.

Chong ID[1], Sandefur BJ[2], Rimmelin DE[3], Arbelaez C[3], Brown CA 3rd[3], Walls RM[3], Pallin DJ[4].

- ✓ Retrospective review
- ✓ Single, urban academic center
- ✓ 292 pts paralyzed
- ✓ 18% did not receive concurrent sedation

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- Target lighter levels of sedation
  - ✓ RASS 0 to -2
- Use non-benzodiazepine sedatives
  - ✓ Propofol
  - ✓ dexmedetomidine

Pain Treatment

- Tylenol
- NSAIDS
- Opioids
  - Fentanyl
  - Morphine
  - Hydromorphone

Propofol

- Sedative
- Hypnotic
- Anxiolytic
- Amnestic
- Antiemetic
- Anticonvulsant
- NO analgesic effect

Propofol

- Side-effects

✓Respiratory depression
✓Hypotension
✓Hypertriglyceridemia
✓Acute pancreatitis
✓Myoclonus
✓Propofol infusion syndrome (PRIS)

Dexmedetomidine

- Selective α_2-receptor agonist
- Sedative
- Analgesic / opioid sparing
- Sympatholytic
- Minimal respiratory depression

Dexmedetomidine

- Side-effects
  - ✓Hypotension
  - ✓Bradycardia
- Advantages
  - ✓Use in non-intubated patients
  - ✓Reduces opioid requirement

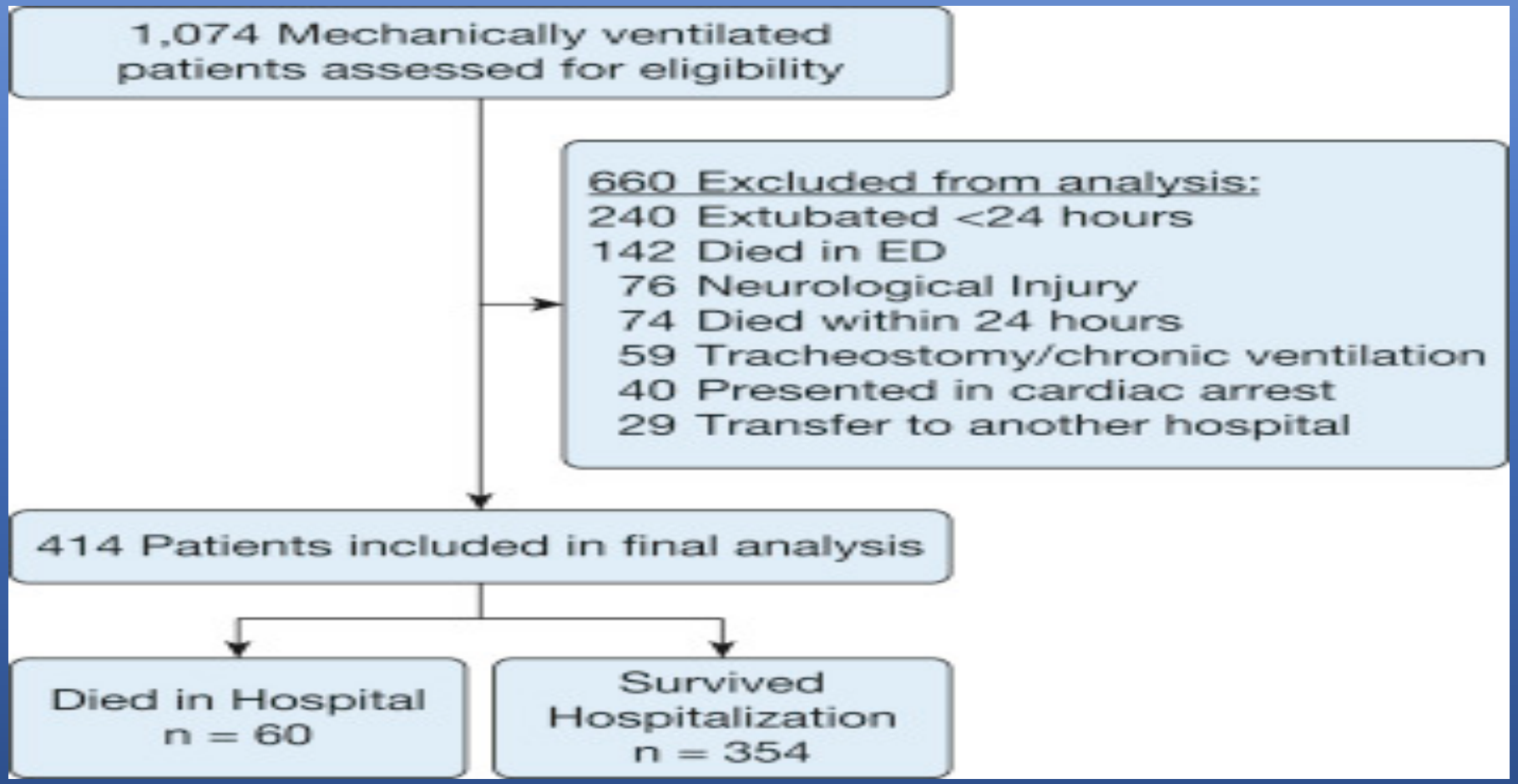
Analgosedation Practices and the Impact of Sedation Depth on Clinical Outcomes Among Patients Requiring Mechanical Ventilation in the ED

A Cohort Study

Robert J. Stephens, BS, Enyo Ablordeppey, MD, MPH, Anne M. Drewry, MD, Christopher Palmer, MD, Brian T. Wessman, MD, Nicholas M. Mohr, MD, Brian W. Roberts, MD, Stephen Y. Liang, MD, MPHS, Marin H. Kollef, MD, Brian M. Fuller, MD

- Single, tertiary, academic center
- Assess relationship between ED sedation depth and outcome
- Measured sedation depth by RASS -3 to -5

Analgosedation



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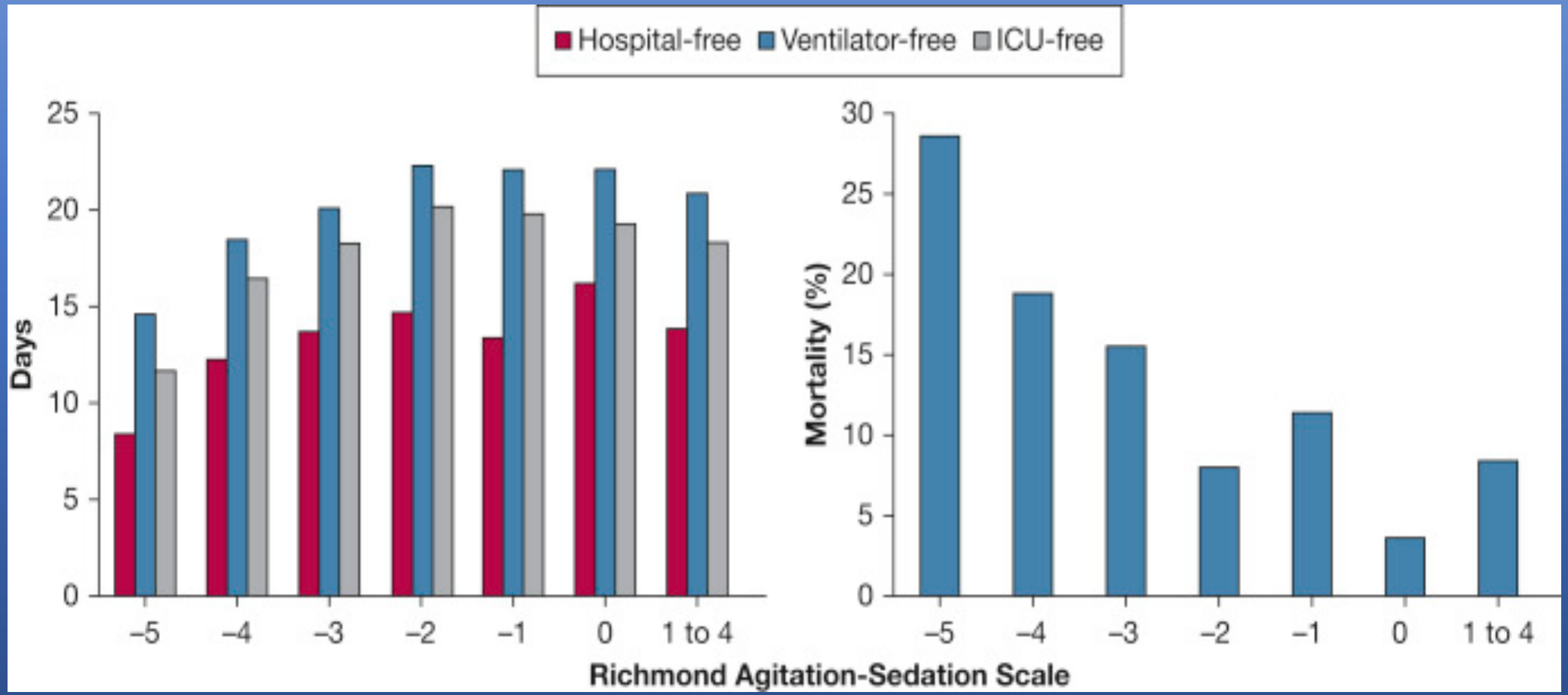
- Primary outcome
  - ✓ Hospital mortality
- 414 patients
  - ✓ 85.5% Fentanyl
  - ✓ 61.3% Midalzolam
  - ✓ 46.9% Propofol

Analgosedation



Analgesia & Sedation

- Consequence of untreated pain / agitation
- Vital signs alone are not adequate predictors
- Implement protocols
- Start with analgesics
- Target RASS 0 to -2
- Avoid benzodiazepines

To Do List:

- Critical Care Ultrasonography (CCUS)

  - ✓Cardiac
  - ✓Thoracic
  - ✓Abdominal
  - ✓Vascular

To Do List:

- Targeted Temperature Management
- Prevent Ventilator-associated Pneumonia
- Prevent Stress-related Mucosal Injury
- Prevent Deep Venous Thrombosis
- Monitor Glucose

ROSC! Now What Do I Do?

- Mechanical Ventilation
- Circulatory Support
- Pain & Anxiety
- Agitation
- Critical Care Ultrasonography
- Therapeutic Hypothermia
- Supportive care

ED Ventilator Settings Matter!

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Questions