Management of Critically Ill Patients

David Tofovic

34 y.o. M

- Presents with to the ED via EMS.
- Unable to provide history.
- Last seen earlier that morning by neighbor.
- Sister states she found him down at home.
- Started CPR, neighbor called 911.
- Sister is a nurse, believed that she couldn't feel a pulse
- Complained of "cold and and a bad cough" several days prior.
- Initial rhythm: asystole
- Epi x 1
- ROSC

- Per Brother/Chart Review:
  - PMHx: SLE, Type 1 Diabetes (well controlled)
  - PSHx: Tonsillectomy, Insulin Pump (recently removed)
  - Allergies: NKDA
  - Home Meds
    - Prednisone (unknown dose or duration)
    - Cellcept (mycophenolate)
    - Glargine
    - Lispro
  - SHx: No tobacco, no EtOH, no illicits
  - FHx: SLE, HTN, DLD, stroke

34 y.o. M

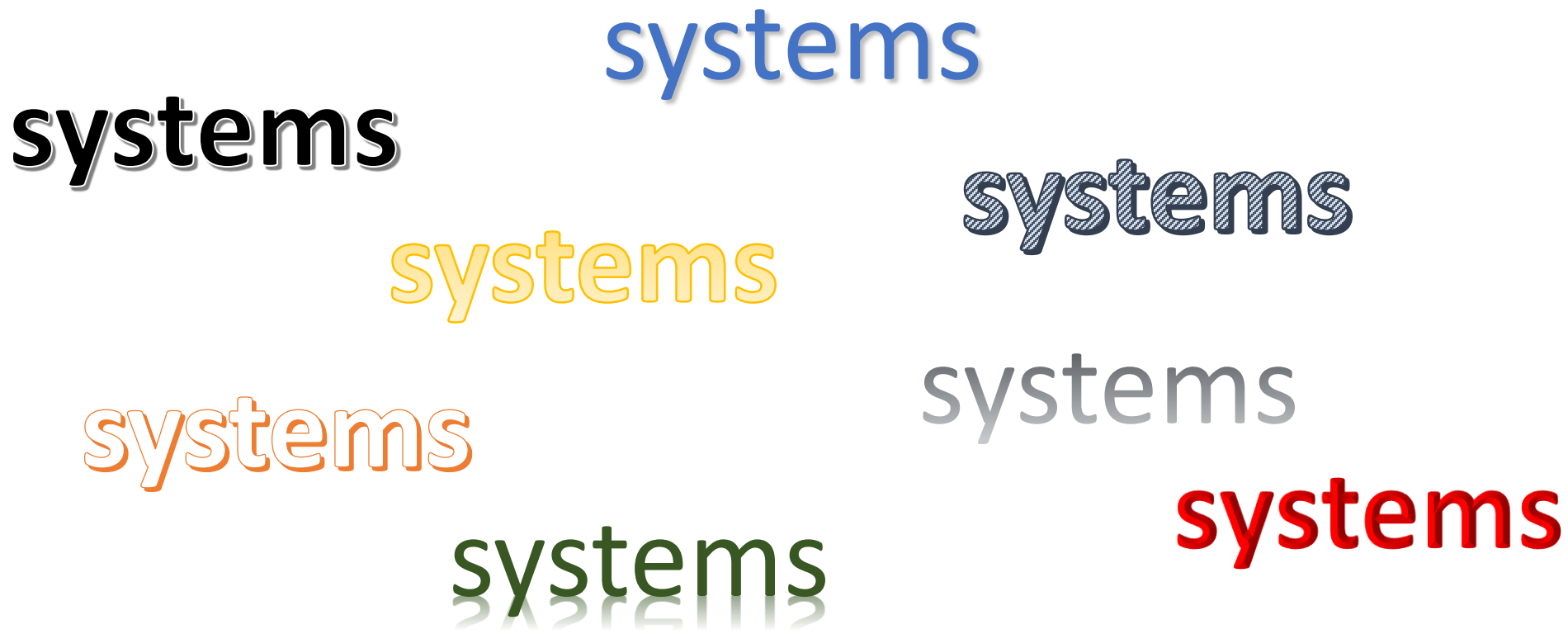
- Vitals:
  - T: 38.3° C
  - HR: 130s
  - BP: 76/44
  - RR: 24
  - Pox: 88% on bag and mask
  - Per EMR: Wgt 88 kgs
  - Per EMR: Hgt 184 cm

- Physical Exam:
- General: nonresponsive
- CVS: RRR, no m/r/g/c
- Lung: tachypnea, coarse breathe sounds bilaterally
- Neuro: PERRL, GCS 7
- Extremities: Radial, DP and PT 2+, no lower extremity pitting edema
- Skin: No rashes, no ulcers

34 y.o. M

- CBC: 13>17&50.1<294
- RFP: 122/7.3/81/5/74/5.53/1369
- Ca/Mg/Phos: 7.8/2.24/3.3
- INR/PTT: 2.2/64
- LFT
  - AST ~2100
  - ALT ~1800
  - ALKPHOS >3000
  - Tbili: 6.5
  - Dbili:4.1
  - Alb: 3.3
  - Tp: 6.4
- ABG: 6.9/55/18/3.1
- Lactate: 4.8
- Beta-hydroxybutyrate: 6.3

What’s wrong?


systems
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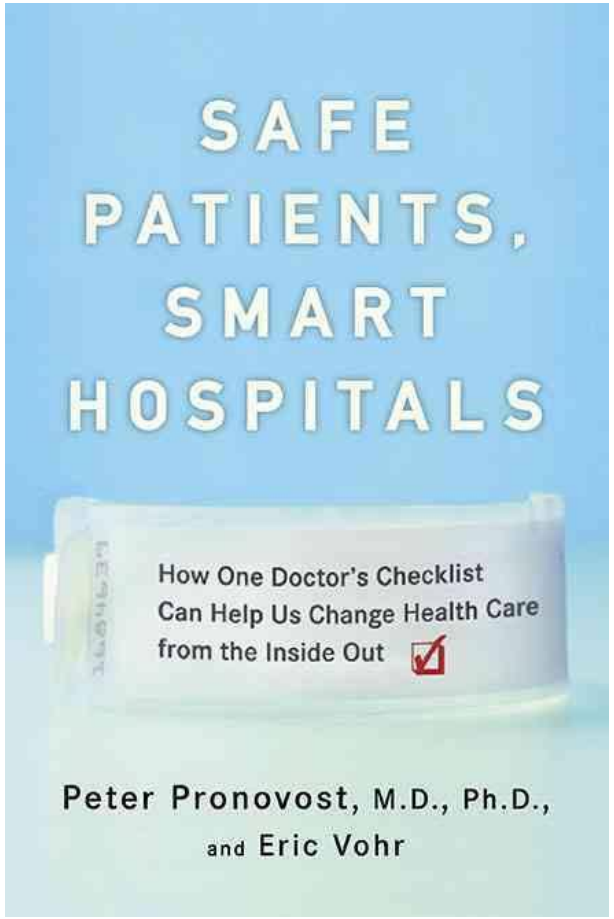
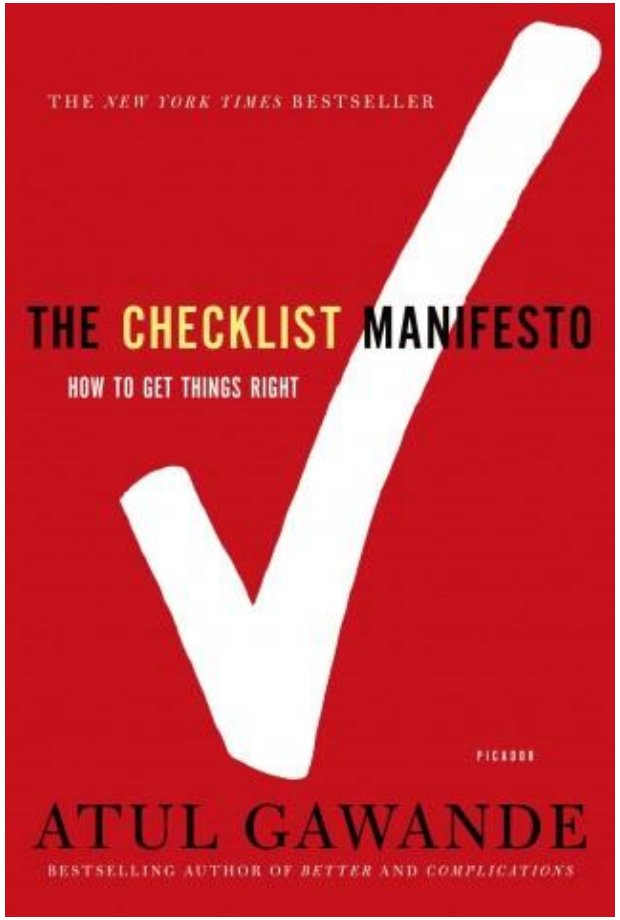
Systems Based

- CVS
- Pulmonary
- Neuro/Psych
- GU
- GI
- Endo/Rheum
- Infectious
- Heme

- Infectious
- Heme
- Supportive (FASTHUGS BID)
- Lines
- CODE
- Dispo
- PT/OT

Procotalized Medicine





You don’t look so good.

Let me just get my senior..

Sepsis

- SIRS Criteria (needs 2/4)
  - T <36° C or >38° C
  - HR > 90
  - Tachynpea
    - RR > 20 or PaCO2 <32mmHg
  - WBC >12 or <4
    - or immature neutrophils >10%

- qSOFA (needs 2/3)
  - AMS (GCS<14)
  - Tachypnea (RR≥22)
  - Hypotension (SBP≤100mmHg)

KM Kaukonen, M Bailey, D Pilcher, DJ Cooper, and R. Bellomo. Systemic Inflammatory Response Syndrome Criteria in Defining Severe Sepsis. N Engl J Med 2015; 372:1629-1638
M Singer, CS Deutschman, CW Seymour et al. The Third International Consensus Definitions for Sepsis and Septic Shock (Sepsis-3). *JAMA.* 2016;315(8):801-810.

SOFA

Table 1. Sequential [Sepsis-Related] Organ Failure Assessment Score[a]

System	Score 0	1	2	3	4
Respiration					
Pao_2/Fio_2, mm Hg (kPa)	≥400 (53.3)	<400 (53.3)	<300 (40)	<200 (26.7) with respiratory support	<100 (13.3) with respiratory support
Coagulation					
Platelets, $\times 10^3/\mu L$	≥150	<150	<100	<50	<20
Liver					
Bilirubin, mg/dL (μmol/L)	<1.2 (20)	1.2-1.9 (20-32)	2.0-5.9 (33-101)	6.0-11.9 (102-204)	>12.0 (204)
Cardiovascular	MAP ≥70 mm Hg	MAP <70 mm Hg	Dopamine <5 or dobutamine (any dose)[b]	Dopamine 5.1-15 or epinephrine ≤0.1 or norepinephrine ≤0.1[b]	Dopamine >15 or epinephrine >0.1 or norepinephrine >0.1[b]
Central nervous system					
Glasgow Coma Scale score[c]	15	13-14	10-12	6-9	<6
Renal					
Creatinine, mg/dL (μmol/L)	<1.2 (110)	1.2-1.9 (110-170)	2.0-3.4 (171-299)	3.5-4.9 (300-440)	>5.0 (440)
Urine output, mL/d				<500	<200

Abbreviations: Fio_2, fraction of inspired oxygen; MAP, mean arterial pressure; Pao_2, partial pressure of oxygen.

[a] Adapted from Vincent et al.[27]

[b] Catecholamine doses are given as μg/kg/min for at least 1 hour.

[c] Glasgow Coma Scale scores range from 3-15; higher score indicates better neurological function.

M Singer, CS Deutschman, CW Seymour et al. The Third International Consensus Definitions for Sepsis and Septic Shock (Sepsis-3). *JAMA.* 2016;315(8):801-810.

Sepsis

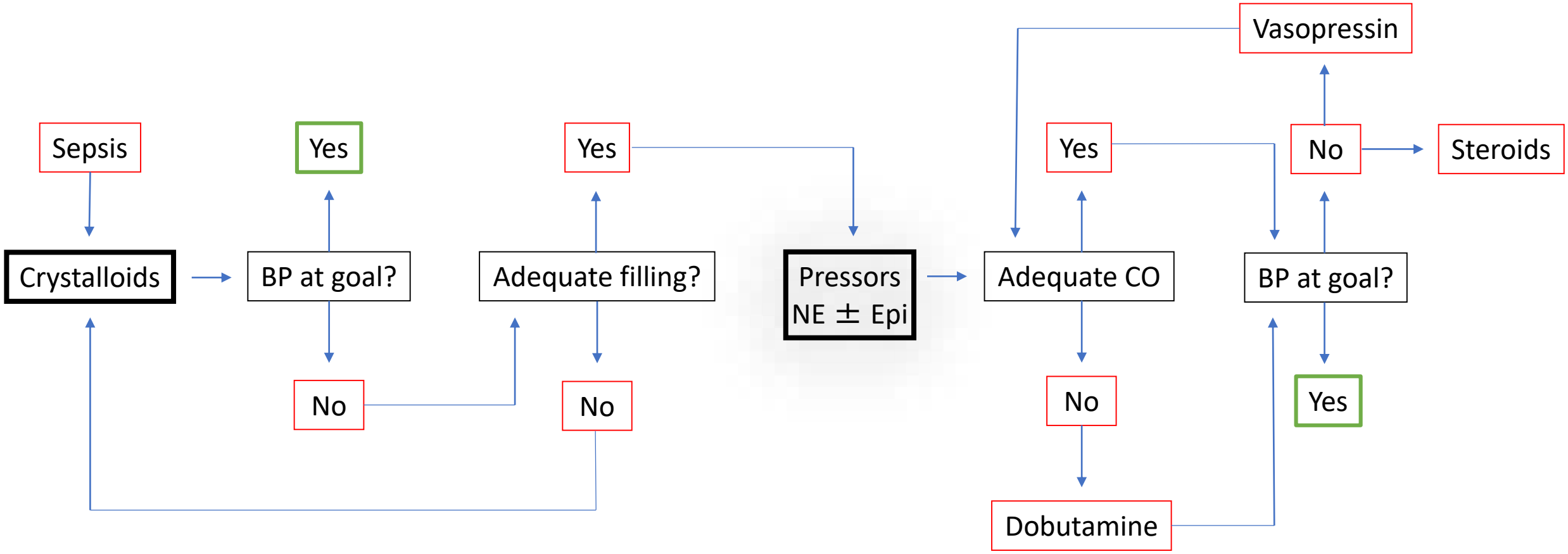
- **Within 3 hours**
  - Obtain lactate level
  - Obtain blood cultures prior to administration of antibiotics
    - Unless significantly delays giving abx (>45 minutes)
    - Broad if unknown source
    - Try SIRS orderset
  - Give antibiotics (Grade 1B)
  - Crystalloid Fluids (Grade 1B)
    - At least 30 cc/kg
- **Within 6 hours**
  - If Septic shock (i.e. hypotension and lactate>2 after fluids), vasopressors (Grade 1B)
  - If continued shock, reassess volume status and tissue perfusion.
    - Focused exam (i.e. vital signs, cardiopulmonary, capillary refill, pulse and skin findings)
    - Two of the following
      - CVP
      - ScvO2
      - TTE
      - Passive leg raise or fluid challenge

Dellinger RP et al. Surviving sepsis campaign: International guidelines for management of severe sepsis and septic shock, 2012. Crit Care Med 2013

Septic Shock

- 1st line pressor (Grade 1B)
  - Norepinephrine (Levophed)
    - Requires central venous access
      - Can be given peripherally for a short time.
    - Code White nurses
- 2nd line pressor (Grade 2B)
  - Epinephrine
- Can add vasopressin
    - No titration, run at steady dose of 0.03-0.04 units/min
    - Effective in severely acidotic patients
- If nonresponsive aforementioned management, consider steroids.
  - Hydrocortisone 50mEq IV q6hrs
  - Taper once shock resolves
- Evaluate CO
- HgB >7

Septic Shock



Ventilators

Are Great

But why intubate?

- Ventilation
  - CO2 exchange issue
- Oxygenation
  - O2 exchange issue
- Work of Breathing
- Airway Protection

Ventilators

- Control Types
  - Volume Control (VC)
    - Inhalation proceeds until set tidal volume is obtained
    - Risk of barotrauma
  - Pressure Control (PC)
    - Inhalation proceeds until a set peak inspiratory pressure is obtained
  - “Dual Control”
    - Pressure controlled to give set volume, automatically adjusts pressure based on lung compliance

Ventilators

- Mode Types
  - Assist/Support
    - Delivers volume/pressure with patient effort
    - Detects assist pressure
      - Which can be adjusted
  - Control
    - Delivers volume/pressure regardless of patient effort
  - Assist-Control (A/C)
    - Both support types are utilized

Ventilators

- Phases of cycle
  - Trigger
    - What causes the beginning of the respiratory cycle
    - Typically flow vs pressure
      - Autotriggering
  - Limit
    - What determines the size of breathe
  - Cycle
    - What causes the end of the breathe

Ventilators

- Continuous Mandatory Ventilation (CMV)
  - Assist-Control mode
  - Given set breathe rate
  - Spontaneous breathes above set rate **are** supported
- Intermittent Mandatory Ventilation (IMV)
  - Given set breathe rate
  - Spontaneous breathes above set rate **are NOT** supported
  - SIMV = synchronized IMV to match patient's breathing rate
- Continuous Spontaneous Ventilation (CSV)

OOoooOo! What are all these buttons?!

- Vents will be set to either CMV (A/C) or CPAP (if weaning)
  - Unless paralyzed or inverse-ratio
- Oxygenation
  - FiO2
  - PEEP
  - Inspiration time
- Ventilation
  - Frequency
  - Tidal Volume
  - Expiration time

New Tube? Where to start?

- Depends on the reason for intubation.
- Lung Protective Strategy
  - based on the ARDSNet ARMA study (showed mortality benefit)
  - Most patients, particularly anyone showing signs of lung injury
  - Goal is to reduce barotrauma and volutrauma
  - Low tidal volumes
- Obstructive Strategy
  - Asthma/COPD with active bronchospasm
  - Goal is prevent autoPEEPing by allowing for maximum exhalation
  - Slower rates, no PEEP

Weingart, S. Managing initial mechanical ventilation in the emergency department. *Ann Emerg Med*. 2016;68:614–617.

New Tube? Where to start?

	Lung Protective Strategy	Obstructive Strategy
Mode	Volume assist control	Volume assist control
Tidal volume	Start at 8 mL/kg PBW; adjust for plateau pressure goal	8 mL/kg PBW
Inspiratory flow rate	Start at 60 L/min; adjust for comfort	60–80 L/min
Respiratory rate	Start at 16 breaths/min; adjust for $PaCO_2$ goal	Start at 10 breaths/min; adjust to allow full expiration
PEEP	Start at 5 cm H_2O; adjust according to table	0 cm H_2O (some may treat pt with PEEP $\leq$5 cm H_2O)
FiO_2	Start at 40%; adjust according to table	Start at 40%; adjust for SpO_2 $\geq$88%
Check for safety	Measure plateau pressure. If $\geq$30 cm H_2O, decrease tidal volume by 1 mL/kg	Measure plateau pressure or observe flow time graph. If plateau pressure $\geq$30 cm H_2O or flow/time graph shows incomplete expiration, decrease respiratory rate

PBW, Predicted body weight; *pt*, patient.

Weingart, S. Managing initial mechanical ventilation in the emergency department. *Ann Emerg Med*. 2016;68:614–617.

Acute Respiratory Distress Syndrome

- Widespread inflammation in the lungs due to stressor
  - Alveolar damage, surfactant dysfunction, deceased lung compliance
- Inclusion Criteria
  - PaO2/FiO2 >300mmHg
  - Bilateral (patchy, diffuse, or homogeneous) infiltrates consistent with pulmonary edema
  - No evidence of left atrial hypertension (i.e. L sided heart failure)

Lower PEEP/higher FiO2

FiO_2	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.7
PEEP	5	5	8	8	10	10	10	12

FiO_2	0.7	0.8	0.9	0.9	0.9	1.0
PEEP	14	14	14	16	18	18-24

Higher PEEP/lower FiO2

FiO_2	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5
PEEP	5	8	10	12	14	14	16	16

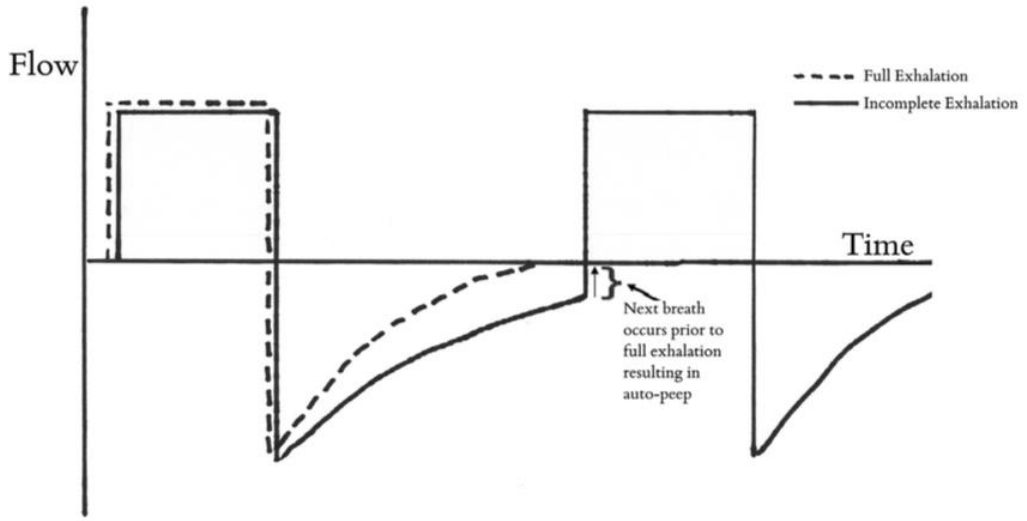
FiO_2	0.5	0.5-0.8	0.8	0.9	1.0	1.0
PEEP	18	20	22	22	22	24

http://www.ardsnet.org/files/ventilator_protocol_2008-07.pdf

Fanelli, Vito; Ranieri, V. Marco (2015-03-01). "Mechanisms and clinical consequences of acute lung injury". *Annals of the American Thoracic Society*. 12 Suppl 1: S3–8.

Auto-PEEP

- Incomplete expiration
- Leads to hyperinflation
  - I.e. airtrapping
- Increased alveolar pressure
- Leads to..
  - BAROTRAUMA!!!
  - Decreased venous return
- Check by end expiratory hold
- Treatment:
  - Disconnect from ventilator
  - Rarely require significant external PEEP
    - Overcomes obstruction



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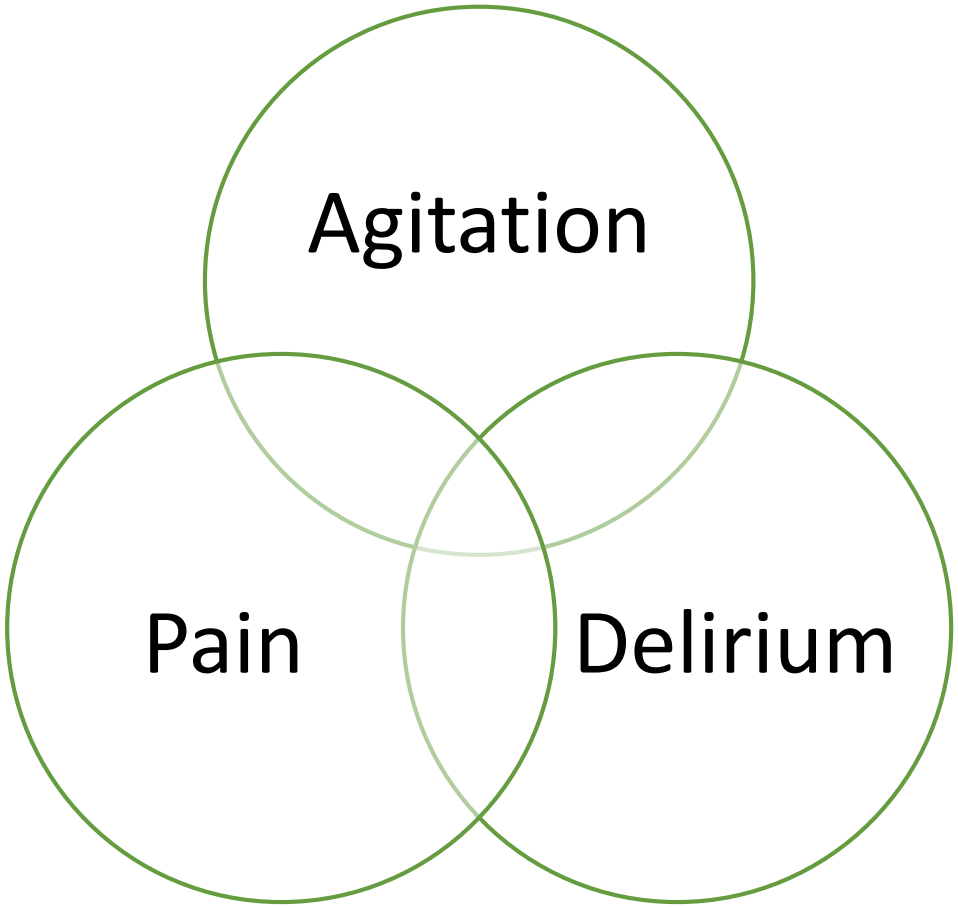
So I’m intubated? Now what?

- **F**eeding/fluids: All intubated patients on enteral feeding after 48hrs
- **A**nalgesia
- **S**edation
- **T**hromboprophylaxis
- **H**ead up position: All intubated patients with head of bed >30˚
- **U**lcer prophylaxis: All intubated patients > 24hrs
- **G**lycemic control: BG 140-180
- **S**pontaneous breathing trial
- **B**owel care: All intubated patients >24 hrs
- **I**ndwelling catheter removal: know insertion dates, are they still needed
- **D**escalation of antibiotics.

Sedation Algorithm

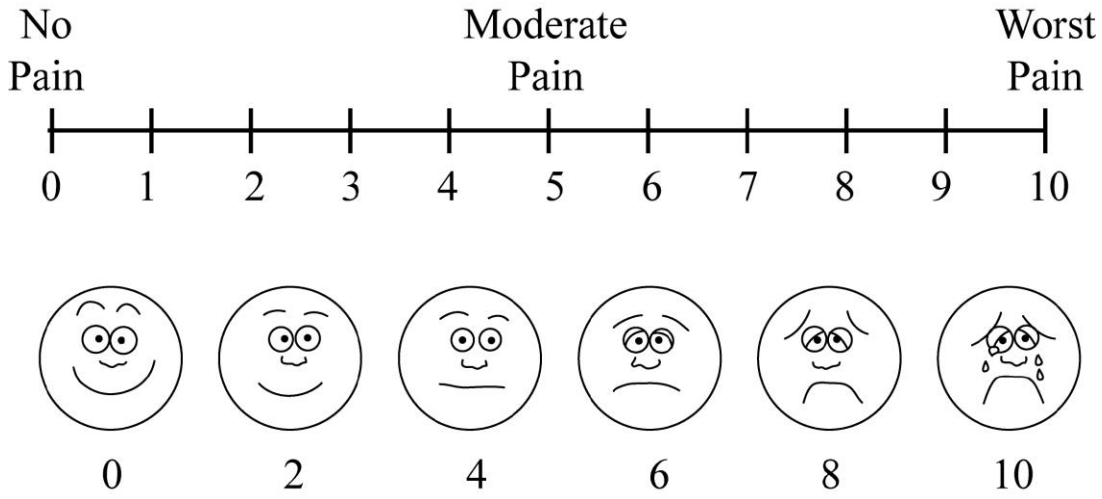


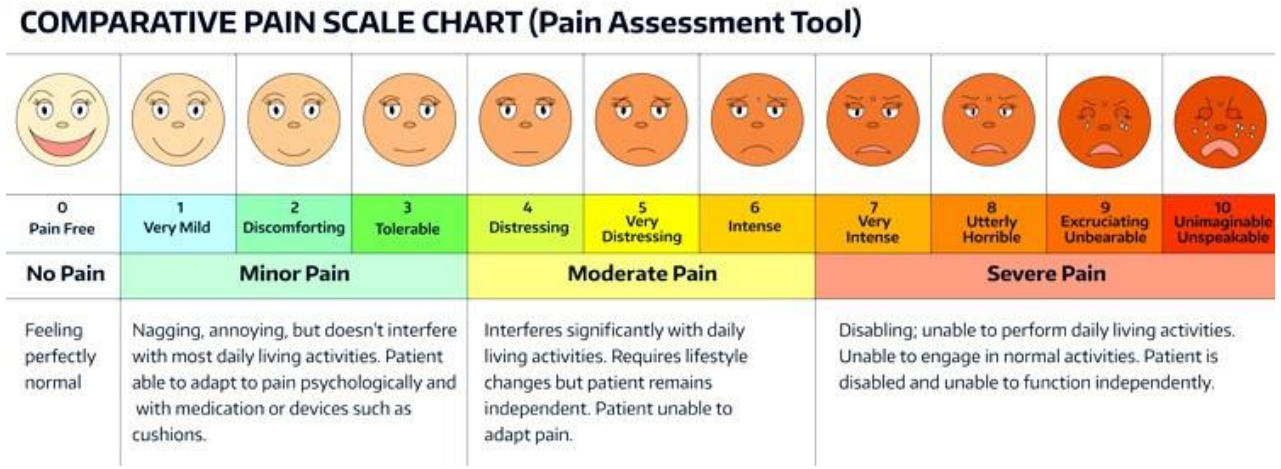
Richmond Agitation-Sedation Score

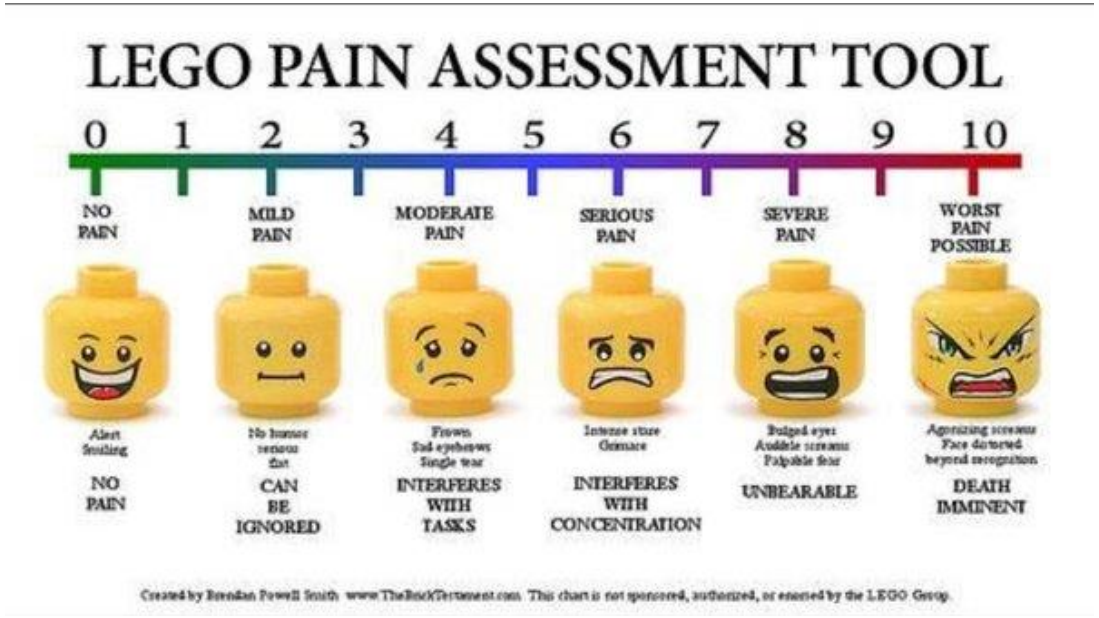
+4	Combative	Overtly combative/violent; immediate danger to others
+3	Very Agitated	Reaching at tube(s) or catheter(s) or aggressive behavior
+2	Agitated	Frequent nonpurposeful movement or patient–ventilator dyssynchrony
+1	Restless	Anxious or apprehensive
0	Alert and Calm	Spontaneously paying attention
-1	Drowsy	Not fully alert, but >10 seconds awakening to voice with eye contact
-2	Light Sedation	>10 seconds awakening to voice with eye contact
-3	Moderate Sedation	Any movement to voice
-4	Deep Sedation	No response to voice, but movement to physical stimulation
-5	Unarousable	No response to voice or physical stimulation

Curtis N. Sessler, Mark S. Gosnell, Mary Jo Grap, Gretchen M. Brophy, Pam V. O'Neal, Kimberly A. Keane, Eljim P. Tesoro, and R. K. Elswick "The Richmond Agitation–Sedation Scale", American Journal of Respiratory and Critical Care Medicine, Vol. 166, No. 10 (2002), pp. 1338-1344. doi: 10.1164/rccm.2107138

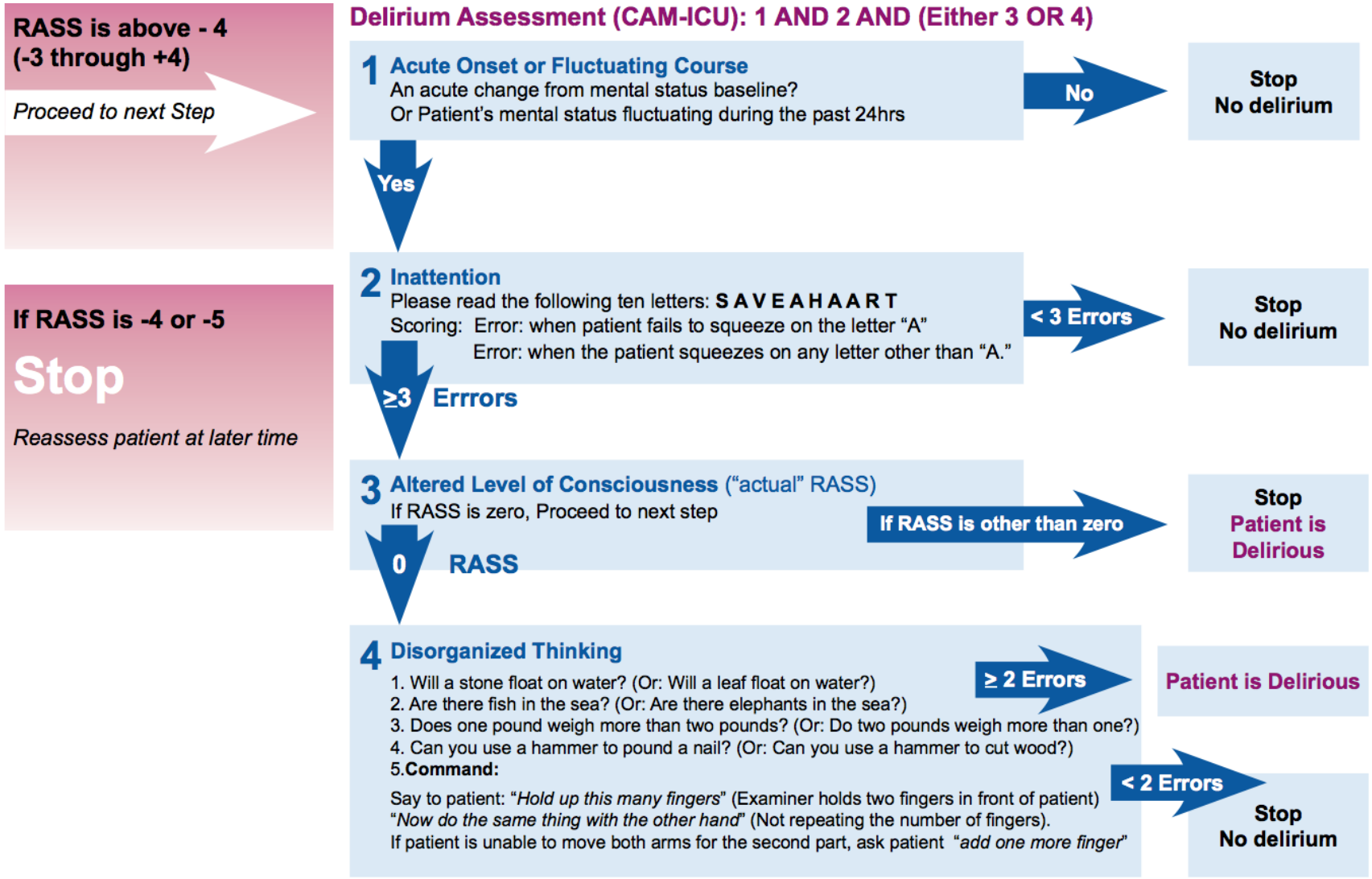
Visual Analogue Scale (VAS)





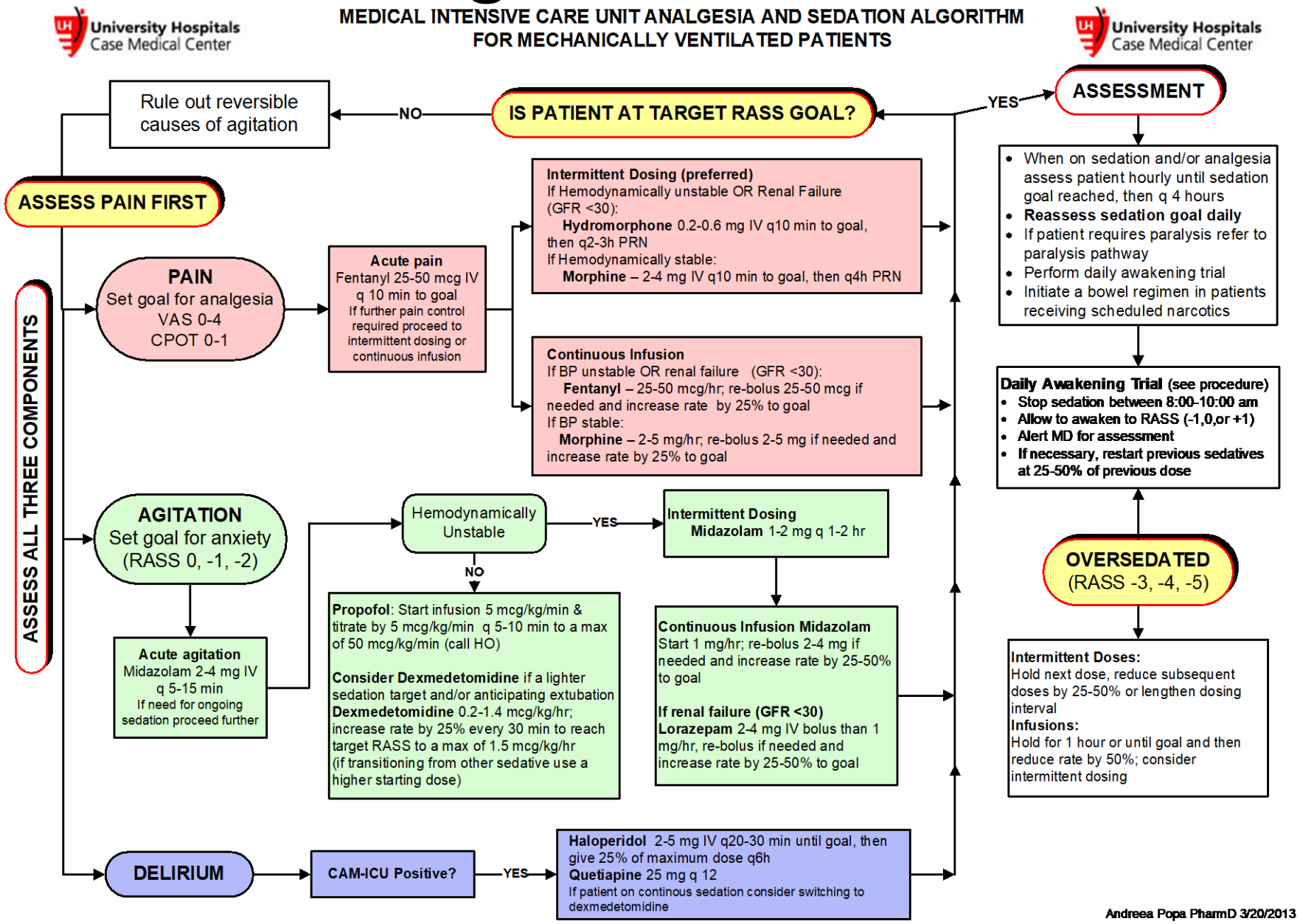


Confusion Assessment Method for ICU



Gusmao-Flores D, Salluh JI, Chalhub RA, Quarantini LC. The confusion assessment method for the intensive care unit (CAM-ICU) and intensive care delirium screening checklist (ICDSC) for the diagnosis of delirium: a systematic review and meta-analysis of clinical studies. Crit Care 2012; 16: R115.

MICU Sedation Algorithm



I’m tired of this ventilators..

- Spontaneous Awakening Trial (SAT) Screen
  - Reason for ventilation is improving
  - $FiO_2 < 55\%$
  - PEEP ≤ 5 mmHg
  - Off paralytics
  - Hemodynamically Stable
  - Acceptable pH/O_2/CO_2/bicarb
  - No seizures
  - No myocardial ischemia
  - No withdrawal symptoms
- If ok, hold tube feeds and sedation holiday
- Once daily

Esteban A, Frutos F, Tobin MJ, Alía I, Solsona JF, Valverdú I, Fernández R, de la Cal MA, Benito S, Tomás R, et al. A comparison of four methods of weaning patients from mechanical ventilation. Spanish Lung Failure Collaborative Group. N Engl J Med. 1995 Feb 9;332(6):345-50.

I’m tired of this ventilators..

- Spontaneous Breathing Trial (SBT)
  - PS ≤ 5 mmHg and/or PEEP ≤ 5 mmHg and/or trach collar
  - RR between 38-6 bpm
  - SpO2 > 92%
  - Tidal volume > 325 mL
  - Stable HR (stop if HR >140 or 25% above baseline)
  - Stable BP(stop if SBP >40 above baseline)
  - No significant agitatation
  - Rapid Shallow Breathing Index (RSBI) <105 min/L
    - RSBI = Rate/tidal volume
    - Best predictor
- Negative Inspiratory Force (NiF)
  - ≤ -30mmHg H20
- Minute ventilation:
- RR x Vt <10 to 15L/min
- Spontaneous volume:
- ≥ 5 ml/kg

Esteban A, Frutos F, Tobin MJ, Alía I, Solsona JF, Valverdú I, Fernández R, de la Cal MA, Benito S, Tomás R, et al. A comparison of four methods of weaning patients from mechanical ventilation. Spanish Lung Failure Collaborative Group. N Engl J Med. 1995 Feb 9;332(6):345-50.

I love acid-base!

Said no one.. ever.

6 Step guide

- Is the patient acidotic or alkalotic?
  - cutoff is pH = 7.4
- What is the primary abnormality?
  - Bicarb and PCO2 always go..
    - Same direction as pH in metabolic disorder
    - Opposite direction as pH in respiratory disorder
- If a primary respiratory disorder, is it acute or chronic?

Acute Respiratory Acidosis	expected ↓pH =	0.08	x	$\frac{(PaCO2 - 40)}{10}$
Chronic Respiratory Acidosis	expected ↓pH =	0.03	x	$\frac{(PaCO2 - 40)}{10}$
Acute Respiratory Alkalosis	expected ↑pH =	0.08	x	$\frac{(40 - PaCO2)}{10}$
Chronic Respiratory Acidosis	expected ↑pH =	0.03	x	$\frac{(40 - PaCO2)}{10}$

Morganroth, M. 1990. Six steps to acid-base analysis: Clinical Applications. The Journal of Critical Illness. 5, 460-469.

6 Step guide

- For metabolic alkalosis..

Chloride Responsive	**Chloride Resistance**
Urine chloride < 10 mEq/L	Urine chloride > 20 mEq/L
Usually hypovolemic	Usually hypervolemic/hypertensive
Emesis	Hyperaldosteronism
Prior Diuretics	Current Diuretics
Contraction alkalosis	Antacids
Post hyperventilation	Bartter/Liddle Syndrome
Cystic Fibrosis	Aminoglycoside Toxicity

6 Step guide

- Is the metabolic disturbance, appropriately compensated?
  - For metabolic **acidosis**, use Winter's formula
  - **Expected $PaCO_2$ = 1.5 x HCO_3 + 8 ± 2**
  - If measure $PaCO_2$ **>** expected $PaCO_2$, then also primary respiratory **acidosis**
  - If measure $PaCO_2$ **<** expected $PaCO_2$, then also primary respiratory **alkalosis**
  - For metabolic **alkalosis**, $PaCO_2$ should be >40 and less than 50
- Is there a second metabolic disorder?
  - Delta Ratio (**Δ Ratio) = (AG – 12) / (24 – HCO_3^-)**
  - < 0.4 pure NAGMA (or mixed*)
  - 0.4 - 0.8 mixed NAGMA + HAGMA
  - 0.8 - 2.0 pure HAGMA
  - >2.0 mixed HAGMA + metabolic alkalosis (or pre-existing compensated respiratory acidosis)

Morganroth, M. 1990. Six steps to acid-base analysis: Clinical Applications. The Journal of Critical Illness. 5, 460-469.

Case 1

Na 123, Cl 99, HCO3 5, PaCo2 10, pH 7.31

- Step 1
  - Acidotic
- Step 2
  - Primary metabolic acidosis
- Step 3
  - Skip
- Step 4
  - AG = 19, so AGMA
- Step 5
  - Expected PaCO2 between 13-17, but PaCO2 is 10. So primary respiratory alkalosis.
- Step 6
  - Delta ratio = (19-12)/(24-5) = 0.37

Mixed AGMA + primary respiratory alkalosis + NAGMA

Morganroth, M. 1990. Six steps to acid-base analysis: Clinical Applications. The Journal of Critical Illness. 5, 460-469.

Case 2

Na 135, Cl 93, HCO3 30, PaCo2 80, pH 7.18

- Step 1
  - Acidotic
- Step 2
  - Primary respiratory acidosis
- Step 3
  - If acute, pH = 7.08, if chronic pH = 7.28, so..

Mixed acute ON chronic respiratory acidosis

Morganroth, M. 1990. Six steps to acid-base analysis: Clinical Applications. The Journal of Critical Illness. 5, 460-469.

Case 3

Na 130, Cl 78, HCO3 10, PaCo2 25, pH 7.20

- Step 1
  - Acidotic
- Step 2
  - Primary metabolic acidosis
- Step 3
  - Skip
- Step 4
  - AG = 42, so AGMA
- Step 5
  - Expected PaCO2 between 21-25, but PaCO2 is 25. So no respiratory disturbance
- Step 6
  - Delta ratio = (42-12)/(24-10) = 2.14

Mixed AGMA + primary metabolic alkalosis

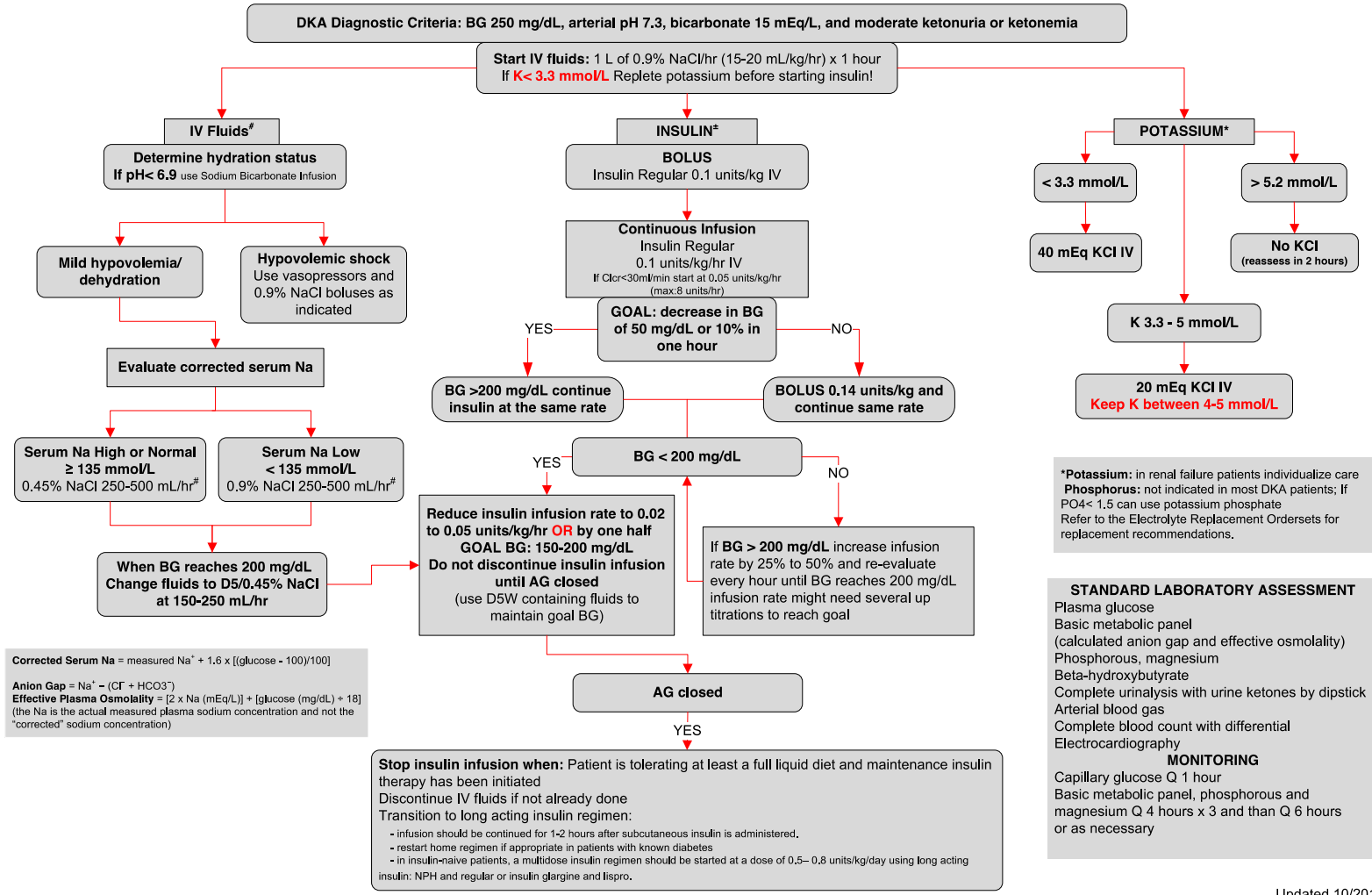
Morganroth, M. 1990. Six steps to acid-base analysis: Clinical Applications. The Journal of Critical Illness. 5, 460-469.

Diabetic Ketoacidosis

University Hospitals Case Medical Center

MEDICAL ICU GUIDELINES FOR THE MANAGEMENT OF ADULT PATIENTS WITH DIABETIC KETOACIDOSIS

Use the corresponding "Diabetic Ketoacidosis Management" orderset available in UHCare



***Potassium:** in renal failure patients individualize care
Phosphorus: not indicated in most DKA patients; If PO4< 1.5 can use potassium phosphate
Refer to the Electrolyte Replacement Ordersets for replacement recommendations.

STANDARD LABORATORY ASSESSMENT

Plasma glucose
Basic metabolic panel
(calculated anion gap and effective osmolality)
Phosphorous, magnesium
Beta-hydroxybutyrate
Complete urinalysis with urine ketones by dipstick
Arterial blood gas
Complete blood count with differential
Electrocardiography

MONITORING

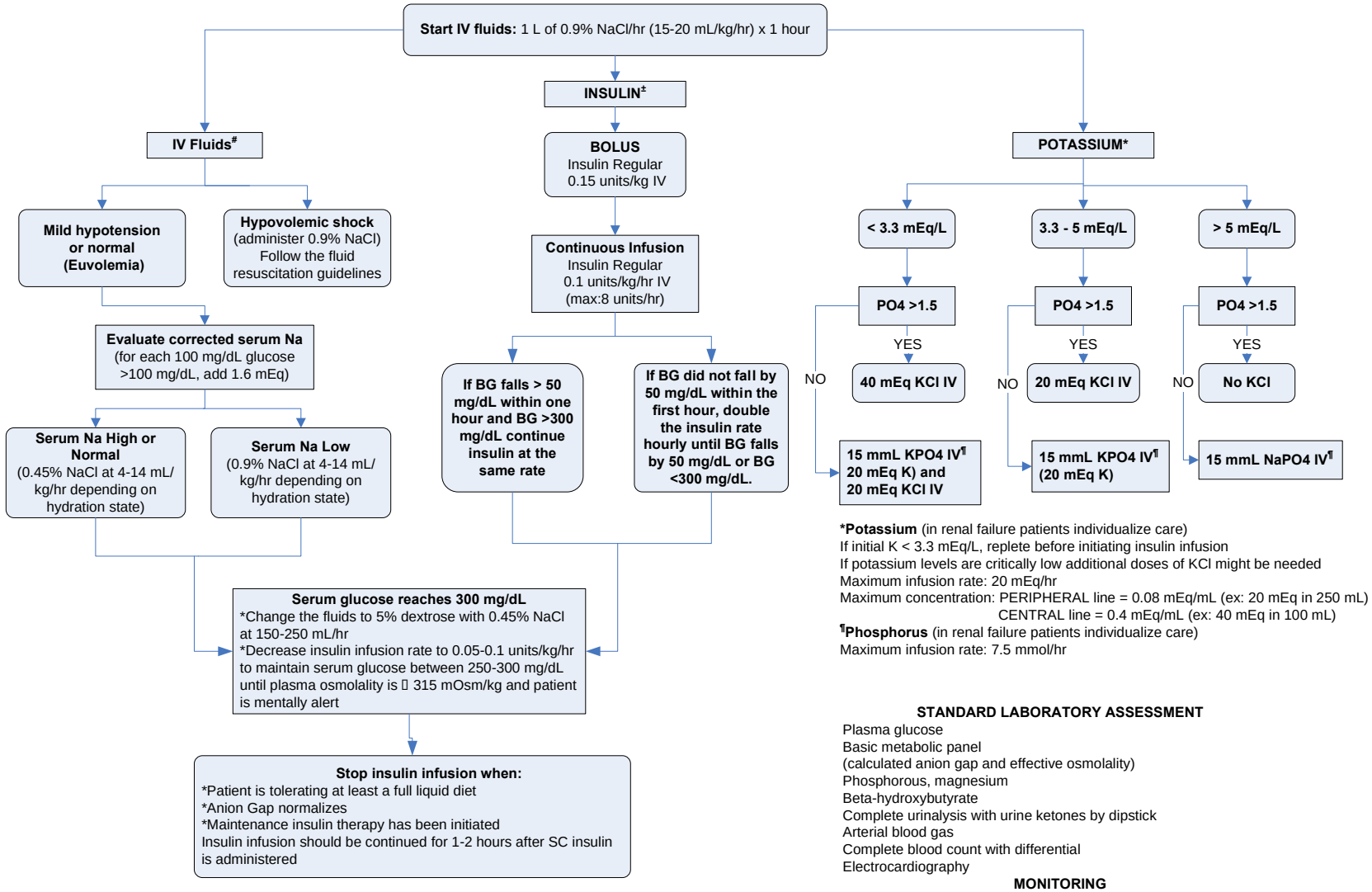
Capillary glucose Q 1 hour
Basic metabolic panel, phosphorous and magnesium Q 4 hours x 3 and than Q 6 hours or as necessary

Individualize the treatment of patients with underlying renal failure, and/or heart failure.
‡ For dosing insulin use Ideal Body Weight
References: Diabetes Care 2009

Updated 10/2015
Andreea Popa PharmD, Mariana Petrozzi MD

Hyperosmolar Hyperglycemia

GUIDELINES FOR THE MANAGEMENT OF ADULT PATIENTS WITH HYPEROSMOLAR HYPERGLYCEMIC STATE



***Potassium** (in renal failure patients individualize care)
If initial K < 3.3 mEq/L, replete before initiating insulin infusion
If potassium levels are critically low additional doses of KCl might be needed
Maximum infusion rate: 20 mEq/hr
Maximum concentration: PERIPHERAL line = 0.08 mEq/mL (ex: 20 mEq in 250 mL)
CENTRAL line = 0.4 mEq/mL (ex: 40 mEq in 100 mL)
¶Phosphorus (in renal failure patients individualize care)
Maximum infusion rate: 7.5 mmol/hr

STANDARD LABORATORY ASSESSMENT

Plasma glucose
Basic metabolic panel
(calculated anion gap and effective osmolality)
Phosphorous, magnesium
Beta-hydroxybutyrate
Complete urinalysis with urine ketones by dipstick
Arterial blood gas
Complete blood count with differential
Electrocardiography

MONITORING

Capillary glucose Q 1 hour
Basic metabolic panel, phosphorous and magnesium Q 4 hours x 3 and than Q 6 hours or as necessary

Individualize the treatment of patients with underlying renal failure, and/or heart failure.
± For dosing insulin use Ideal Body Weight

Diabetes Care 27;S94102, 2004.

References

1. See bottom of individual slides.
2. My brain.

Special Thanks

- To everyone who helped developed the MICU handouts.