# Case discussion

2011/03/05

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# Discussion

- Shock
- Metabolic acidosis

# Definition of shock

- An imbalance between tissue oxygen supply (delivery) and oxygen demand (consumption)
- Systemic oxygen delivery
  - arterial oxygen content
  - Cardiac output
- Systemic oxygen consumption
  - Normally: 25% of oxygen carried on hemoglobin
  - 75% saturated venous blood return to right heart
    - I.e. $ScvO_2 \approx 75\%$

# Definition of shock

- If supply < demand
  - Anaerobic metabolism
  - Formation of lactic acid and lactate
  - Lactic acidosis
    - Normal lactate: 0.5-1.5 mmol/L

# Autonomic responses to shock

- Arteriolar vasoconstriction
- Increase in heart rate and contractility
- Constriction of venous capacitance vessels
- Release of vasoactive hormones: Epi, NEP, dopamine, cortisol
- Release of antidiuretic hormone and activation of renin-angiotension axis

# Classification of shock

| Type | Comment |
| --- | --- |
| Hypovolemic | Caused by inadequate circulating volume |
| Cardiogenic | Caused by inadequate cardiac pump function |
| Obstructive | Caused by extra cardiac obstruction to blood flow |
| Distributive | Metabolic derangements that impair cellular respiration such as cyanide toxicity, sepsis |

# Empirical criteria for diagnosis of shock

- Including > 4 criteria:
  - Ill appearance or altered mental status
  - HR >100 beats/min
  - RR >20 breaths/min, or PaCO2 <32 mmHg
  - Arterial base deficit <-4 mEq/L, or lactate >4 mM/L
  - U/O <0.5 ml/kg/hr
  - Arterial hypotension >20 minutes duration

# Definitions and criteria for septic shock

- Systemic inflammatory response syndrome (SIRS): ≥2 of following:
  - BT >38 or <36
  - HR >90 bpm
  - RR >20 or Paco2 <32 mmHg
  - WBC >12000, <4000, or >10% band form
- Severe sepsis
  - SIRS+infection+organ dysfunction or hypotension
- Septic shock
  - SIRS+infection+hypotension despite adequate fluid resuscitation

# Definitions and criteria for hemorrhagic shock

- Simple hemorrhage
  - Bleeding with HR <100, normal RR, normal BP, normal BE
- Hemorrhage with hypoperfusion
  - Bleeding, BE <-4 mEq/L or persistent pulse >100
- Hemorrhagic shock
  - Meet the shock criteria

# Definitions and criteria of cardiogenic shock

- Cardiac failure
  - Clinical evidence of impaired forward flow of the heart
  - Including: dyspnea, tachycardia, pulmonary edema, peripheral edema, cyanosis
- Cardiogenic shock
  - Cardiac failure with shock criteria

# Clinical features

- History taking first!
  - Volume depletion: bleeding, vomiting, diarrhea, excessive urination, insensible losses due to fever, orthostatic light-headedness
  - CV disease? Chest pain? CHF?
  - Anaphylactic reaction: new medication?
  - Medication history: b-blockers, CCB, diuretics

# Physical examination

- SBP <90 mmHg: usually, but NOT always
  - Shock may occur with a normal blood pressure
  - Hypotension may occur without shock
- Shock index

$$\frac{\text{Heart rate}}{\text{SBP}}$$

  - To evaluate volume loss, LV dysfunction
  - Normal: 0.5-0.7
  - >1.0: high mortality rate

# Physical examination

- BT: hyperthermia or hypothermia
- HR: usually elevated; paradoxical bradycardia in hemorrhage (>30%), hypoglycemia, b-blocker use, CV disease
- SBP, DBP
- Pulse pressure: increases early in shock, decreases before SBP
- Pulsus paradoxus: decrease in SBP when inspiration

# Physical examination

- CNS: acute delirium, brain failure, restlessness, disorientation, confusion, coma
- Skin: pallor, dusky, clammy, cyanosis, sweating…
- CV: neck vein distention or flattening, tachycardia, arrhythmia, murmur…
- Respiration: tachypnea, hypocapnia, resp. failure…

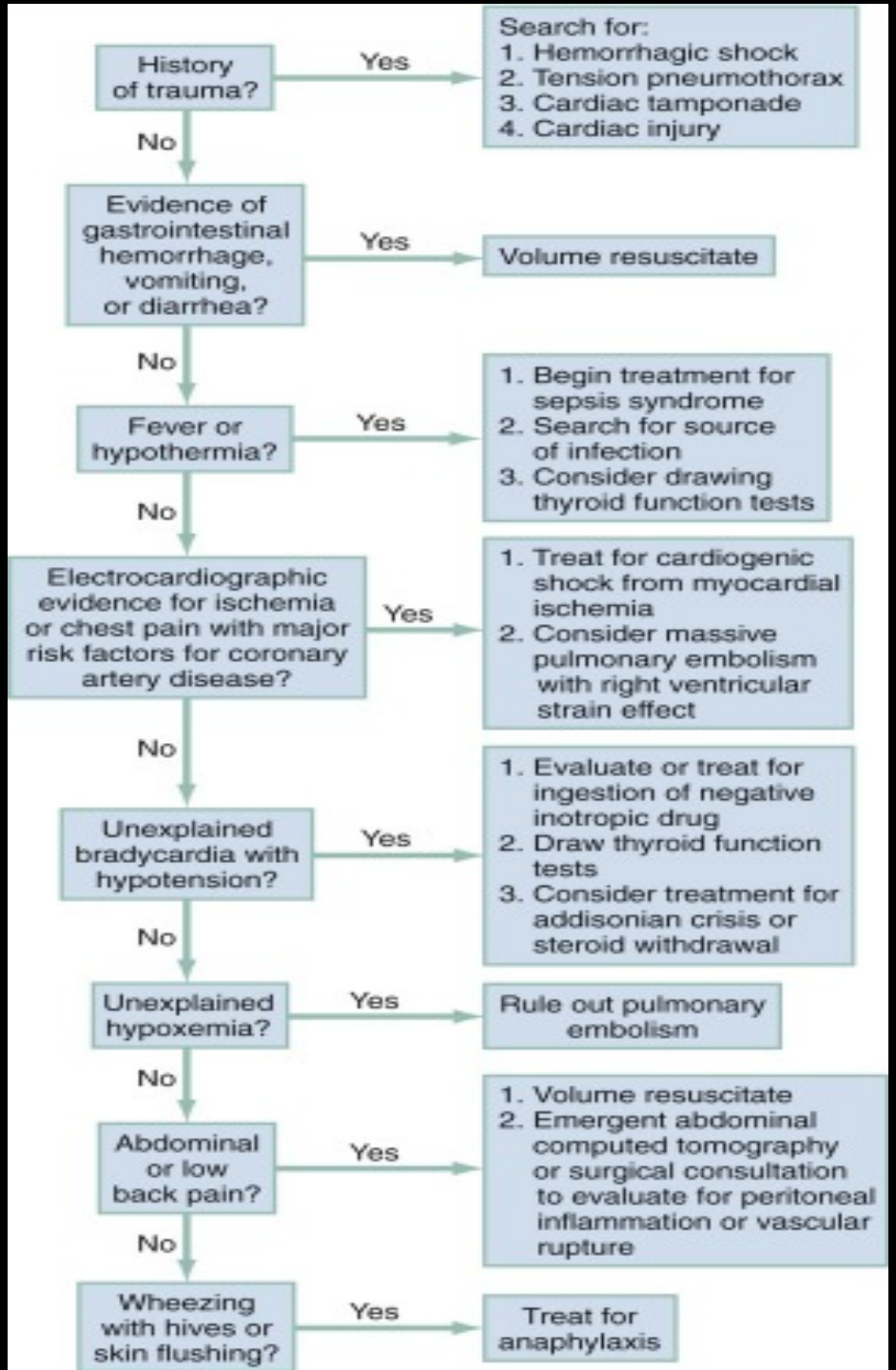
# Physical examination

- Splanchnic organs: ileus, GI bleeding, pancreatitis, acalculous cholecystitis, mesenteric ischemia
- Renal: reduced GFR, oliguria, paradoxical polyuria can occur in sepsis
- Metabolic: resp. alkalosis at first; metabolic acidosis later; hyperglycemia, hypoglycemia, hyperkalemia

# Ancillary studies in shock

- Basic evaluation: CBC, ion, glucose, Ca, Mg, P, BUN, Cre, PT/PTT, U/A, CXR, EKG
- Moderate physiologic assessment: ABG, lactate, fibrinogen, D-dimer, liver function
- Noninvasive hemodynamic assessment: end-tidal $CO_2$, echocardiogram
- Invasive hemodynamic assessment: CVP, $S_{CV}O_2$….
- Others: CT, echo, cortisol level, pregnancy test….

# Flow diagram to classify undifferentiated shock



# Treatment of shock

- Ensure ABCDE
  - Airway:
    - Sedative: hypotension
    - Positive pressure ventilation: reduce preload and CO
    - Consider volume resuscitation or give vasoactive agents before intubation
  - Breathing:
    - Arterial oxygen saturation >93%
    - PaCO2 35-40 mmHg

# Treatment of shock

- Circulation
  - Trendelenburg position: no improvement
  - Passive leg raising above the level of heart: effective
  - Isotonic crystalloid at first: 500-1000 ml
    - Initial 20 ml/kg
    - Exception: cardiogenic shock with pulmonary edema
  - To restore MAP >65 mmHg or SBP >90 mmHg
  - Consider to give vasopressor agents
- Assuring adequate oxygen Delivery
  - SaO2: 93-95%
  - Hb ≥10 g/dL

# Treatment of shock

- End points of resuscitation
  - No therapeutic end point
  - Urine output >0.5 ml/kg/hr
  - CVP 8-12 mmHg
  - MAP 65-90 mmHg
  - $S_{CV}O_2$ >70%

# Treatment of hemorrhagic shock

- Immediate control of hemorrhage
- Isotonic crystalloid solution (10-20 ml/kg)
- If poor organ perfusion and 30-minute anticipated delay to hemorrhage control, give pRBC infusion (5-10 ml/kg)
- If CNS trauma, or GCS <9, immediate pRBC transfusion
- Treat dysrhythmia

# Treatment of cardiogenic shock

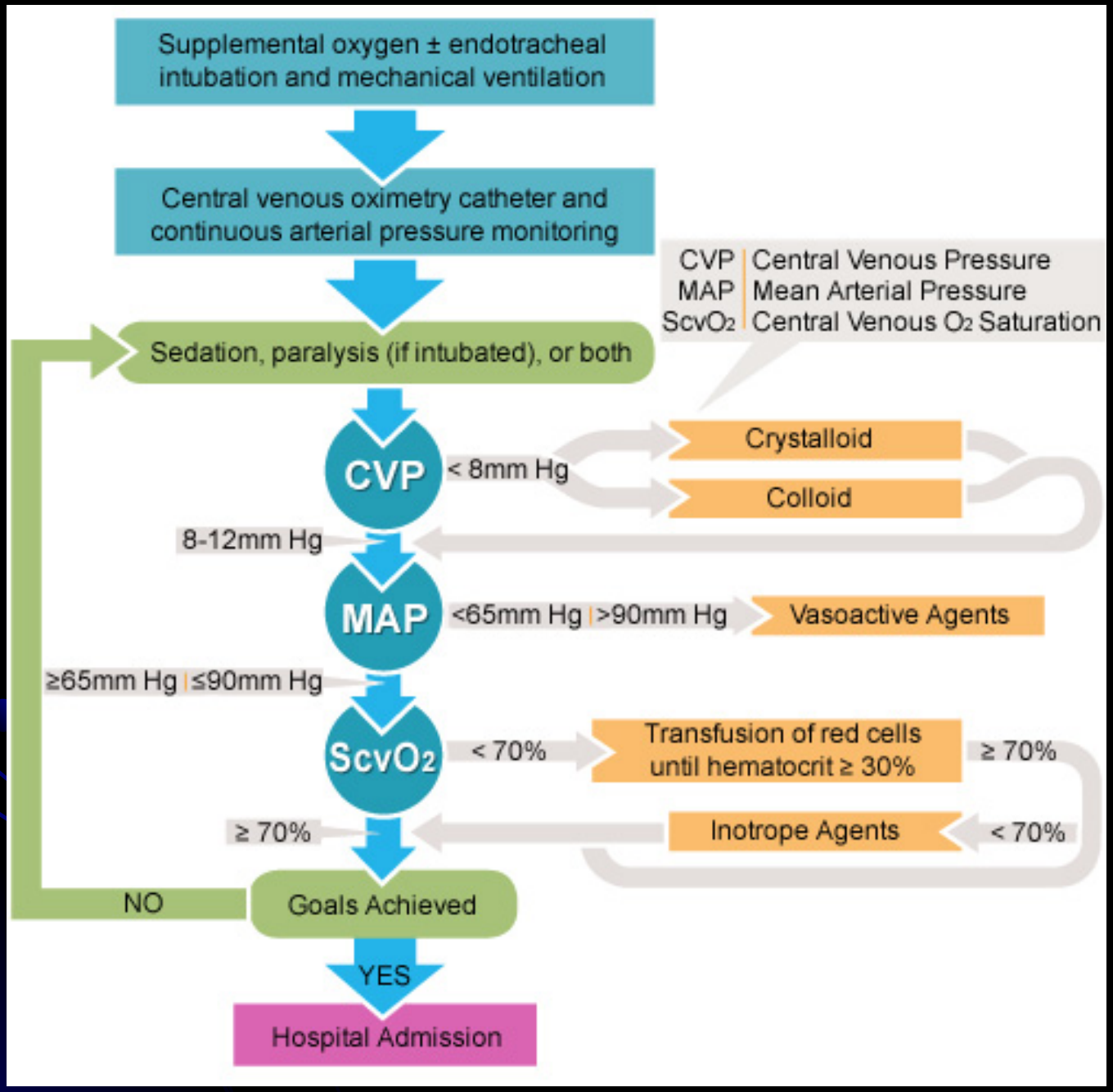
- Give vasopressor or inotropic support
  - Norepinephrine 0.5 ug/min
  - Dobutamine 5 ug/kg/min
- Reverse the insult: e.g. initiate thrombolysis, PTA…
- Consider IABP for refractory shock

# Treatment of septic shock

- Give 20 ml/kg of crystalloid or 5 ml/kg of colloid
- Antimicrobial therapy
- Surgical drainage or debridement
- Transfusion for Hb < 8 g/dl
- Vasopressor support
  - Dopamine, 5-15 ug/kg/min
  - Norepinephrine, 0.5 mg/min

# Treatment

- Early goal-directed therapy
  - In 6 hours
  - Reduce mortality by 16%


Supplemental oxygen ± endotracheal intubation and mechanical ventilation
Central venous oximetry catheter and continuous arterial pressure monitoring
CVP | Central Venous Pressure
MAP | Mean Arterial Pressure
ScvO2 | Central Venous O2 Saturation
Sedation, paralysis (if intubated), or both
CVP
< 8mm Hg
Crystalloid
Colloid
8-12mm Hg
MAP
<65mm Hg | >90mm Hg
Vasoactive Agents
≥65mm Hg | ≤90mm Hg
ScvO2
< 70%
Transfusion of red cells until hematocrit ≥ 30%
≥ 70%
≥ 70%
Inotrope Agents
< 70%
NO
Goals Achieved
YES
Hospital Admission

# What fluid is better?

- Normal saline: slightly hyperosmolar, 154 mEq/L of Na and Cl; hyperchloremic metabolic acidosis
- Lactated Ringer's solution: as a buffer; risk of hyperkalemia in renal insufficiency
- Albumin: may increase mortality in trauma pt with head injury
- Hydroxyethyl starch (Voluven): should be avoided in sepsis; cause renal impairment, coagulopathy, impaired plt function…

# Metabolic acidosis

# Metabolic acidosis

- Gain of $H^+$
- Loss or $HCO_3^-$

# Initial workup of metabolic acidosis

- Anion gap (AG)
  - AG=Na-(Cl+HCO3), normal=12
  - Expected AG=[Albumin]x2.5
  - ↑AG: increased organic acids, phosphates, sulfates…
  - ↓AG: decreased albumin or increased Ca, Mg, K, Li, Br, Ig…
- Delta-delta (Δ Δ= ΔAG/ ΔHCO3)
  - ΔAG=calculated AG-expected AG
  - ΔHCO3=24-HCO3
  - Δ Δ=1-2: pure AG metabolic acidosis
  - Δ Δ<1: AG metabolic acidosis+non-AG acidosis
  - Δ Δ>2: AG metabolic acidosis+metabolic alkalosis

# Our patient….

- Initial data:
  - ABG: pH 7.077, $PaCO_2$ 15.7, $HCO_3$ 4.6
  - Na130, Cl 102
- Metabolic acidosis
  - AG=Na-(Cl+$HCO_3$)= 130-(102+4.6)= 23.4
  - AG >12 → anion gap metabolic acidosis
  - Check Δ Δ
    - ΔAG/ Δ$HCO_3$=11.4/19.6=0.58
    - Δ Δ<1 → AG metabolic acidosis+non-AG acidosis

# Etiology of AG metabolic acidosis

- Ketoacidosis: DM, alcoholism, starvation
- Lactic acidosis
  - Type A: impairment in tissue oxygenation, e.g. circulatory or respiratory failure, sepsis, CO…

  Type B: no impairment in tissue oxygenation, e.g. malignancy, alcoholism, medication (Metformin!)
- Renal failure: organic anions, e.g. P, SO3, urate
- Ingestions
  - Methanol, ethylene glycol, propylene glycol, salicylate, acetaminophen
  - Check osmolal gap (OG)
    - Calculated osmoles=2Na+(Glucose/18)+(BUN/2.8)+(EtOH/4.6)
    - OG=measured-calculated

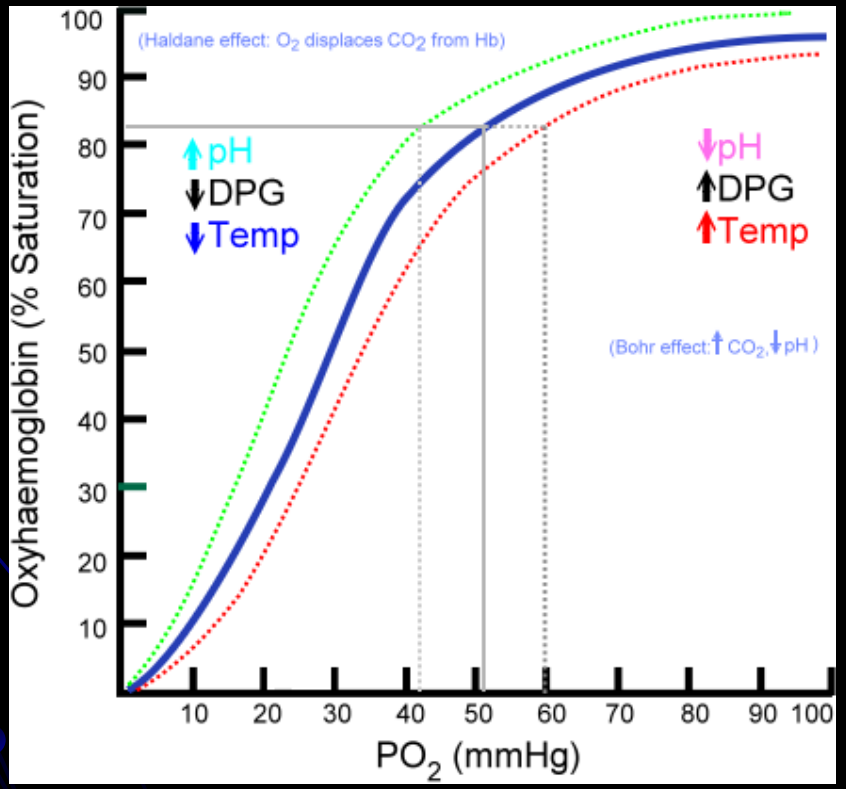
# Etiology of non-AG metabolic acidosis

- GI losses of $HCO_3$: diarrhea…
- Renal tubular acidosis (RTAs)
- Early renal failure: impaired generation of ammonia
- Ingestions
- Dilutional: rapid infusion of $HCO_3$-free fluid
- Post-hypocapnia
- Ureteral diversion: colonic Cl/$HCO_3$ exchange, ammonium reabsorption….

# How to use $NaHCO_3$?

# Bicarbonate use in shock

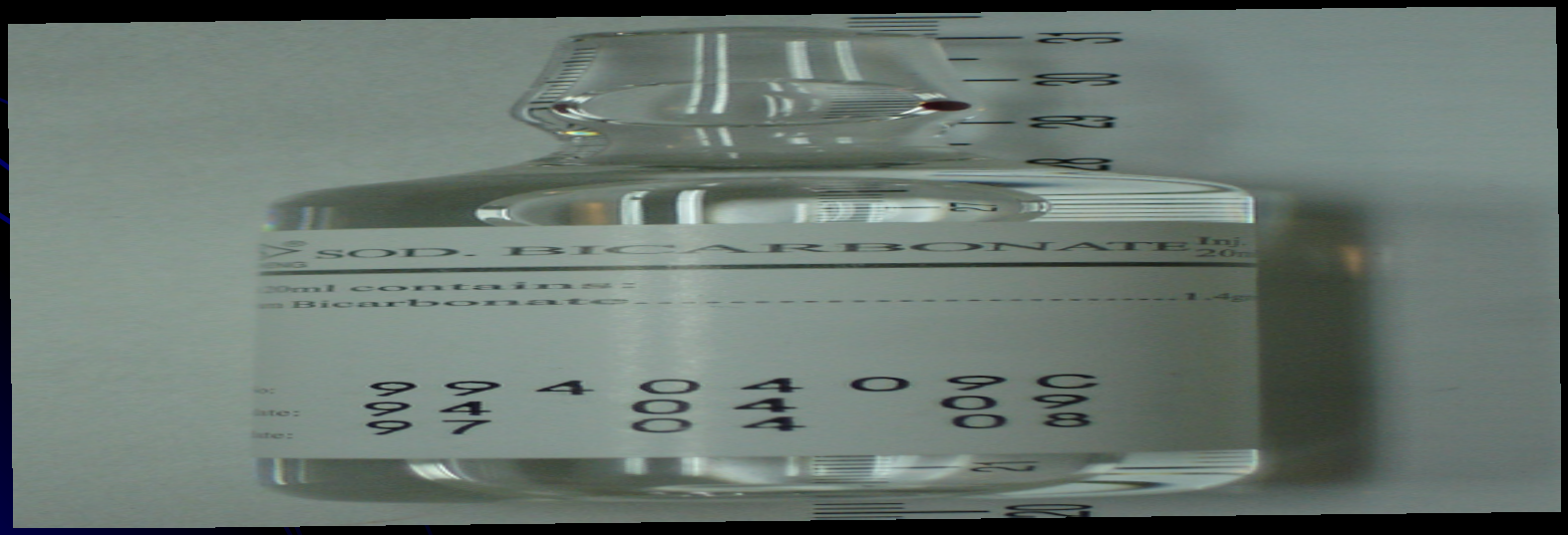
- Shift oxygen-Hb dissociation curve to the left, worsen intracellular acidosis



# Bicarbonate use in shock

- Correct only to arterial pH 7.25
- How to use?
  - Calcuate the bicarbonate deficit
    - (Normal $HCO_3$-pt's $HCO_3$) x 0.5 x BW (Kg)
  - Slowly infuse one half of the calculated deficit
  - Infusion the remainder over 6-8 hours
  - Stop bicarbonate when arterial pH 7.25

- NaHCO3, 7% 20ml/amp
- 1.4 g/amp
- 16.8 mEq/amp



# Thanks