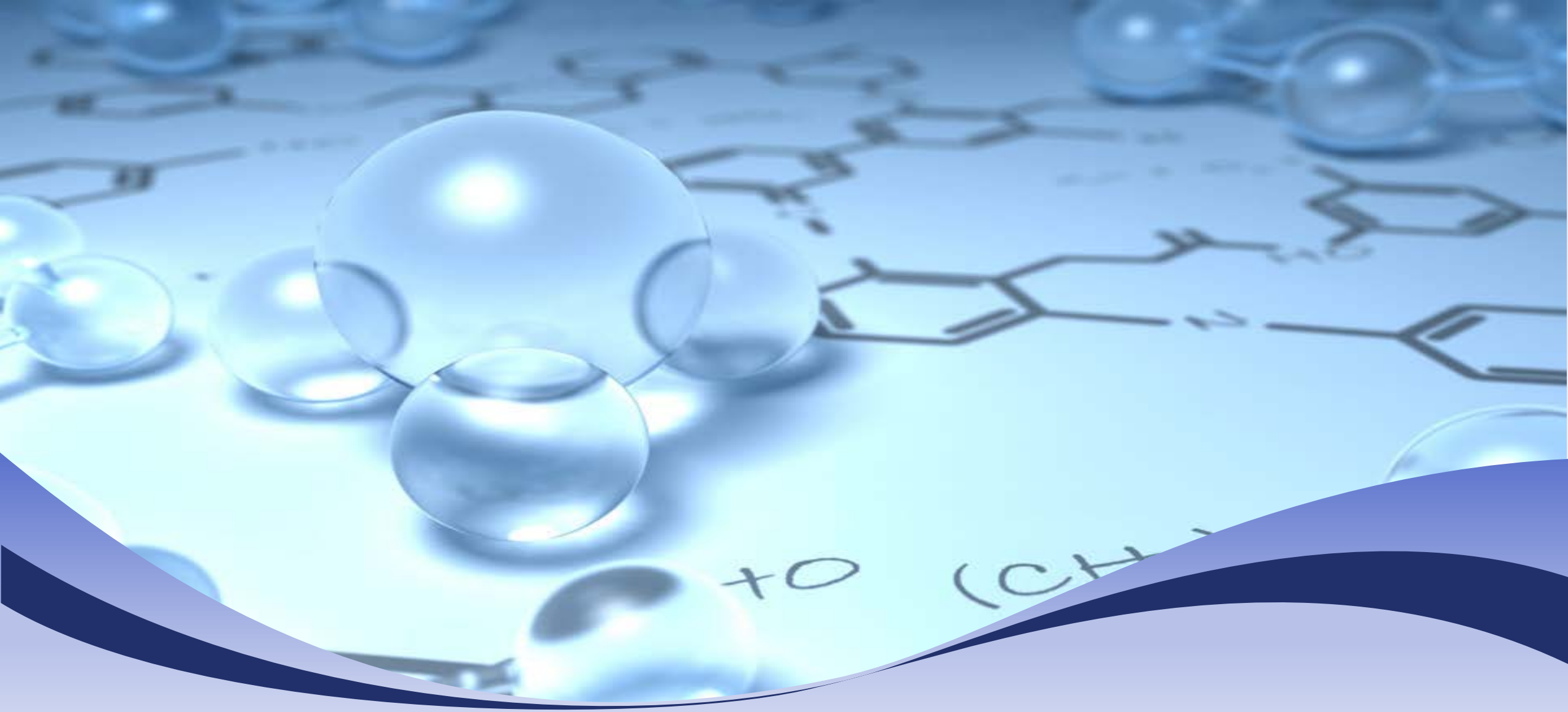


Fetal Acid Base

Fetal heart rate tracings are useful as a window into

A. Oxygen levels in the blood
B. Oxygen saturation in the lungs
C. Oxygenation of the brain

Hypoxemia is a reduction of oxygen in the fetal

A. Blood
B. Tissues
C. Vital organs

Should Cord Blood Gases Be Collected On ALL Deliveries?

- **ACOG Committee Opinion Number 348: Collection of Umbilical Cord Blood Gas and acid base analysis has been withdrawn**

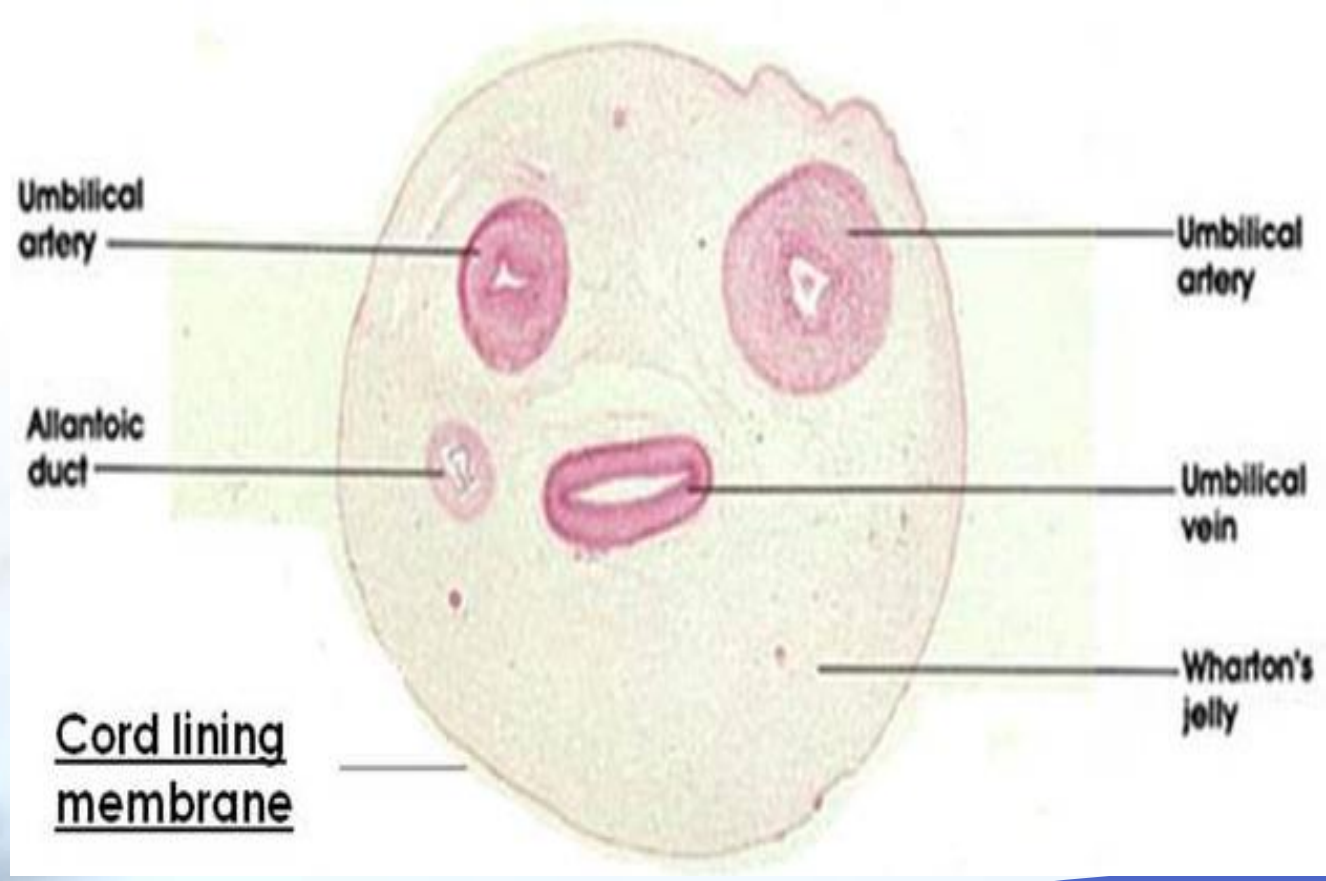
- **According to UpToDate; optimal time to collect cord blood gasses has not been established and hospitals are encouraged to develop their own policies.** *ACOG Practice Bulletin No. 230 (2021) & Simhan, UpToDate (2025)*

The American College of Obstetricians and Gynecologists and the American Academy of Pediatrics recommend performing umbilical artery blood acid-base analysis after any delivery in which a fetal metabolic abnormality is suspected [6]. Some clinical scenarios where such testing is indicated include, but are not limited to, any delivery with one or more of the following:

- Low Apgar score (0 to 3 at ≥5 minutes)
- Category III fetal heart rate pattern (table 1)
- Operative delivery (cesarean, vacuum, forceps) performed for nonreassuring fetal status

Should Both Arterial and Venous Samples Be Collected??????

- Yes, to determine the sample reflects true arterial values and not venous umbilical cord gas values.
- Venous umbilical cord ph values can be differentiated from arterial umbilical cord ph by noting the increase of venous umbilical cord ph.
- Increase in venous umbilical cord sample by .02 to .08.



How does labor effect the fetus?

Uterine contractions during labor results in a ⇩ in perfusion at the level of the intervillous space

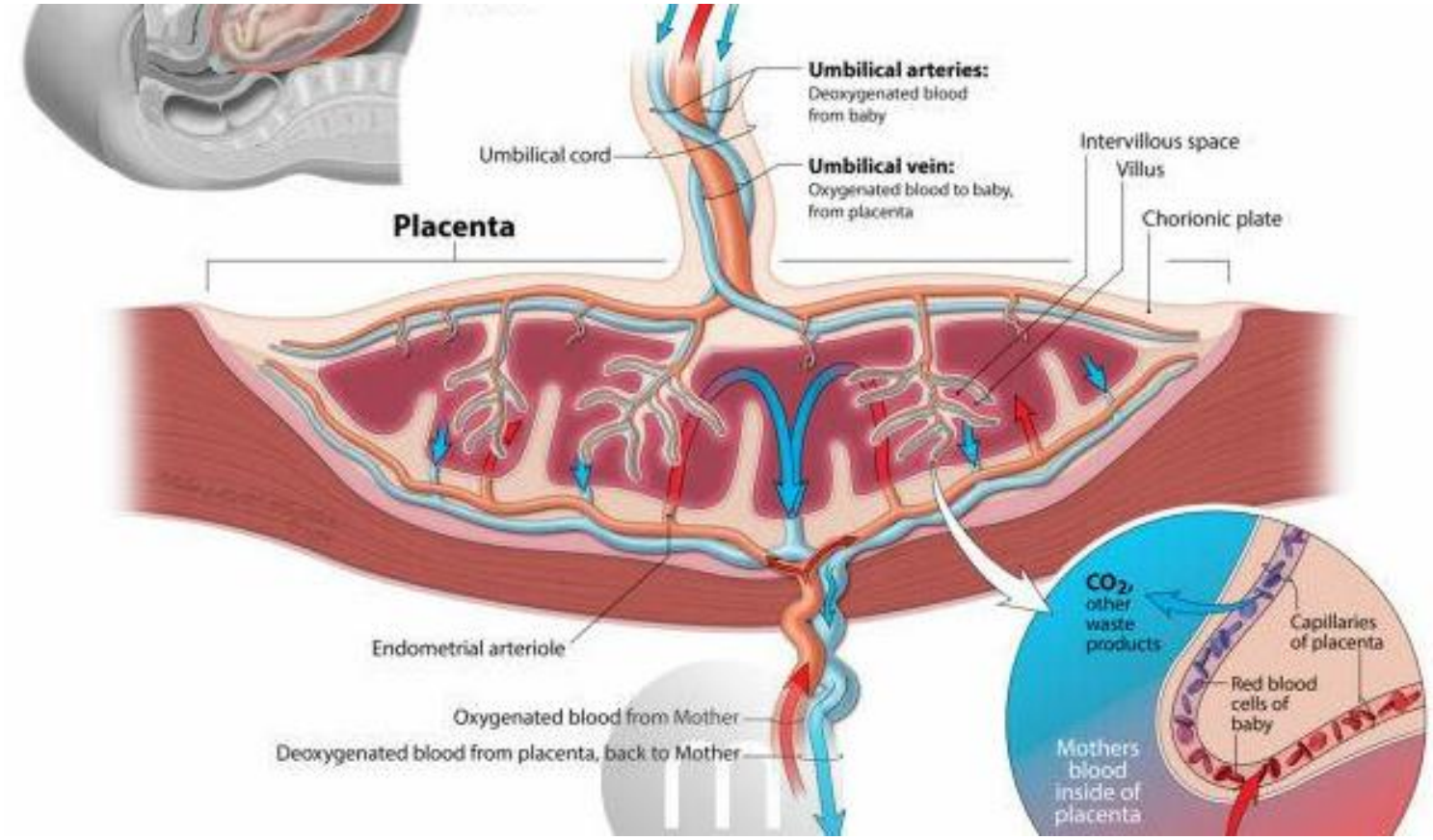
This makes labor a period of oxidative stress for the fetus

Excessive uterine contractions can have a negative impact on fetal oxygenation & acid base balance

Fetal Acid-Base Imbalance May Occur With:

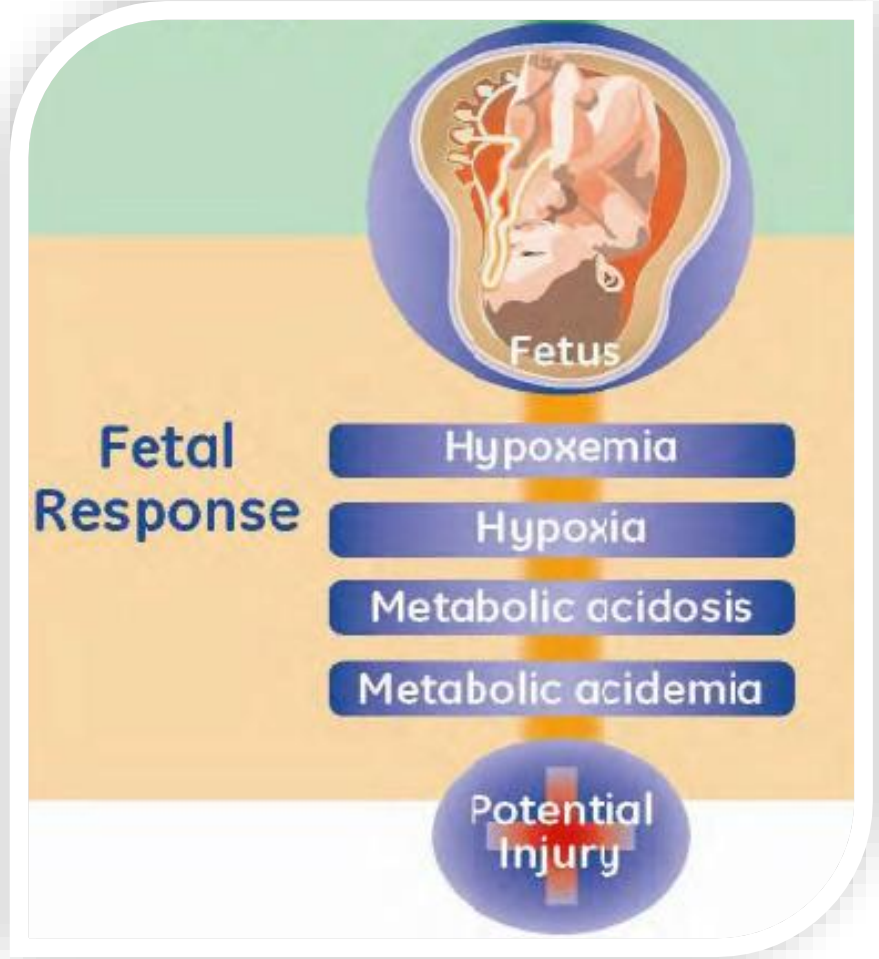
Any interruption in blood flow/oxygen to the:

- **Uterus**
- **Across the placenta, or**
- **Through the umbilical cord**



REMEMBER THE OXYGEN PATHWAY

Oxygen Pathway



Miller, Miller, & Cypher (2027, p. 3)

Acid Base Physiology…

Very Simplified

Aerobic and anaerobic metabolism are responsible for energy

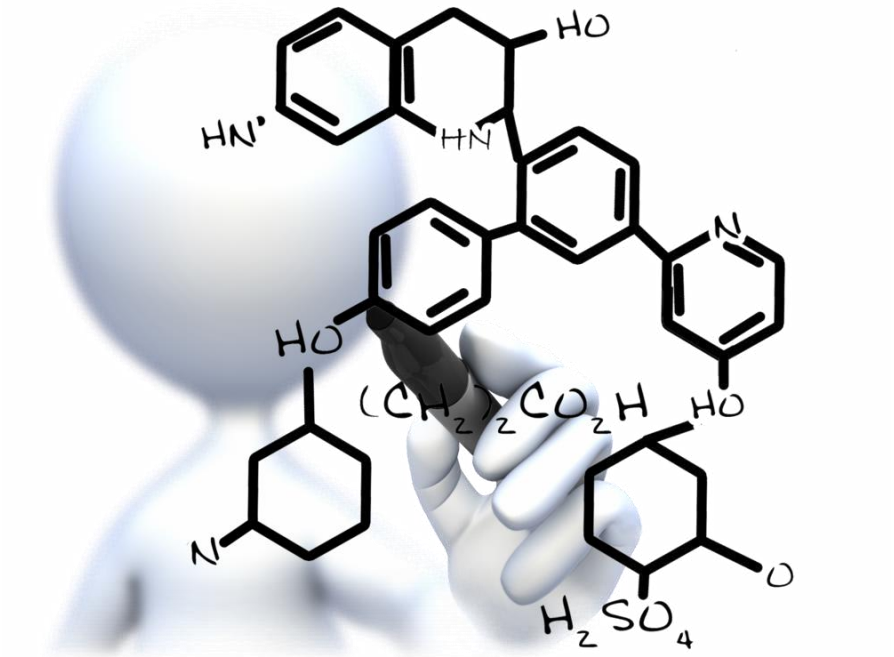
A. Depletion
B. Generation
C. Reserve

Glucose

What is the main fuel used by the fetus for energy…

What happens to the glucose?

Aerobic (with oxygen) Metabolism



Glucose is metabolized

The by-product is lactic acid

Lactic acid is converted to CO_2

Large amount of energy produced (38 high-energy phosphate bonds)

Then CO_2 is transferred across placenta to be excreted by the mother

Which component of the FHR tracing allows us to exclude metabolic acidemia at the time it is observed

A. Short term variability is present
B. Moderate variability is present
C. Long term variability is absent

What if there is not enough oxygen??

Anaerobic (without oxygen) Metabolism

This can lead to Acidemia

Acidemia

Defined as increased hydrogen ion content in the blood.

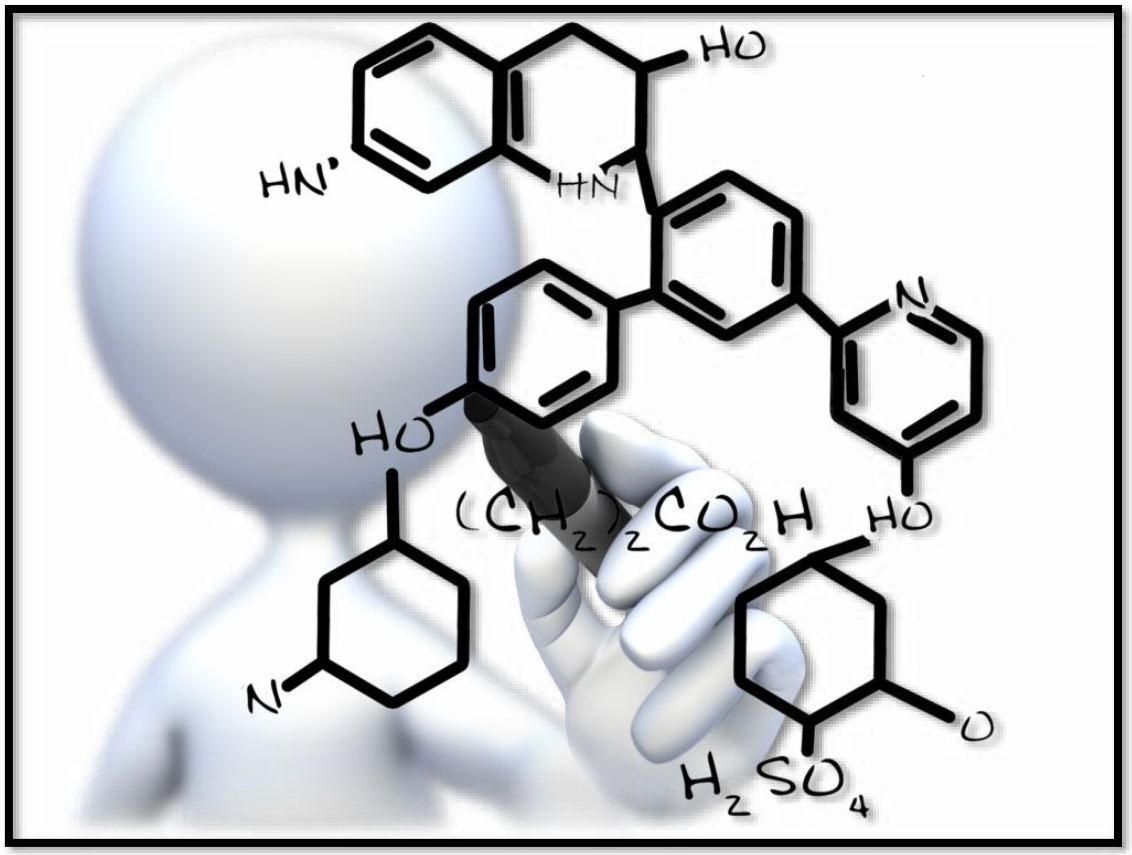
Is measurable via PH

3 Types of Acidemia

- Metabolic
- Respiratory
- Mixed

When anaerobic metabolism occurs due to insufficient oxygen for energy production, this results in excess

A. Adenosine triphosphate
B. Bicarbonate
C. Lactic Acid



Metabolic Acidemia

Metabolic Acidemia

Lactic acid cannot be broke down

Lactic acid accumulates. Low amount of energy produced (2 high-energy phosphate bonds)

Lactic acid is broke down to lactate & hydrogen

Hydrogen ions are retained (H+)

Base buffers (bicarbonate) are utilized to help stabilize the PH however, the base buffers are depleted

Metabolic Acidemia

Decreased PH

<7.2

Normal PCO_2

<60

Increased Base Deficit

> 12

Metabolic Acidemia
defined as abnormally high H+ in the blood

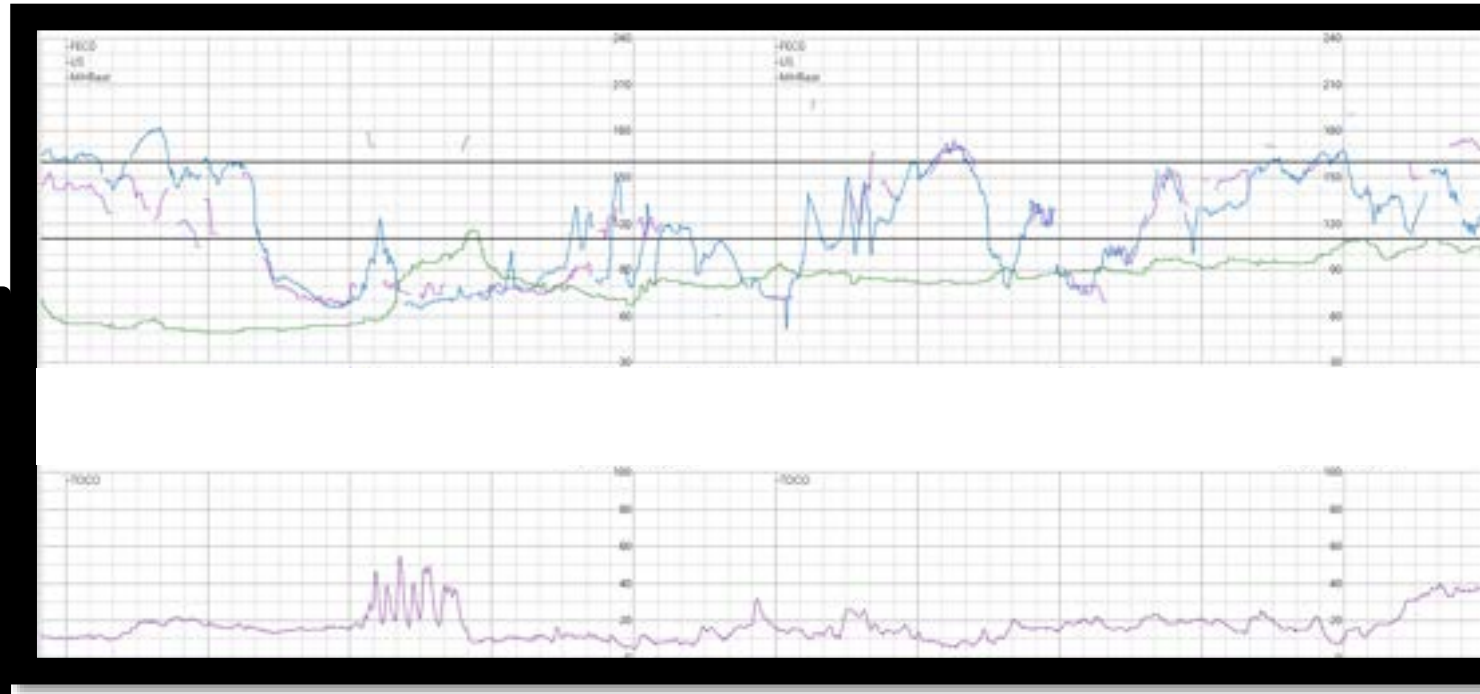
If buffering capacity is exceeded

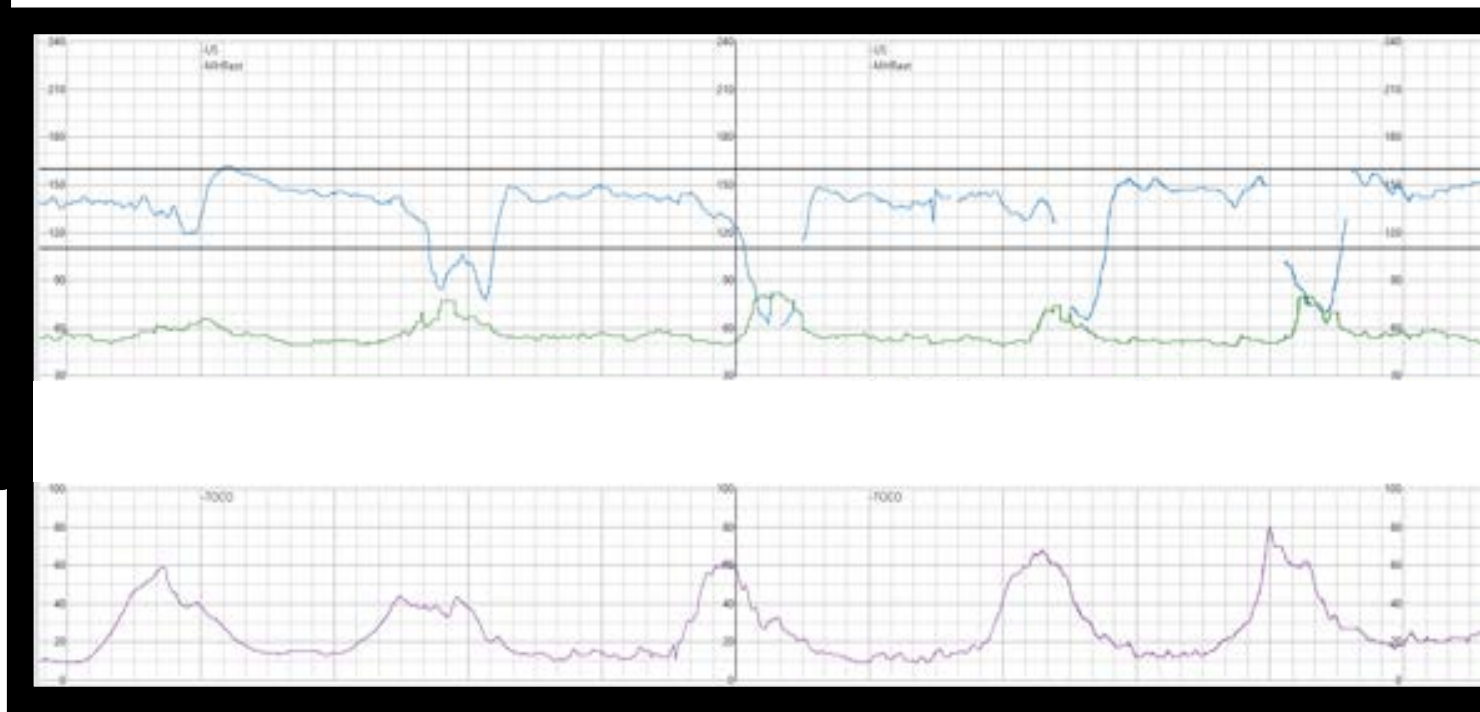
Then H+ ions accumulate in the blood

The more H+ ions there are

- the more acidic the blood
- the lower the pH

If recurrent or sustained, interruption of O_2 transfer at any point along the oxygen pathway can result in progressive deterioration of fetal oxygenation





A general pathway to possible fetal injury due to oxygen deprivation:

A. Hypoventilation to asphyxia

B. Hypoxemia to metabolic acidemia

C. Respiratory acidosis to metabolic acidosis

The progressive cascade that happens:

Hypoxemia	Hypoxia	Metabolic Acidosis	Metabolic Acidemia
↓ Oxygen content in the blood	↓ Oxygen in the tissues	Accumulation of lactic acid in the tissues leads to the utilization of buffer bases (primarily bicarb)	When buffer bases are depleted, this results in ↑ H+ in the blood; the more H+ ions, the more acidic the blood, the lower the PH

Hypotension

If tissue hypoxia and acidosis is recurrent or sustained may lead to

- Loss of peripheral vascular smooth muscle contraction
- Reduced peripheral vascular resistance
- Loss of autoregulation of cerebral blood flow
  - Perfusion to the fetal brain becomes pressure dependent

Fetal hypotension

- Brain does not receive adequate blood flow
  - (becomes ischemic)
  - Does not receive glucose and oxygen

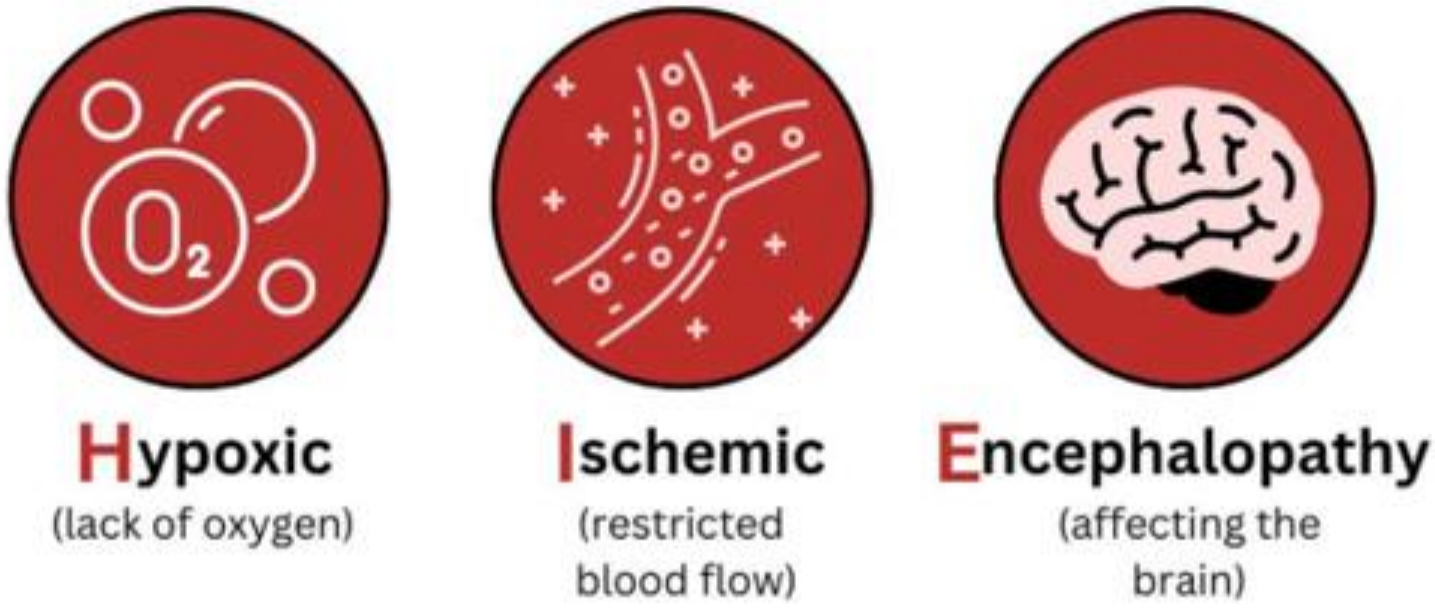
Possible Fetal Injury

If metabolic acidemia and fetal hypotension occur

- Fetus is possibly at risk for cellular damage and injury

Fetal brain injury may occur as a result of decreased oxygen and ischemia

- **HIE is the lack of oxygen from restricted blood flow to the brain and is the second leading cause of infant mortality and lifelong disability, worldwide.**



Important Point

Even in the presence of significant acidemia, most newborns will be neurologically normal

The presence of metabolic acidemia does not define the timing of the onset of a hypoxic-ischemic event

HOWEVER,.....

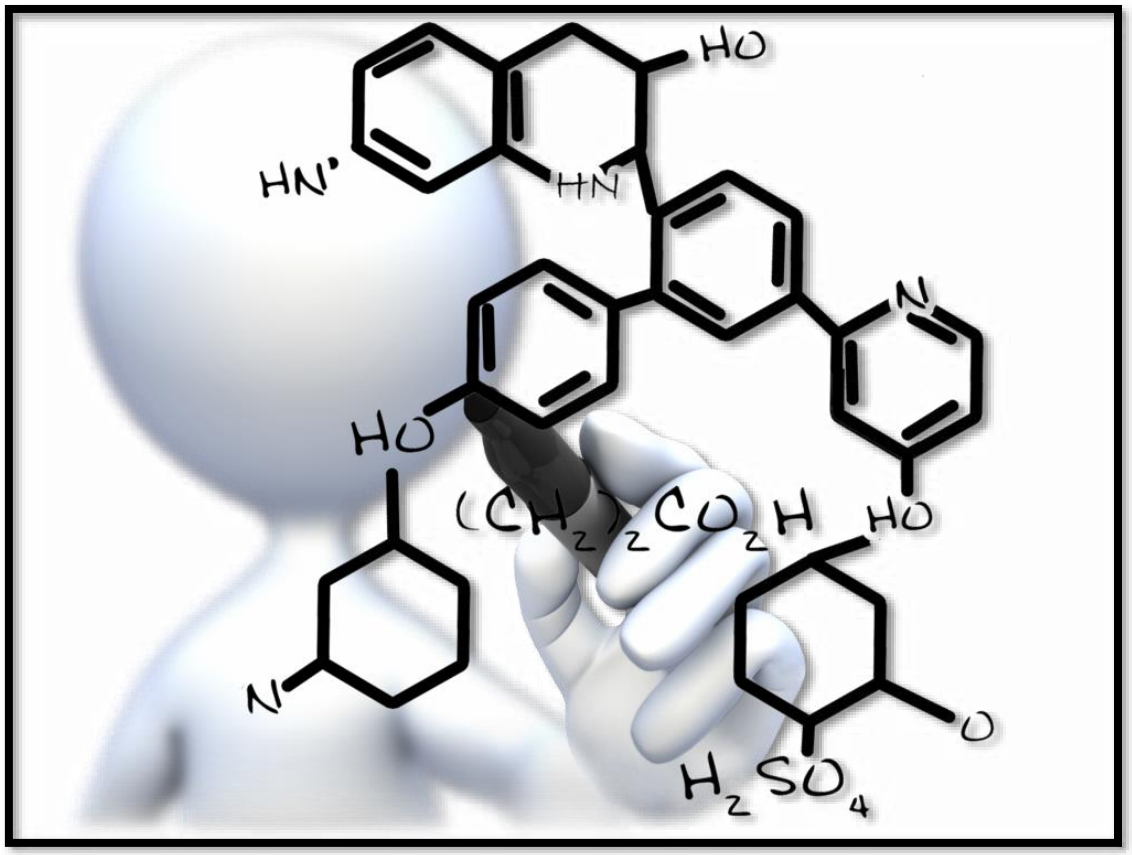
- **The values of the arterial cord blood gases *may* be a criteria for neonatal whole-body cooling to decrease the incidence of HIE [Hypoxic-Ischemic Encephalopathy.**

Table 1: Inclusion and exclusion criteria for therapeutic hypothermia

Inclusion criteria	Exclusion criteria
Greater than or equal to 36 weeks gestation	Greater than 6 h after birth
Evidence of moderate or severe encephalopathy or seizures	Birth weight less than 2 kg
Evidence of intrapartum hypoxia including two of the following criteria	
Life-threatening coagulopathy	
Apgar score less than or equal to 5 at 10 min of age	Life-threatening abnormalities of the cardiovascular or respiratory systems
Mechanical ventilation or resuscitation at 10 min Cord pH <7.00 or arterial pH <7.00 or base deficit of ≥12 mmol/l within 60 min of birth	Major congenital malformations/chromosomal anomalies including imperforate anus

Table 2: Encephalopathy score and neurological examination

Neurological examination	Moderate encephalopathy	Severe encephalopathy
Level of consciousness	Lethargic	Stupor or coma
Spontaneous movement	Decreased activity	No activity
Posture	Distal flexion	Decerebrate
Tone	Hypotonia (focal, general)	Flaccid
Primitive reflexes		
Suck	Weak	Absent
Moro	Incomplete	Absent
Autonomic system		
Pupils	Constricted	Dilated, nonreactive
Heart rate	Bradycardia	Variability: Narrow or wide
Respiration	Periodic breathing	Apnea



Respiratory Acidemia

Respiratory Acidemia

Carbon Dioxide accumulates & can't be transferred from the fetus to the environment

Becomes hydrolyzed & forms carbonic acid (H_2CO_3)

Then disassociates into $H+$ & HCO_3 (bicarbonate)

Respiratory Acidemia

Decreased PH

< 7.2

Increased PCO_2

>60

Normal Base Deficit

≤12

Respiratory Acidemia Hypercapnia and Hypercarbia

Hypercarbia

- Increased CO_2 in blood

Hypercapnia

- Increased CO_2 in tissue

When CO_2 increases, the pH decreases

Can occur with umbilical cord compression

Respiratory Acidemia

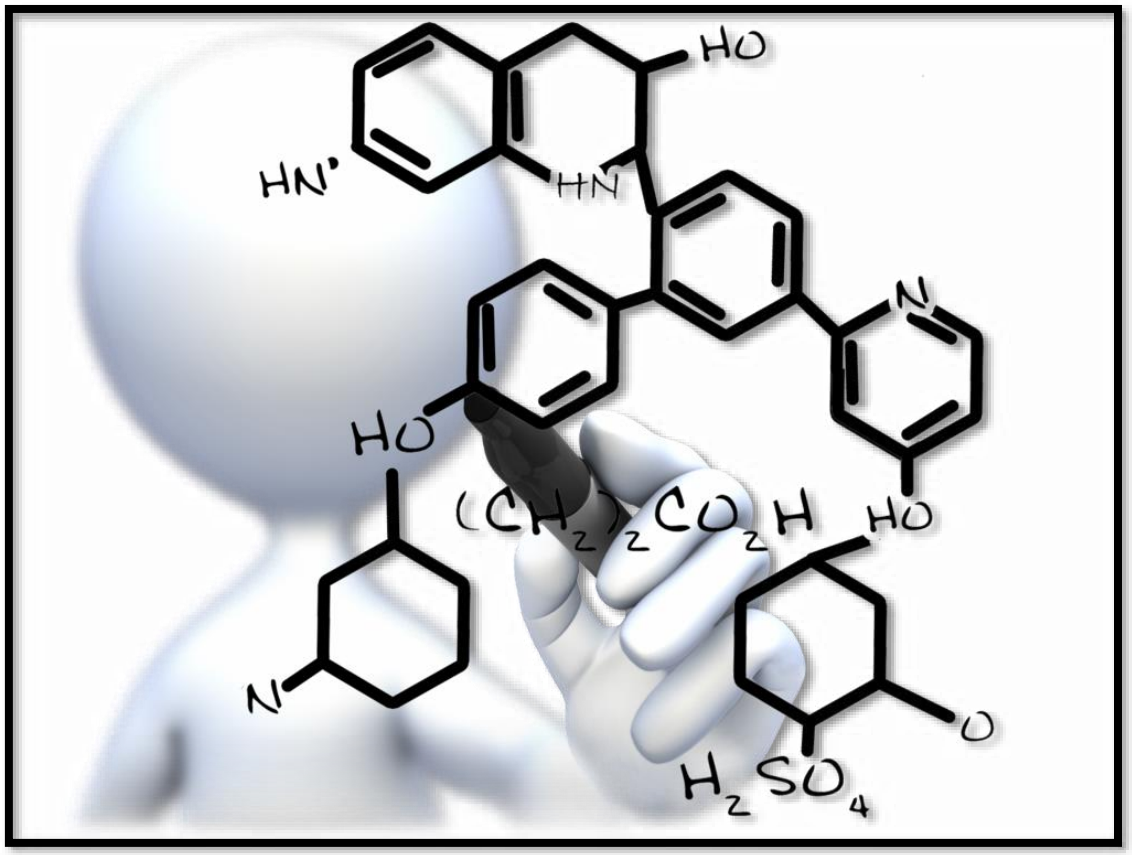
Retention of CO_2 and H+

- **May be more common in nuchal cord & cord compression**

Does not damage organs

Variable decelerations

Resolves quickly with PPV



Mixed Acidemia

Mixed Acidemia

Has both respiratory and metabolic components

- **Low pH** (< 7.2)
- **High pCO_2** (>60)
- **High base deficit** (> 12)

Outcomes

Respiratory

- CO_2 build-up
- Apgar improves readily with resuscitation
- typically by 5 minutes

Metabolic

- Lactic acid build-up
- Low Apgar persists
- Resolves slowly with resuscitation

Blood gases are:

Biochemical component of diagnosis

Umbilical Cord Blood Gases

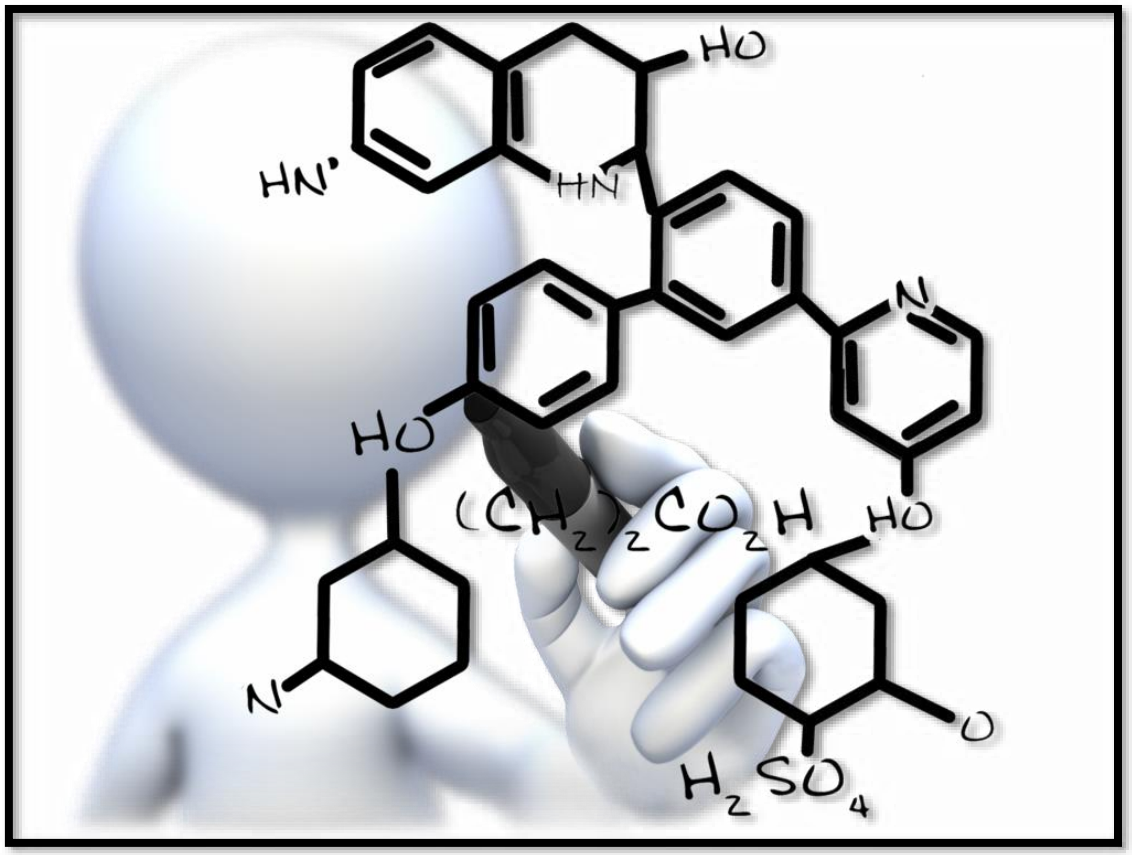
Arterial Umbilical Cord Gases Reflect	Venous Umbilical Cord Gases Reflect	Neither Reflect
Reflect the oxygenation and acid-base status of the newborn at the time of delivery…	Placental function and maternal status	Duration of insult

Umbilical Artery pH and Neonatal Outcome

Umbilical artery pH (particularly base deficit) can provide an index of fetal-acid base status at the time of delivery

Umbilical cord artery metabolic acidemia

- **Has a relatively weak predictive value for long-term complications such as neonatal encephalopathy or cerebral palsy**



How to interpret blood gases

Know the Normal Values

$PH > 7.2$

$PCO_2 < 60$

$PO_2 \geq 20$

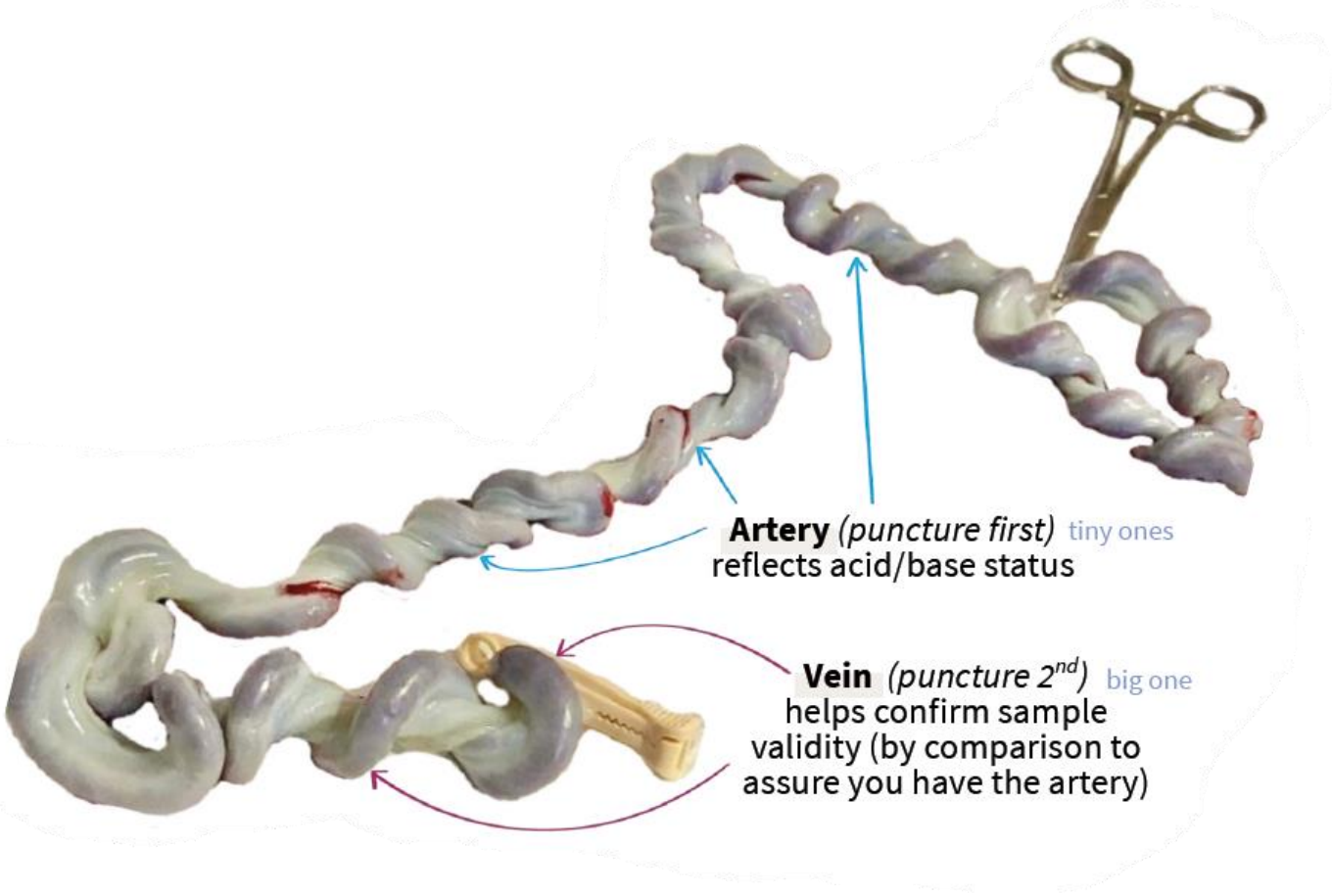
$BD \leq 12$

Is the sample venous or arterial?

- Venous tells you about what was coming into the baby
  - *reflects placental and maternal status*
- Arterial tells you about what was going away from the baby
  - *reflects fetal status*

Tips for Collecting Cord Gases

- **Collect blood from artery and THEN the vein w/in 20-60 mins after clamping**
- **Limit the number of times you poke the cord, as it can decrease the quality of the sample and increase the likelihood of venous blood**
- **Need 0.5-1ml- no air left in syringe**
- **Clearly label- Arterial vs Venous and time of collection**
- **Analyze within 30 mins**
- **Communicate to NICU or Ped team with abnormal lab values**
- **Know your facility policy on routine vs indicated cord gases**



Arterial Blood Gas

Norms

PH >7.2

PCO_2 <60

PO_2 ≥20

BD ≤ 12

Respiratory

PH < 7.2

PCO_2 ↑ (>60)

BD ≤ 12 (normal)

Metabolic

PH < 7.2

PCO_2 normal (<60)

BD ↑ > 12

Mixed

PH < 7.2

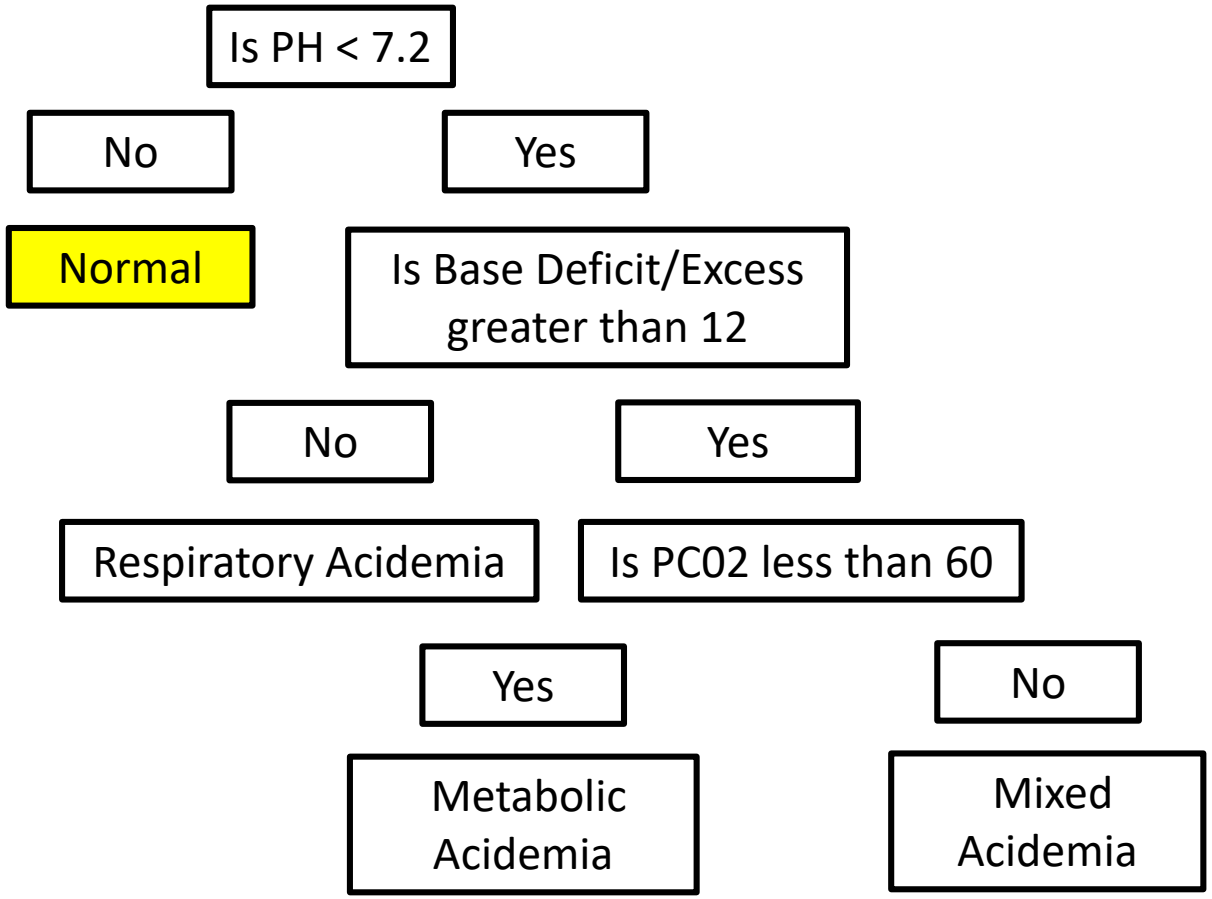
PCO_2 ↑ (>60)

BD ↑ > 12

Let's Practice...

PH	7.30
PO2	24 mmHg
PCO2	47
HCO3	22
BD	7

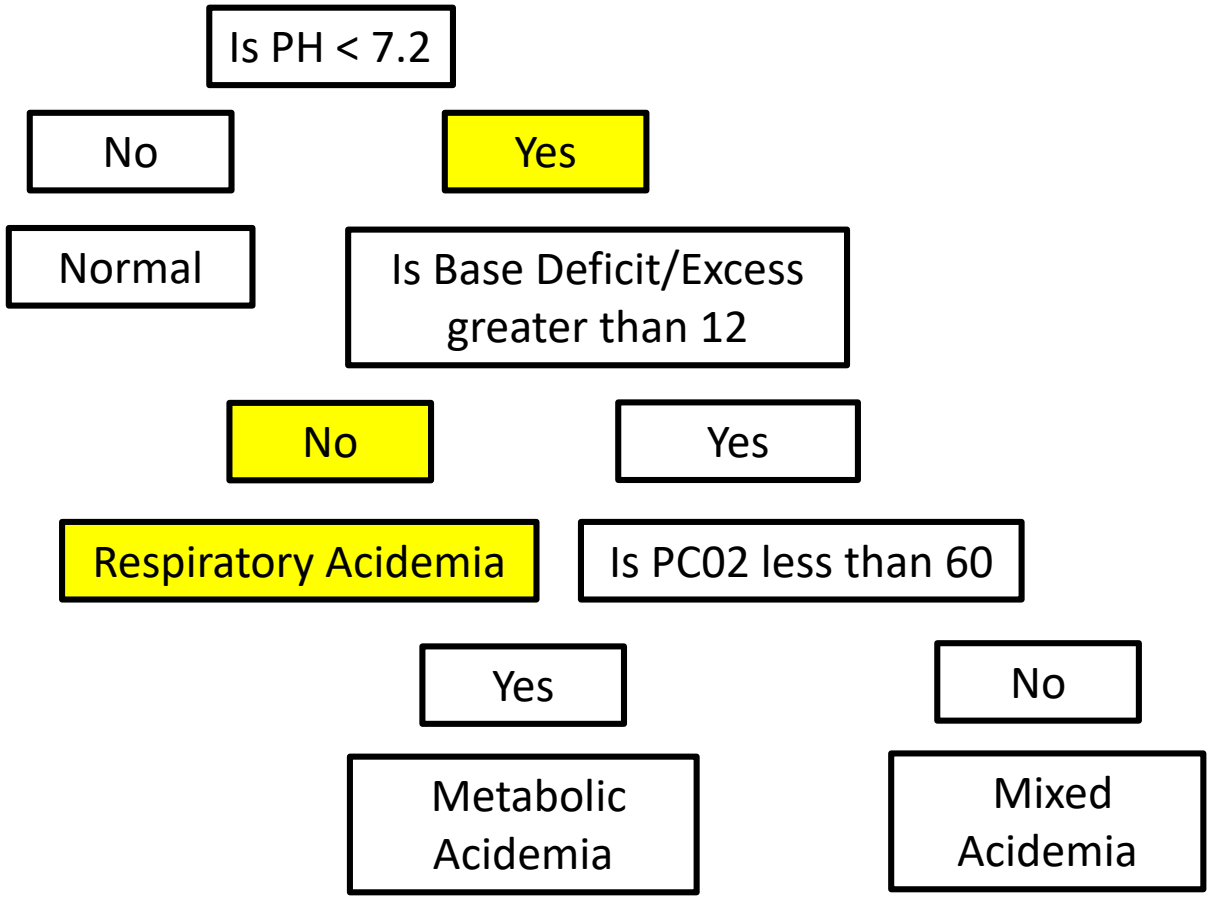
Normal



Let's Practice...

Respiratory

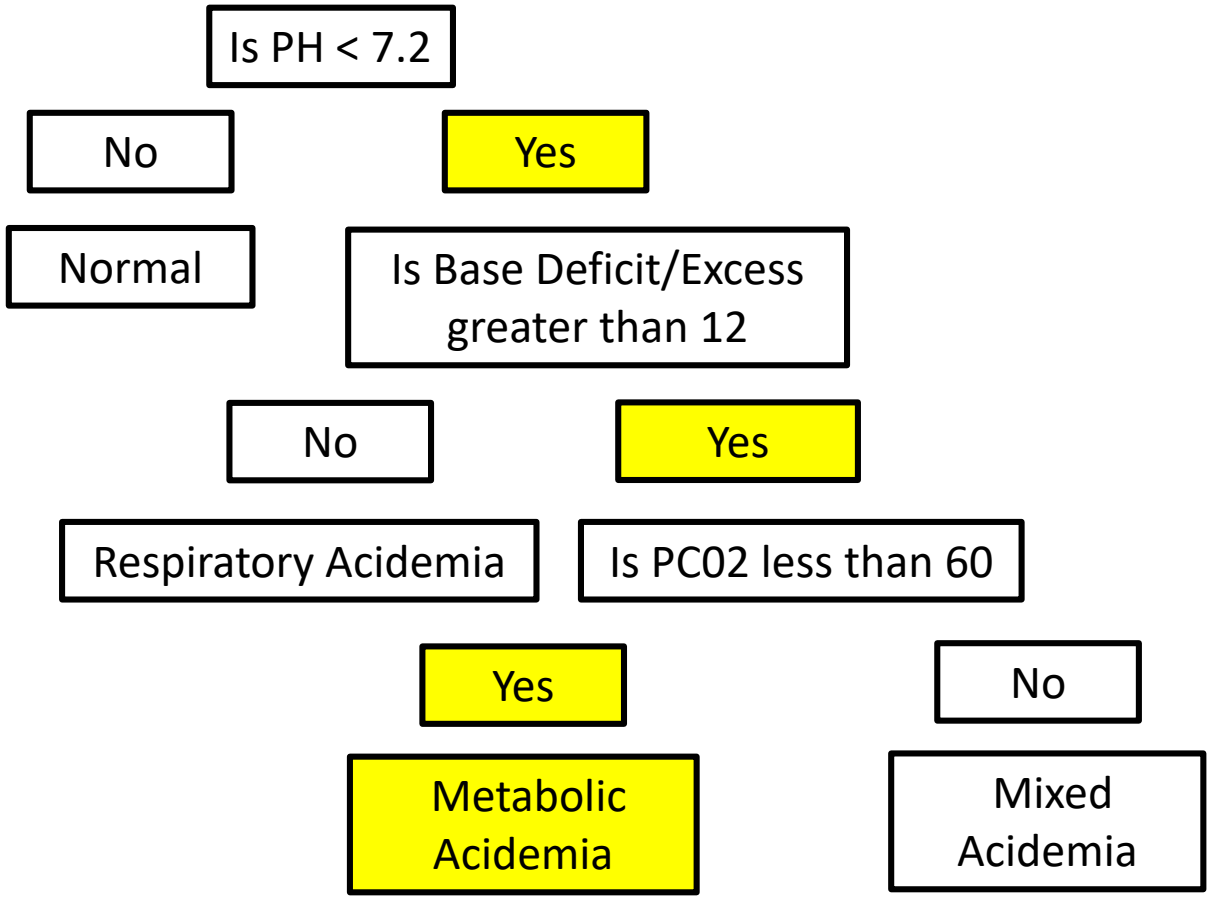
PH	7.05
PO2	21 mmHg
PCO2	80
HCO3	24
BD	9



Let's Practice...

Metabolic

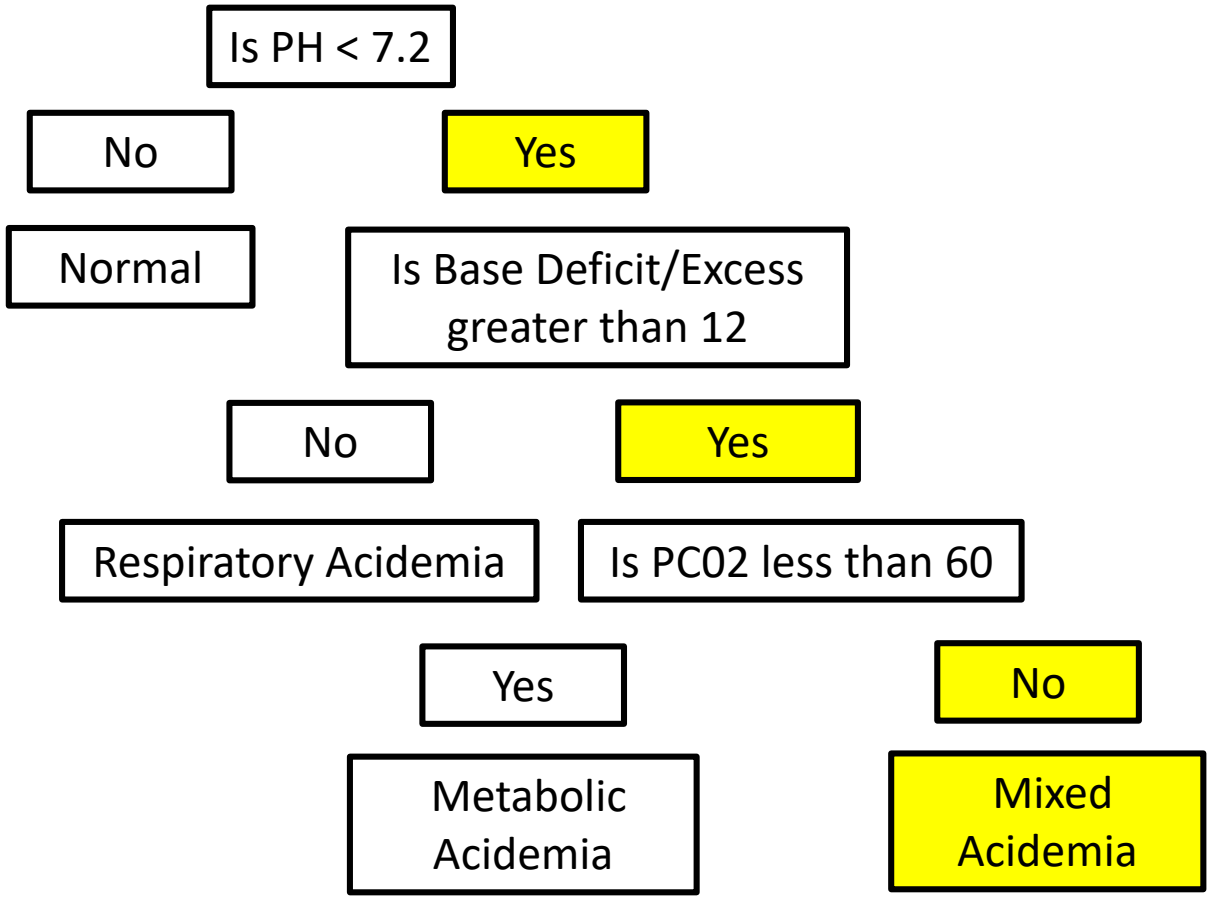
PH	7.0
PO2	5 mmHg
PCO2	50
HCO3	12
BD	14



Let's Practice...

Mixed

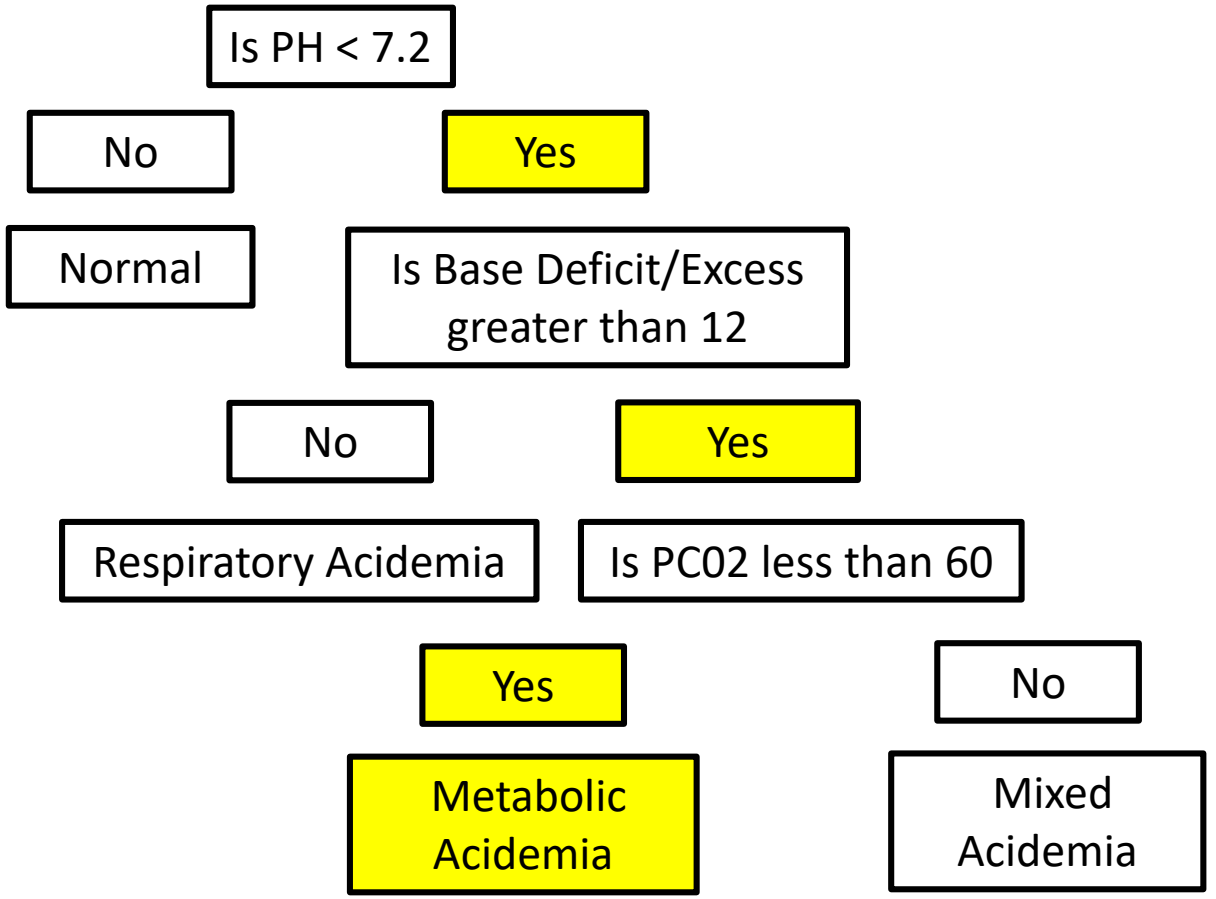
PH	6.91
PO2	17 mmHg
PCO2	106
HCO3	21
BD	18



Let's Practice...

Metabolic

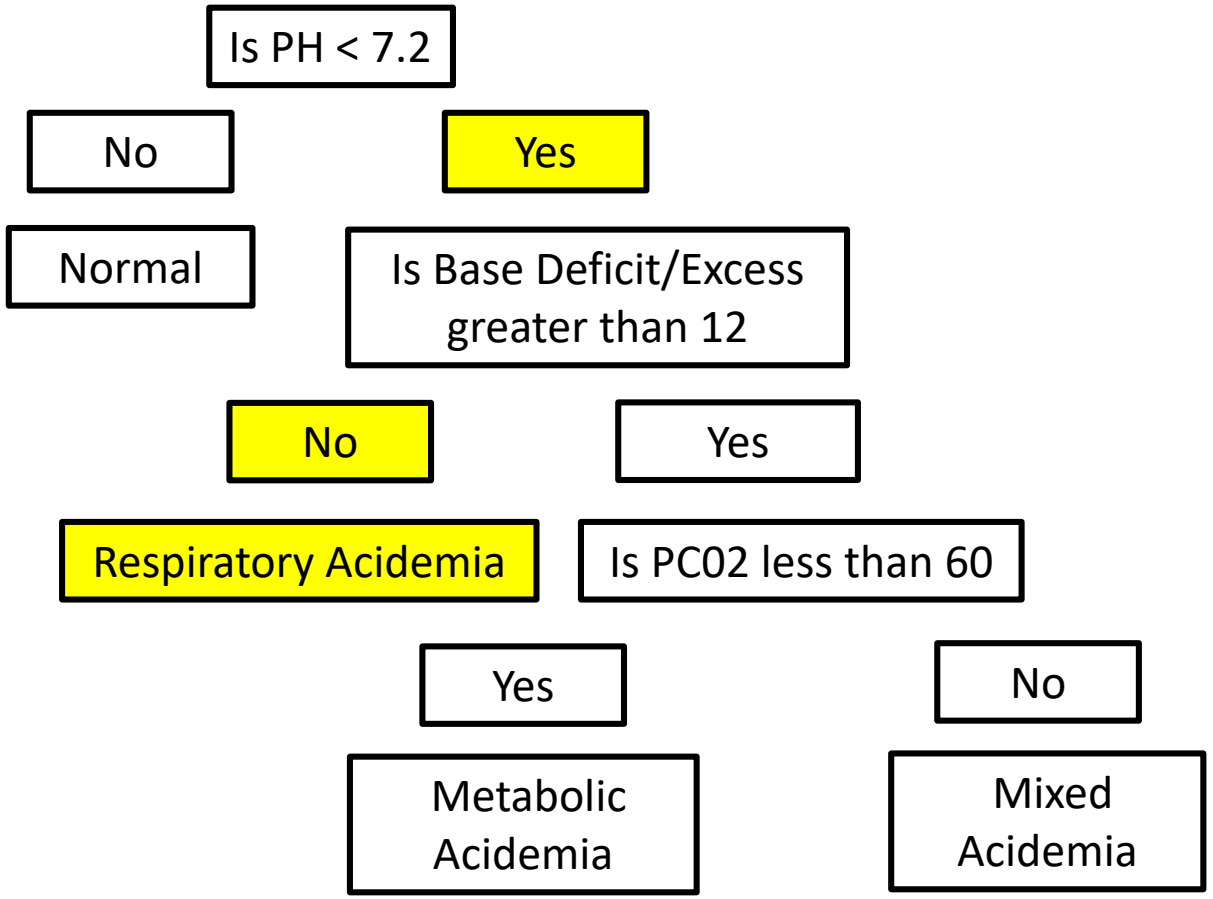
PH	6.91
PO2	2.5 mmHg
PCO2	49
HCO3	8
BD	38.7



Let's Practice...

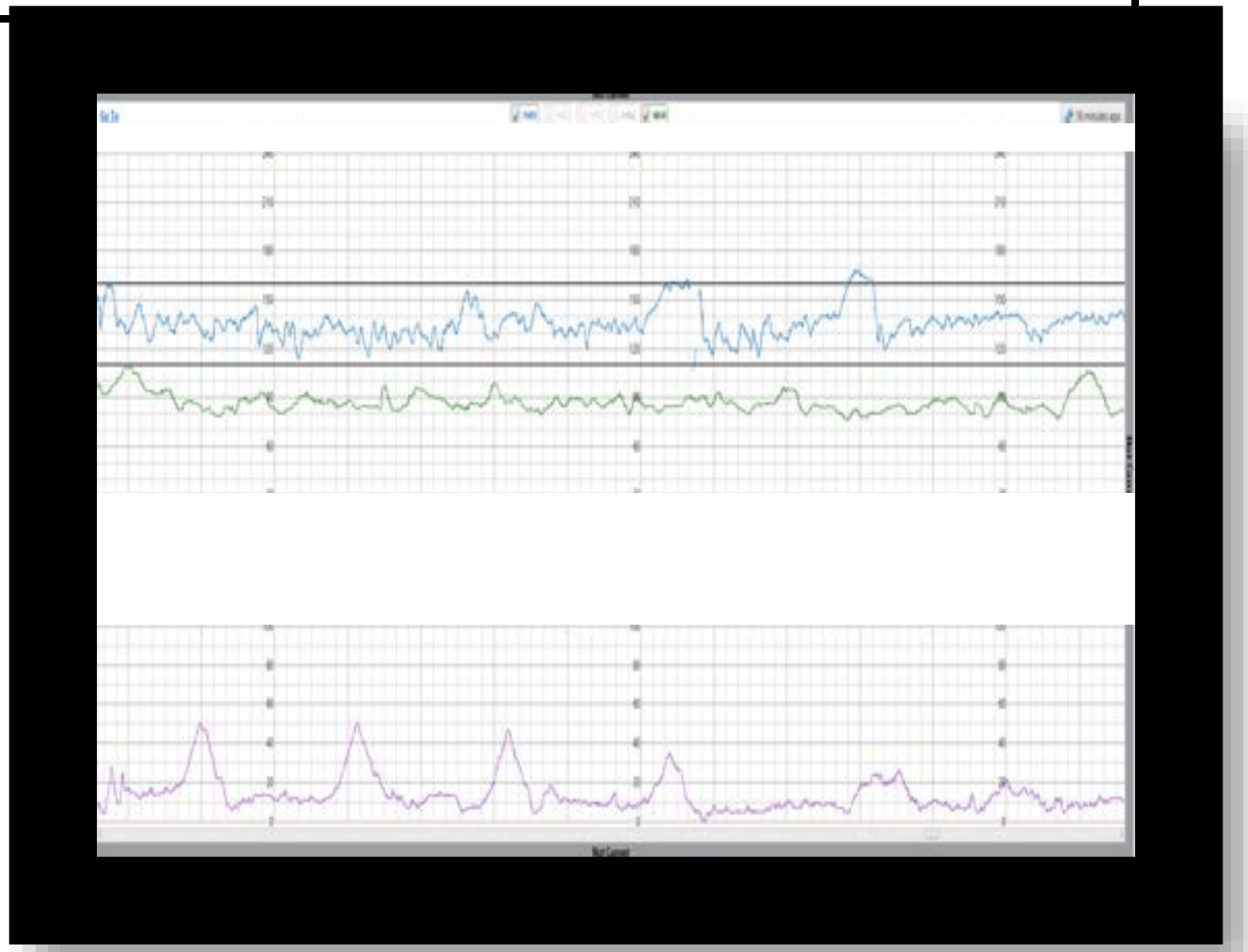
Respiratory

PH	7.0
PO2	21 mmHg
PCO2	90
HCO3	24
BD	6



Acid-Base Status & FHR Patterns

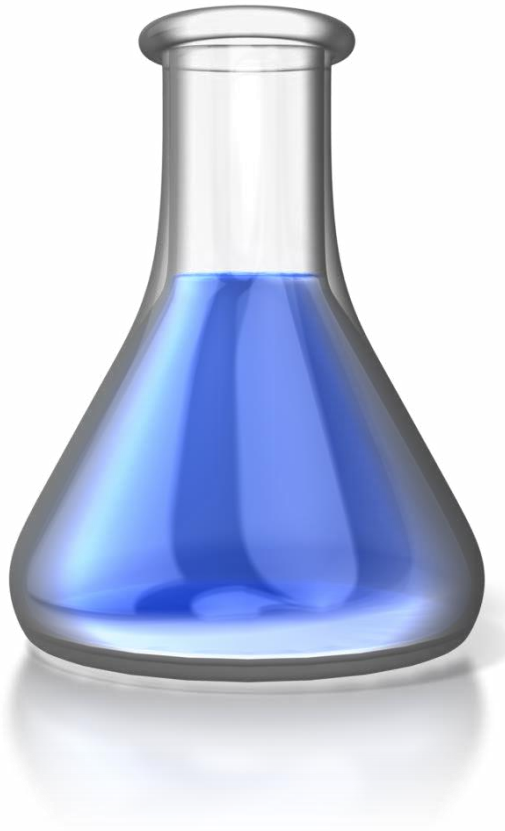
How does fetal acid base status relate to electronic fetal monitoring?



Key Points

The presence of FHR accelerations (either spontaneous or stimulated) reliably predicts the absence of fetal metabolic acidemia at the time it is observed

Moderate FHR variability reliably predicts the absence of metabolic acidemia at the time it is observed



What does absence of accelerations mean?

Indeterminate

Is not predictive of the presence or the absence of metabolic acidemia

Does minimal or absent FHR Variability alone predict presence of fetal hypoxemia or acidemia

May reflect fetal sleep, narcotics, or other drugs

Fetal Heart Rate Interpretation

Category I	Category II	Category III
Are Normal **Strongly predictive of normal acid-base status at the time of observation**	**Are *indeterminate*** **Not predictive of abnormal fetal acid-base status**	**Are *abnormal*** **Predictive of abnormal fetal acid-base status at time of observation**

QUESTIONS???

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