Fetal Monitoring and Umbilical Cord Gases: What's the Secret?

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Objectives

* The learner will be able to
  * *describe the process for umbilical cord blood collection.*
  * *define the normal acid-base parameters of umbilical cord blood gases.*
  * *discuss the clinical value of determining acid-base parameters.*

What is Hypoxia?

* Low levels of oxygen in the tissues

Acidemia & Acidosis

* Acidemia – state of low blood pH
* Acidosis – the process of becoming acidemic

What is Asphyxia?

* *Birth asphyxia* occurs when a baby doesn't receive enough oxygen before, during or just after birth
* Hypoxia, hypercapnia, and respiratory and/or metabolic acidemia

Fetal Asphyxia Occurrence

* ACOG reports that fetal asphyxia occurs in 25 of 1000 live births and 15% of those are moderate to severe

Assessing Fetal Well-Being

* Ultrasound
  * Biophysical Profile (BPP)
  * Doppler studies
* Electronic Fetal Monitor
* Umbilical Cord Blood Analysis

Electronic Fetal Monitor

* "… a valuable but imperfect tool."

(Clark, et al. 2017, p. 163)

Expected Outcomes

* Decrease incidence of cerebral palsy and intrapartum stillbirth

Actual Outcomes

* No difference # intrapartum stillbirth (one in 300)
* There were no differences in the incidence of CP
* Neonatal seizures decreased with EFM

* Continuous monitoring is associated with a significant increase in C/S and operative births

Liability of EFM

Year	CD%
2015	32.0%
2007	31.8%
1996	20.7%
1988	24.7%
1970	5.5%

Benefit Not Realized

* Unrealistically high expectations
* Lack of standardization of FHR definitions until 1997/2008
* Poor reliability for FHR interpretation
* Failure to show the validity of FHR monitoring in detecting fetal asphyxia

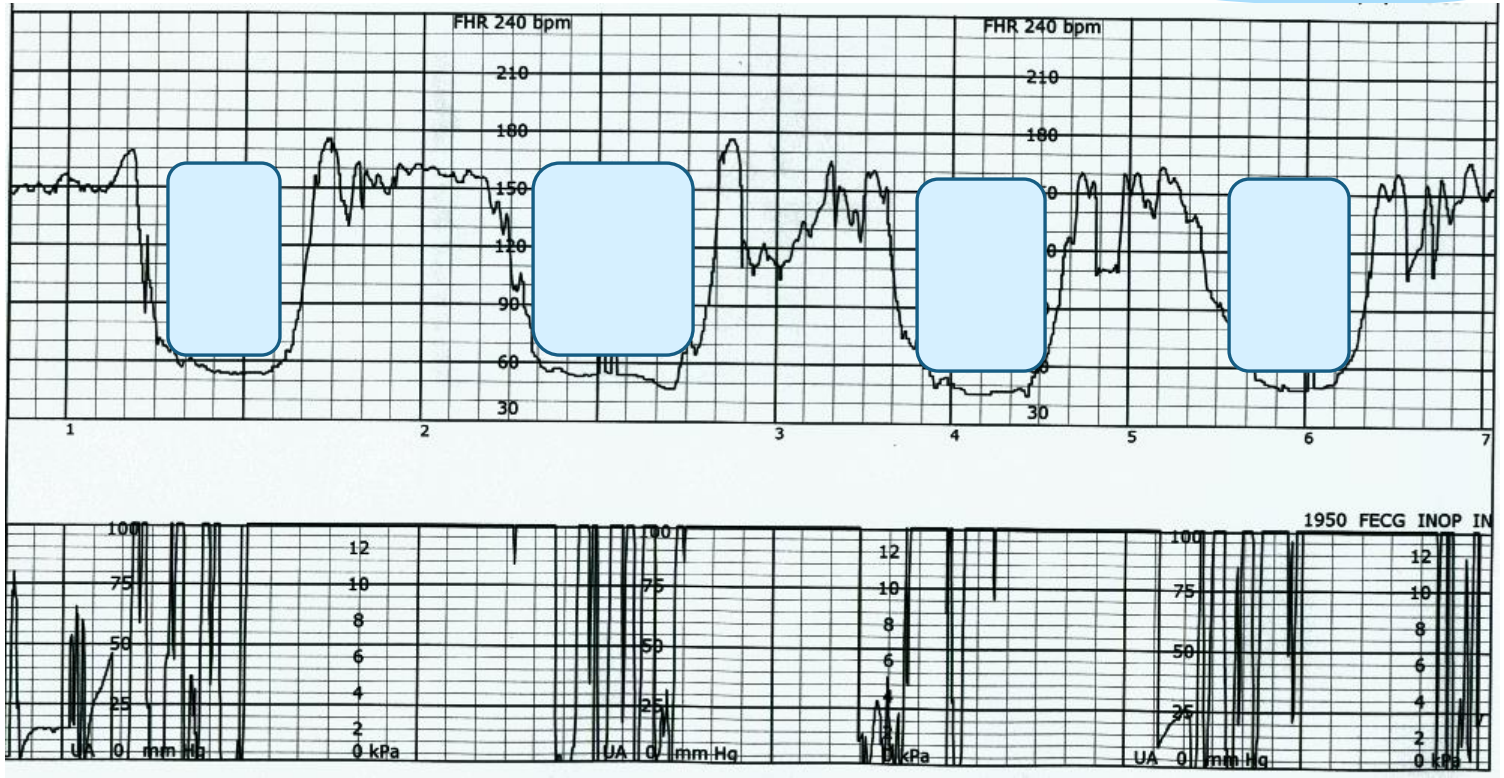
Electronic Fetal Monitor

* "… of infants born with metabolic acidemia, only approximately one-half could be identified potentially and have delivery expedited, even under ideal circumstances."

(Clark, et al, 2017, p. 163)

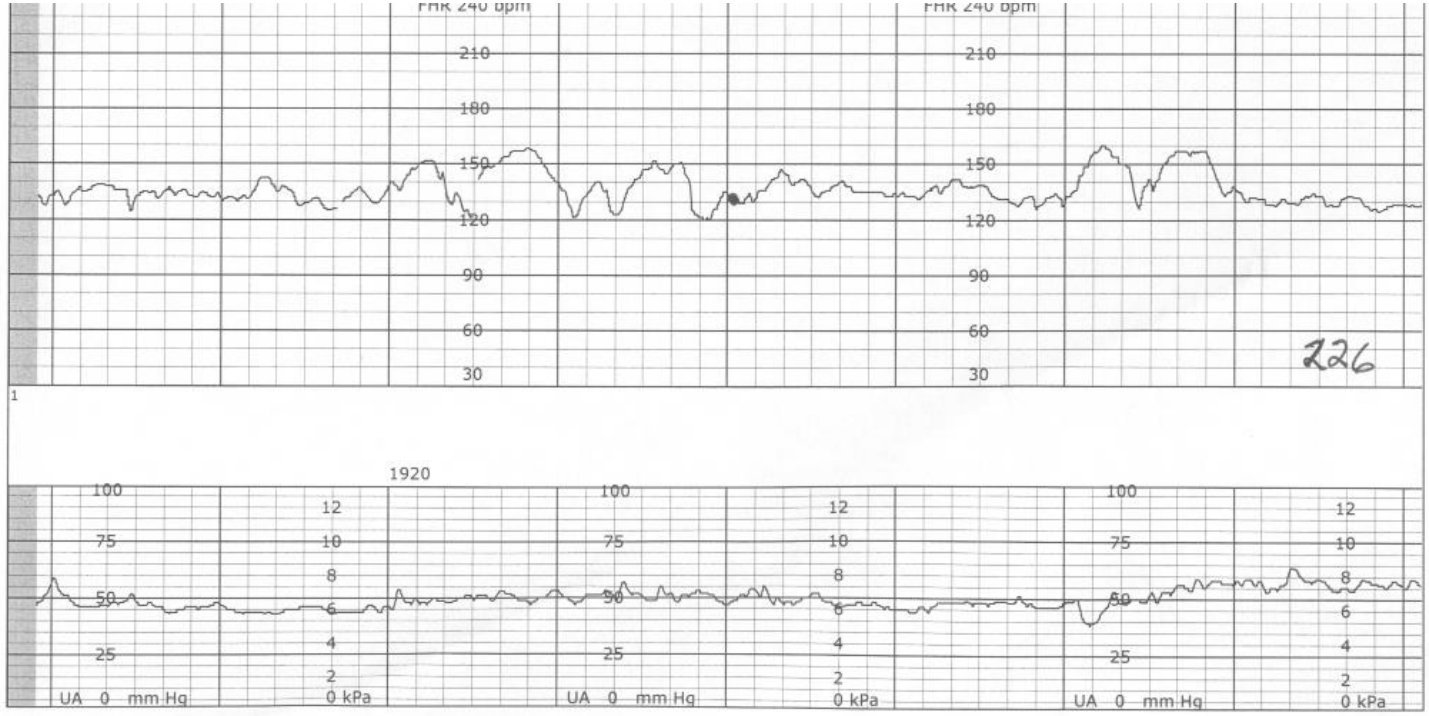
Total Deceleration Area

Total Deceleration Area

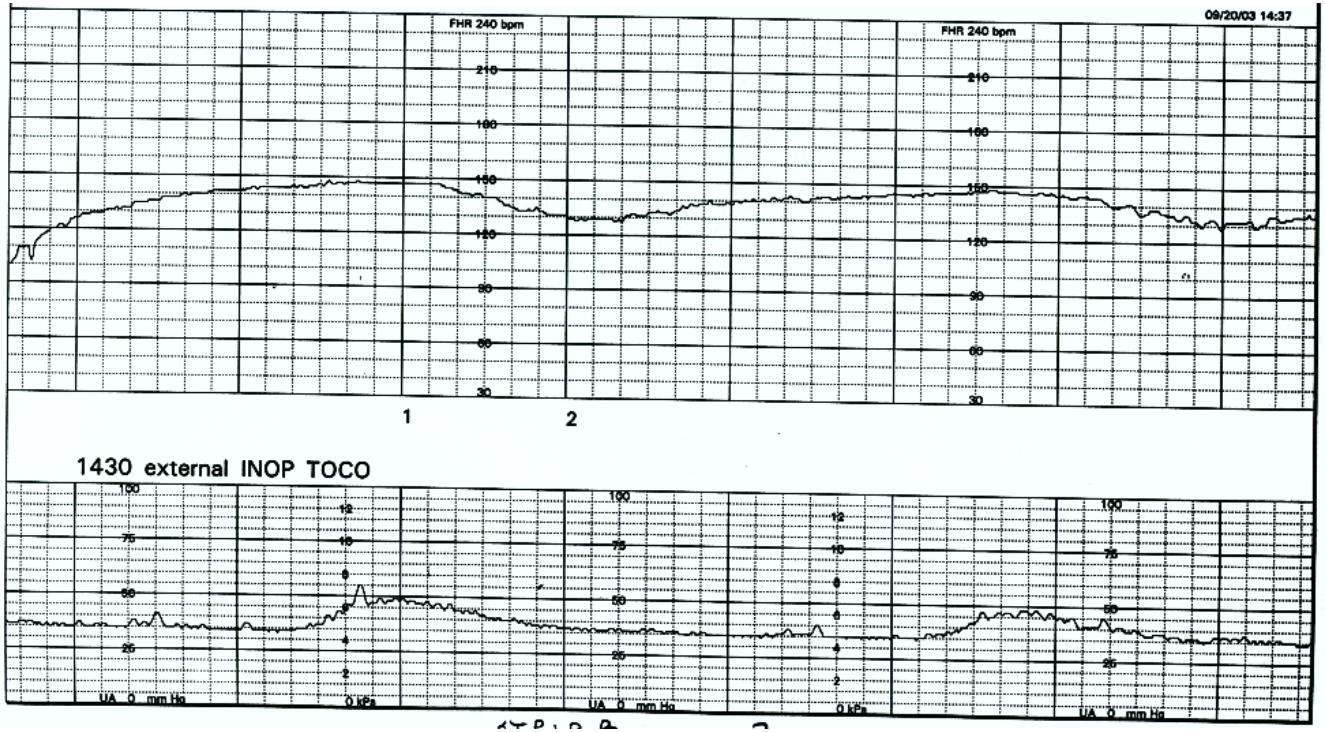


(Cahill, et al., 2012)

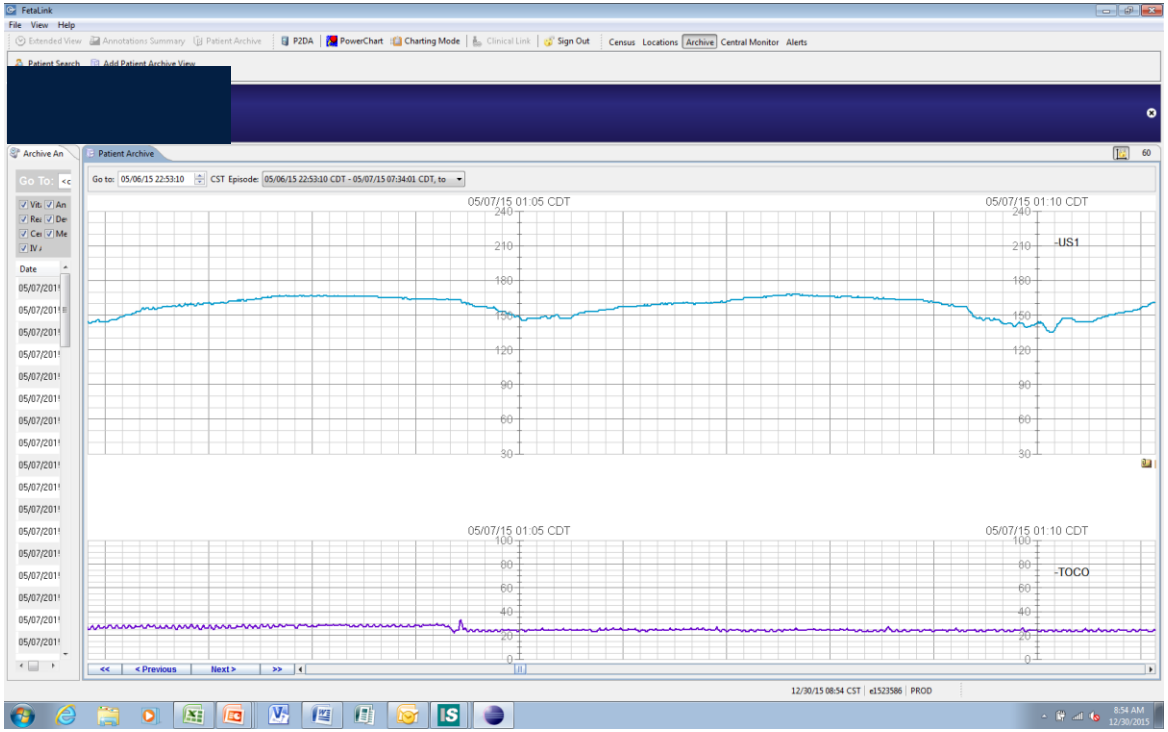
Category I Strip



Category III Strip



Category III Strip



Category III Strips

* Parer et al. (2006) reported that only 24% of fetuses with Category III strips have metabolic acidemia

Hypoxic Ischemic Encephalopathy

* Hypoxic (lack of oxygen)
* Ischemic (restricting blood flow)
* Encephalopathy (affecting the brain)

* Abnormalities during the last hour of fetal heart rate monitoring are poorly predictive of neonatal HIE

Hypoxic Ischemic Encephalopathy

* "Hypoxic-ischemic encephalopathy is associated with significant increases in electronic fetal monitoring abnormalities, but the predictive ability to identify these conditions is low."

Larma, et al., 2007

EFM Predicting Acidosis

* Specificity of 98.9%
  * Percent of healthy pts appearing healthy
* Sensitivity of 7.7%
  * Percent of unhealthy pts appearing unhealthy

Larma, et al., 2007

Is Acidemia Important?

* UCG's are an important parameter in the decision for brain cooling
* *Neonatal* therapeutic hypothermia has been shown to help reduce significant *brain* damage in infants who suffered from lack of oxygen during labor/birth

History of UCBG

* In 1958, James, *et al.* recognized the possibility of interpreting umbilical cord blood gases

ACOG Committee Opinion

* Intrapartum Event =/? Adverse Outcome
* All Non-elective cesareans deliveries
* 5- minute Apgar ≤ 3
* "Abnormal" Fetal Heart Rate Tracing
* Severe IUGR
* Intrapartum Fever
* Maternal Thyroid Disease
* Multiple Gestation

Clinical Relevance

* Cord blood analysis is the most objective way of assessing the fetal condition at birth
* Allows for differentiation of respiratory and metabolic acidemia

Normal Cord Gas Values

* pH >7.1
* pO2 > 20mmHg
* pCO2 < 60mmHg
* Bicarbonate >22mEq/L
* Base Excess >-12mEq/L
  * Base Deficit <12mEq/L

* (Adapted from AWHONN FHMPP, 2016)

Fetal Injury

* Fetal neurologic injury does not occur without significant metabolic acidemia
  * pH <7.0

ACOG, 2010

pH

* Potential for Hydrogen (H+)
  * Increasing H+, decreasing pH
  * Decreasing H+, increasing pH

* Fetal Normal = > 7.10
* ACOG recommends= <7.0 for severe acidemia

pO2

* The amount of dissolved oxygen in the blood
* Normal umbilical gas values >20mmHg

pCO_2

* Dissolved carbon dioxide in the blood
* Normal umbilical gas value <60mmHg
  * Umbilical vein has lower pCO_2
  * Umbilical artery has higher pCO_2

Bicarbonate

* Buffering systems
  * Circulating acids are neutralized
* Bicarbonate (HCO_3) is the largest buffering system

Base Excess

* The **base excess** is **defined** as the amount of H+ ions that would be required to return the pH of the blood to 7.35 expressed as a - number
* Indirect measurement of anaerobic metabolism

Base Excess

* If you had a high H+ content in the blood (metabolic acidemia) it would take a very low amount to return to 7.35

Poor Oxygenation

* Maternal oxygenation is compromised
  * Maternal cardiac disease
* Reduced perfusion of the placenta
  * Preeclampsia
* Delivery of oxygenated blood from the placenta to the fetus is impeded
  * Abruption, cord entanglement

Respiratory Acidemia

* CO_2 accumulates
  * pCO_2 >60mmHg
* pH falls
* Develops quickly, clears quickly
  * Primary Apnea

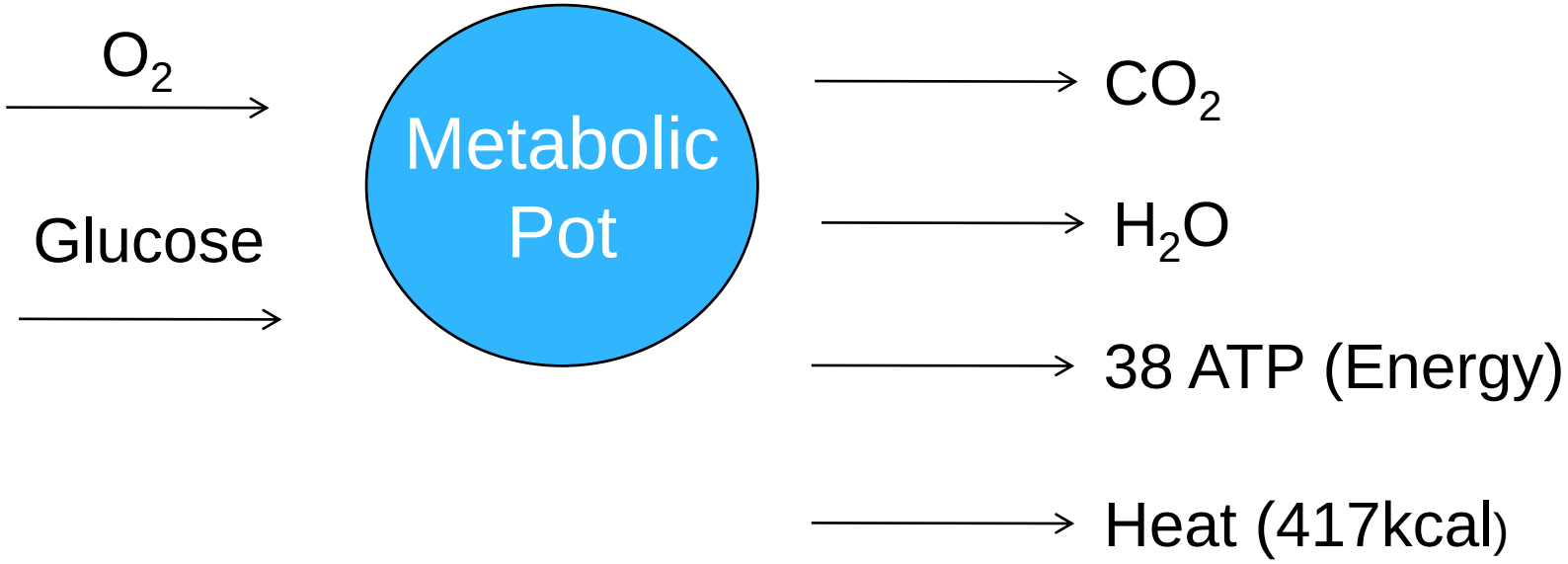
“Hidden Acidemia”

* Delayed Cord Clamping (DCC)
* Reperfusion of the peripheral tissues causes CO_2 to be released and can be detected in the umbilical artery
  * Decreased pH
  * Increased CO_2

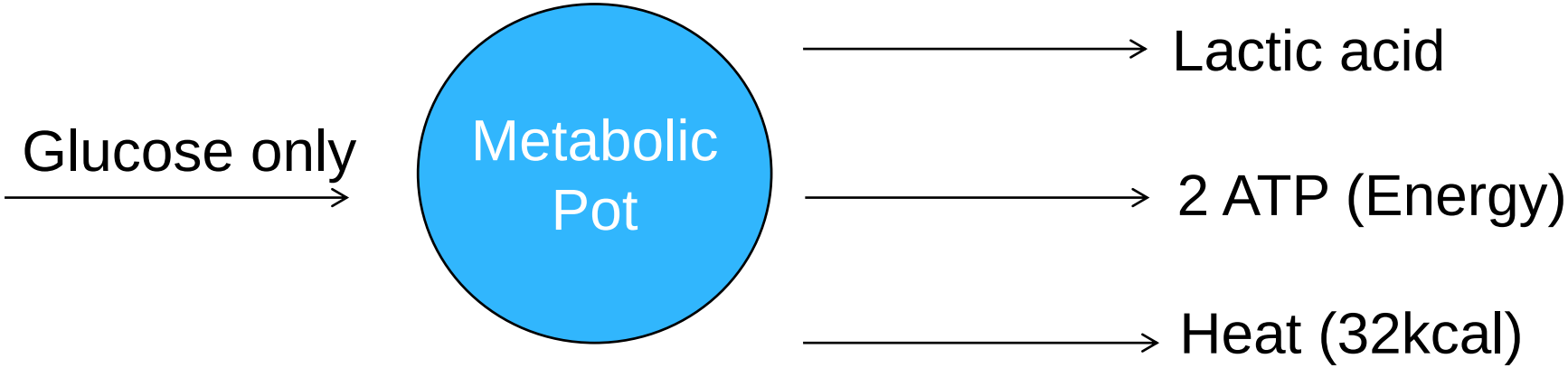
Metabolic Acidemia

* Absence of available O_2 the cells will shift into *anaerobic* metabolism which produces lactic acid as a byproduct
* When lactic acid exceeds buffering capacity the result is metabolic acidemia
* Secondary apnea

Aerobic Respiration



Anaerobic Respiration

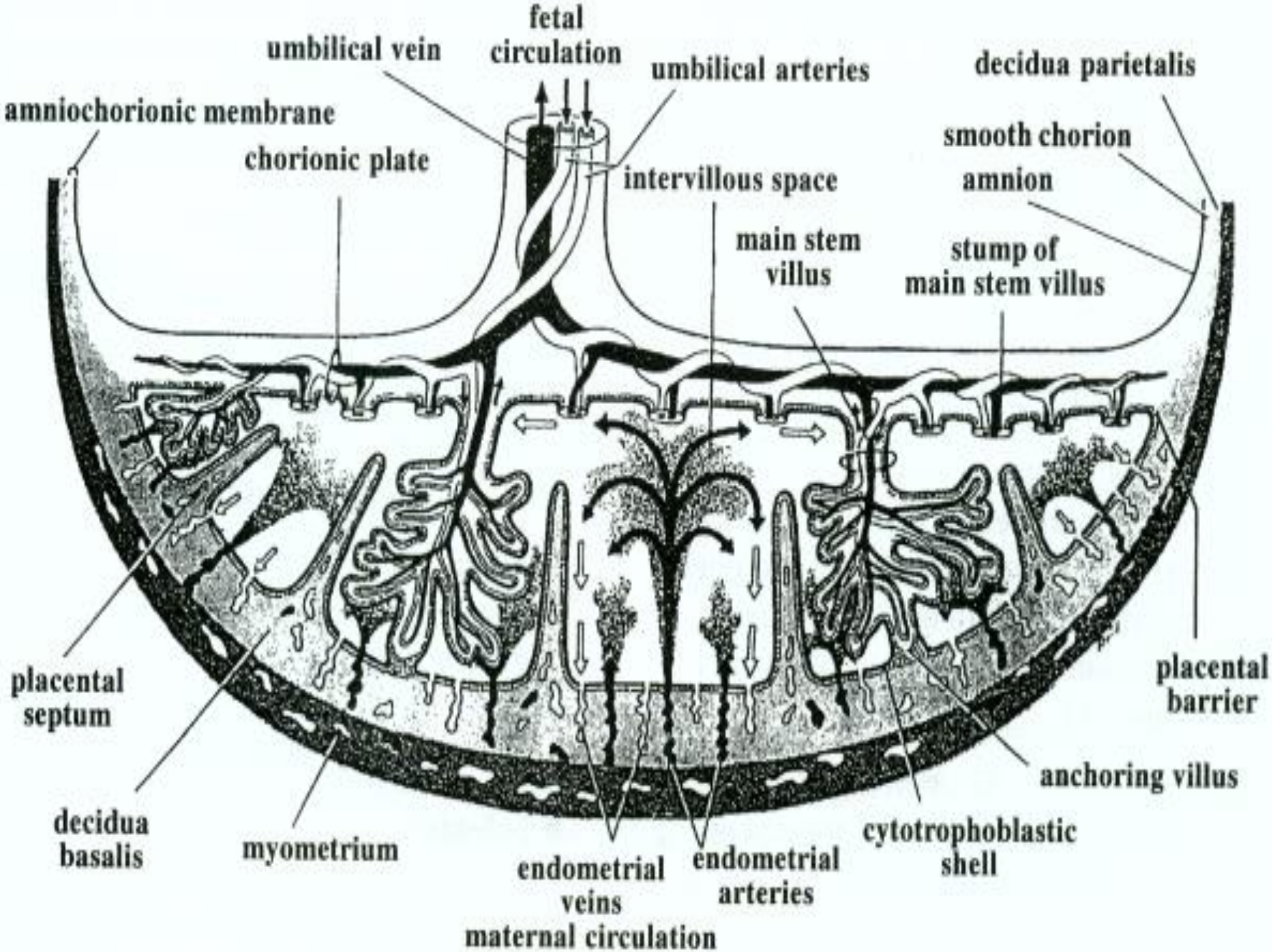


Arterial or Venous or Both

* Both necessary to ensure the biological validity of the samples obtained

Arterial vs. Venous Sample

* pH of the vein will always be higher than the artery (0.02)
* pCO_2 of the vein will always be lower than the artery


fetal circulation
umbilical vein
umbilical arteries
decidua parietalis
amniochorionic membrane
smooth chorion
chorionic plate
intervillous space
amnion
main stem villus
stump of main stem villus
placental septum
placental barrier
anchoring villus
decidua basalis
myometrium
cytotrophoblastic shell
endometrial veins
endometrial arteries
maternal circulation

Arterial vs. Venous Sample

* Umbilical cord arterial pH is a measure of the fetal condition at birth
* Umbilical cord venous pH is a measure of maternal acid-base status and the condition of the placenta

Respiratory, Metabolic or Mixed

* Respiratory acidemia
  * CO_2 greater than 60mmHg
* Metabolic acidemia
  * Bicarbonate <22mEq/L
  * Base Excess <-12mEq/L
* Mixed
  * All of the above

pH Practice

	Arterial	Venous
pH	7.10	7.16
pCO2	16	22
pO2	60	58
Bicarbonate	24	22
Base Excess	-4	-2

pH Practice

	Arterial	Venous
pH	6.90	6.98
CO_2	110	98
O_2	22	20
Bicarbonate	24	26
BE	-10	-6

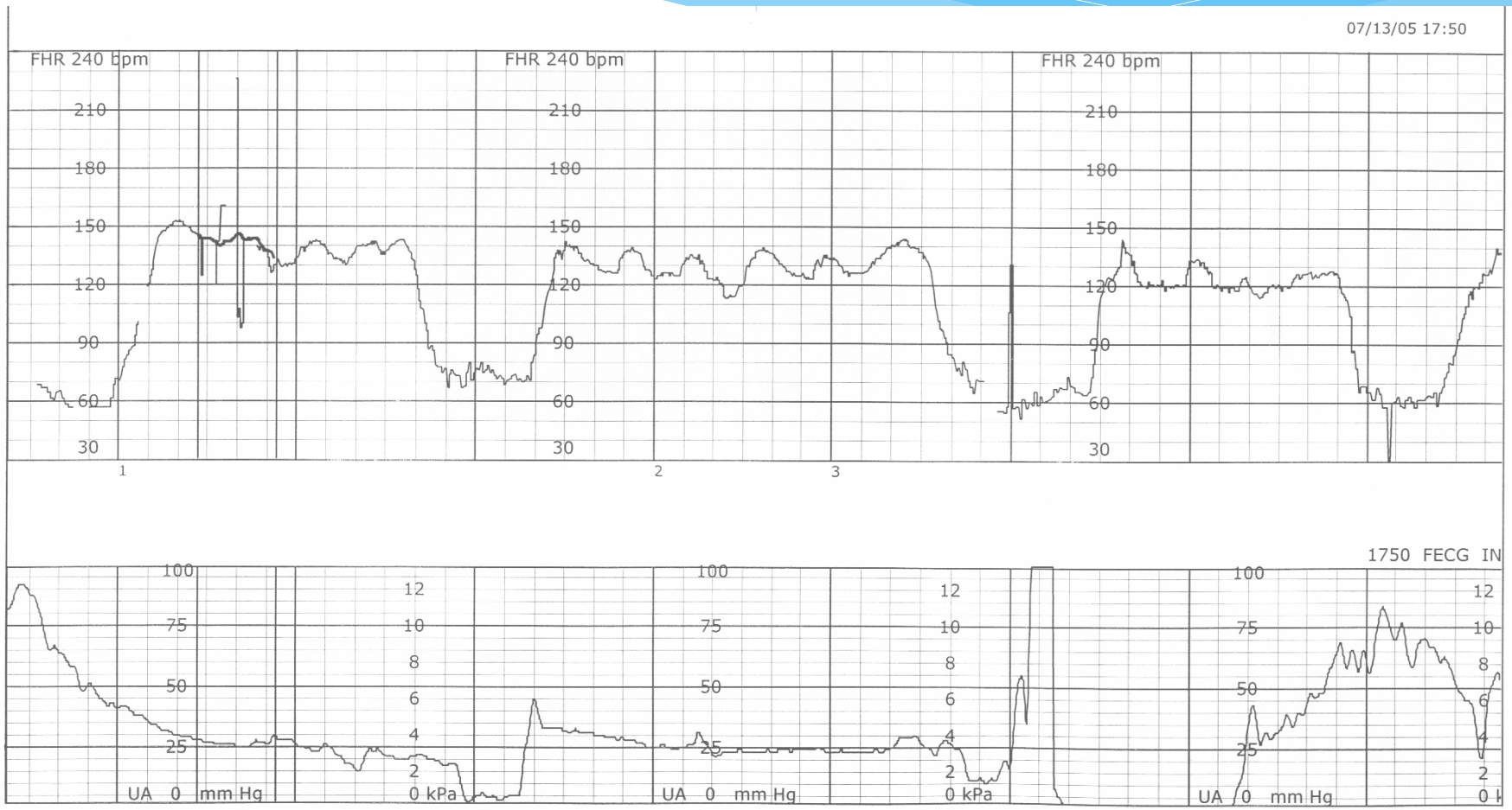
pH Practice

	Arterial	Venous
pH	6.89	7.02
pCO2	102	88
pO2	18	12
Bicarbonate	16	20
BE	-14	-10

UA/UV Differences

* A wide difference in values is often due to obstructed O2 delivery
* A small difference is most likely caused by impairment of maternal perfusion of the placenta

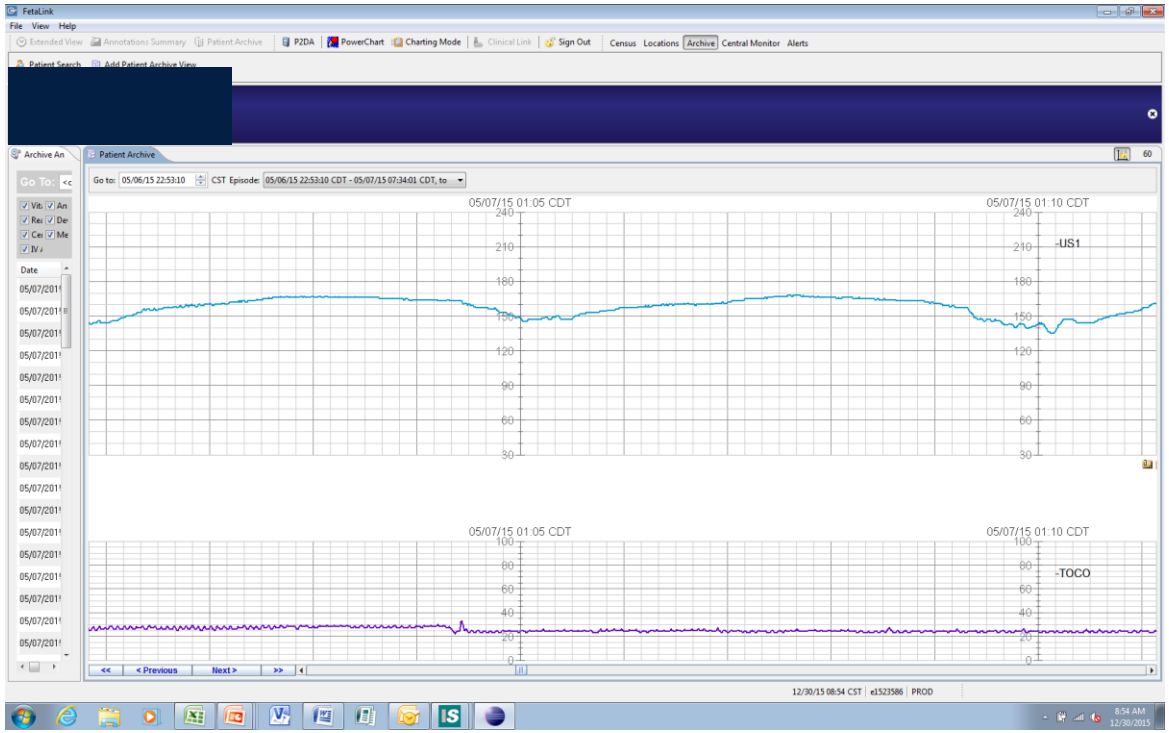
Variable Decelerations



Large UA-UV Difference

	Arterial	Venous
pH	6.88	7.08
pCO_2	121	74
pO_2	21	38.6
Bicarbonate	12	18
Base Excess	-21.2	-14.2

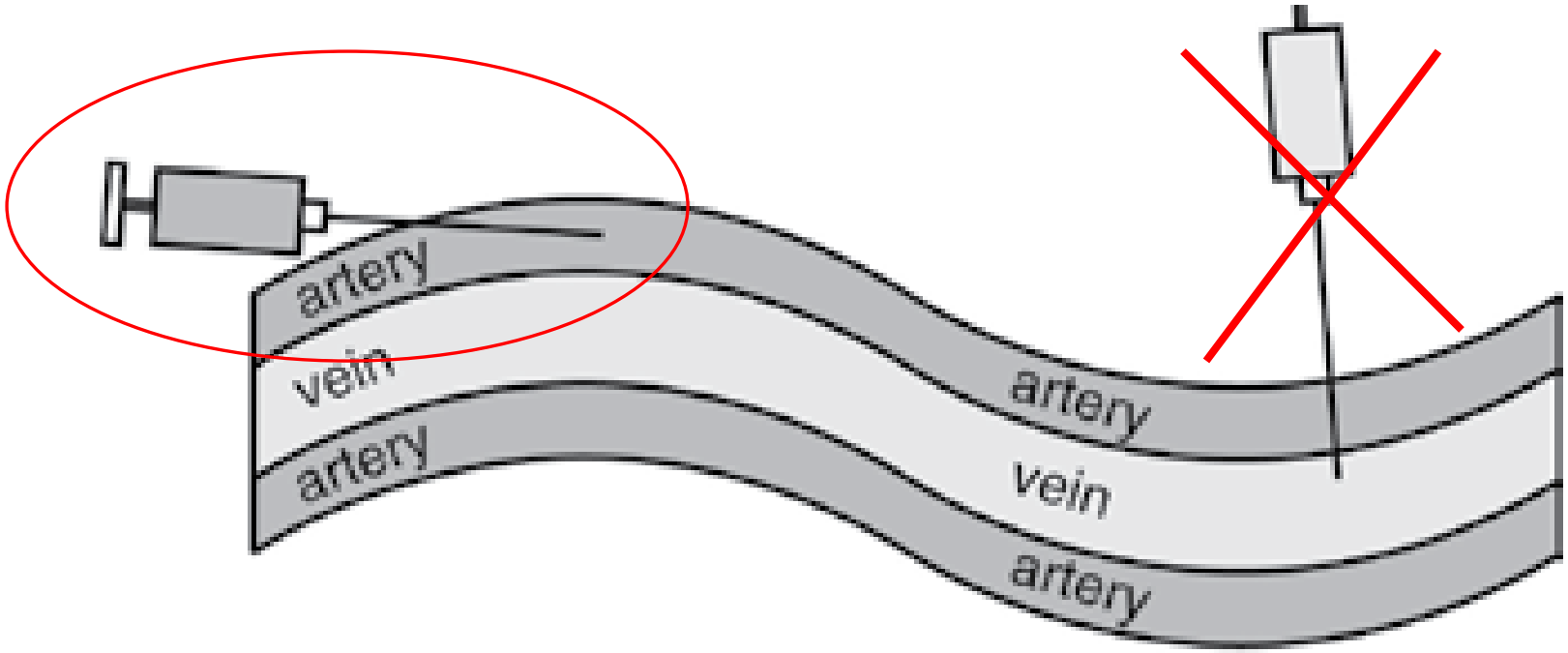
Late Decelerations



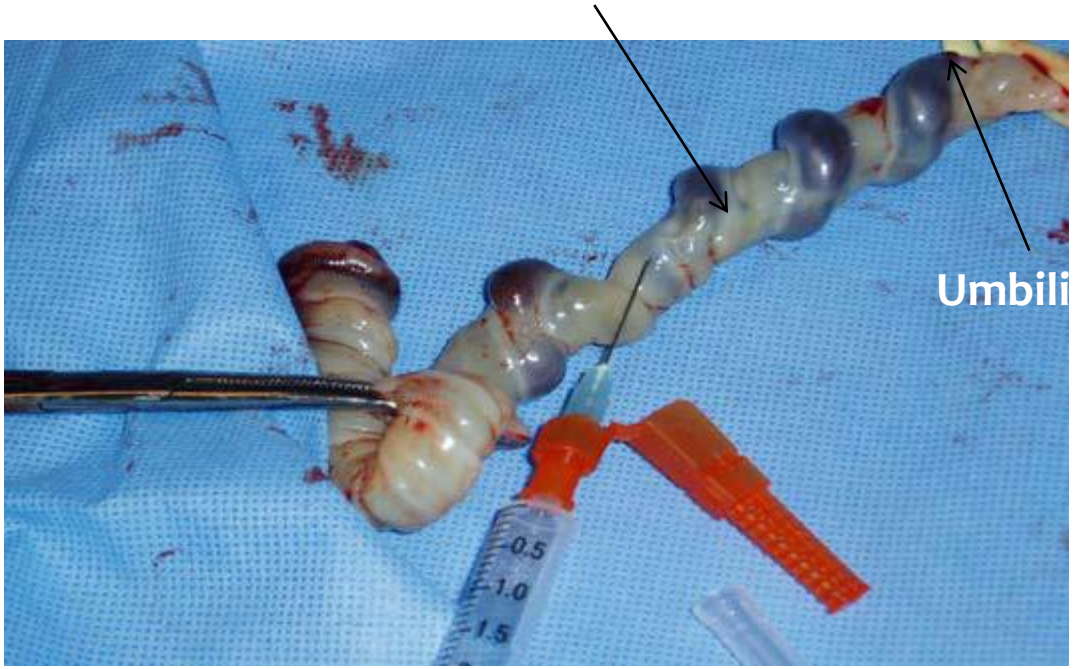
Small UA-UV Difference

	Arterial	Venous
pH	6.88	6.92
pCO2	75	78
pO2	16	18
Bicarbonate	4	6
Base Excess	-22	-20

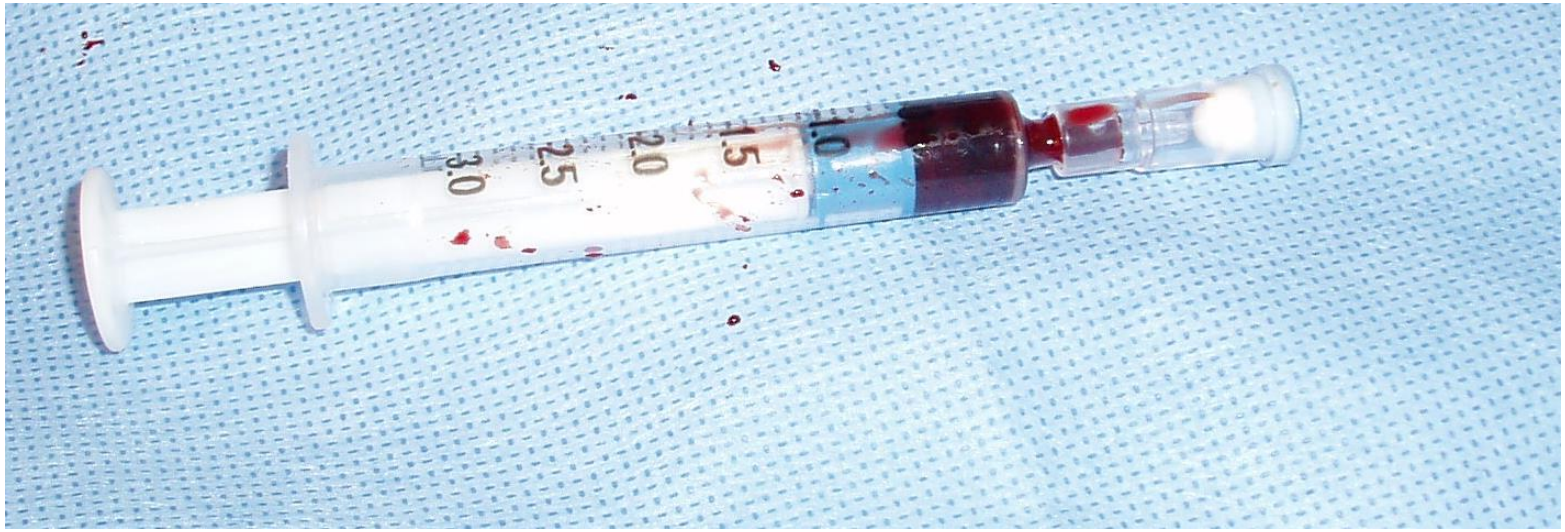
Double Clamped Cord Segment


artery
vein
artery
artery
vein
artery

Umbilical Artery Sampling



No Air in Sample



Wait Time & Transport

* Clamped cord good for 60 minutes at room temperature
* Stable in a plastic syringe for 30 minutes prior to sampling
* Transport at room temperature