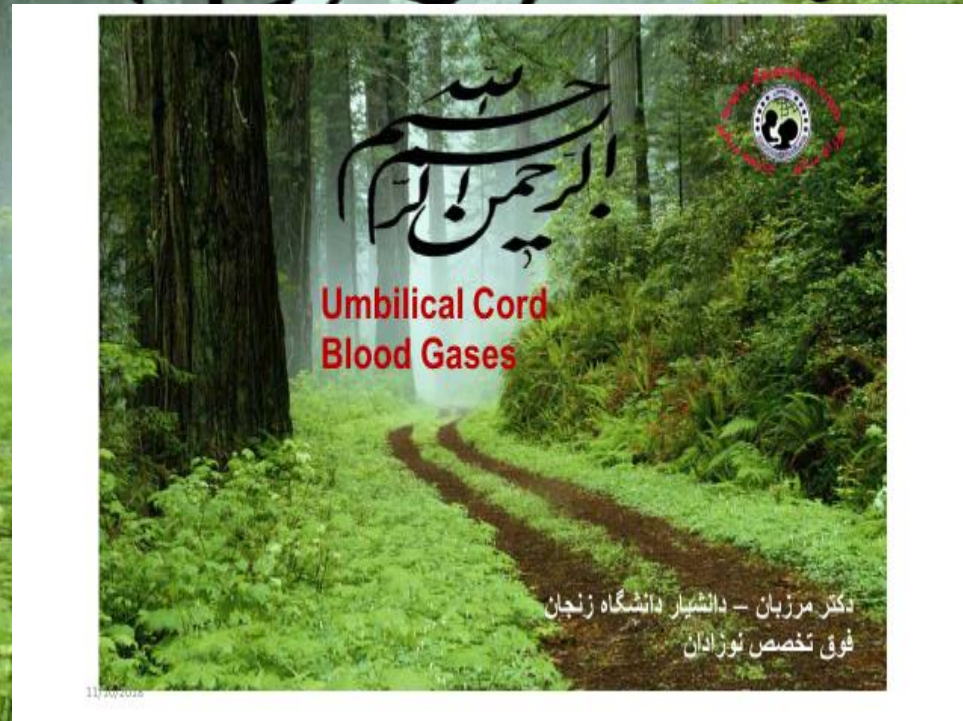


# Umbilical Cord Blood Gases

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ



دکتر مرزبان — دانشیار دانشگاه زنجان  
فوق تخصص نوزادان

## نوزاد سالم

## جامعه سالم

• تولد:

یکی از پرمخاطره ترین و شگفت انگیز ترین مرحله حیات یک انسان می باشد...

■ مخاطرات ۱۲۰ ثانیه اول تولد یک فرد می تواند

سرنوشت ۱۲۰ سال آینده وی را رقم زند .

# umbilical cord blood acid-base analysis at delivery/objective

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## umbilical cord blood acid-base analysis at delivery

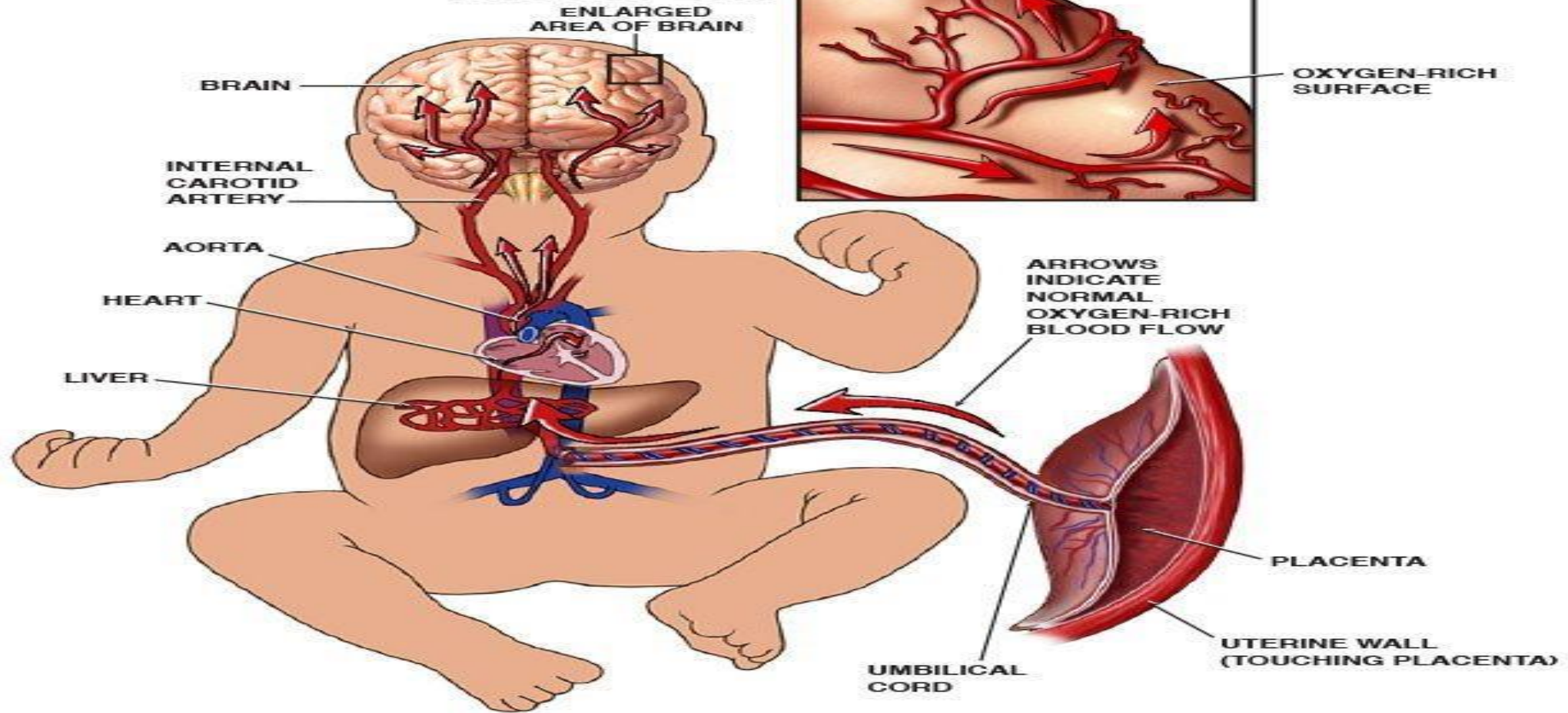
**INTRODUCTION** : Fetal acid-base balance can be assessed in a number of ways:

- 1- **Antepartum**, by percutaneous umbilical cord blood sampling.
2. **Intrapartum**, by fetal scalp blood sampling.
- 3- **Immediately after birth**, by umbilical cord blood sampling.

This is by far the most common time to assess acid-base balance.

The information can **be useful from medical and medico legal** perspectives since **it provides insight into intrapartum fetal physiology**.

## NORMAL PLACENTA-TO-BRAIN BLOOD FLOW



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## acid-base physiology :

- the fetus depends primarily upon the placenta to act as lungs and, to a lesser degree, kidneys to help compensate for acidemia .
- Uteroplacental hypo perfusion is the major cause of both respiratory and metabolic acidemia in the fetus, with progression from the former to the latter over time if decreased utero placental blood flow is not corrected .

# Fetal hypoxia:

- **Fetal hypoxia can occur when maternal oxygenation is compromised**

(eg, respiratory disease), maternal perfusion of the placenta is reduced (eg, preeclampsia, chronic hypertension, hypotension/hypovolemia, cyanotic heart disease), or

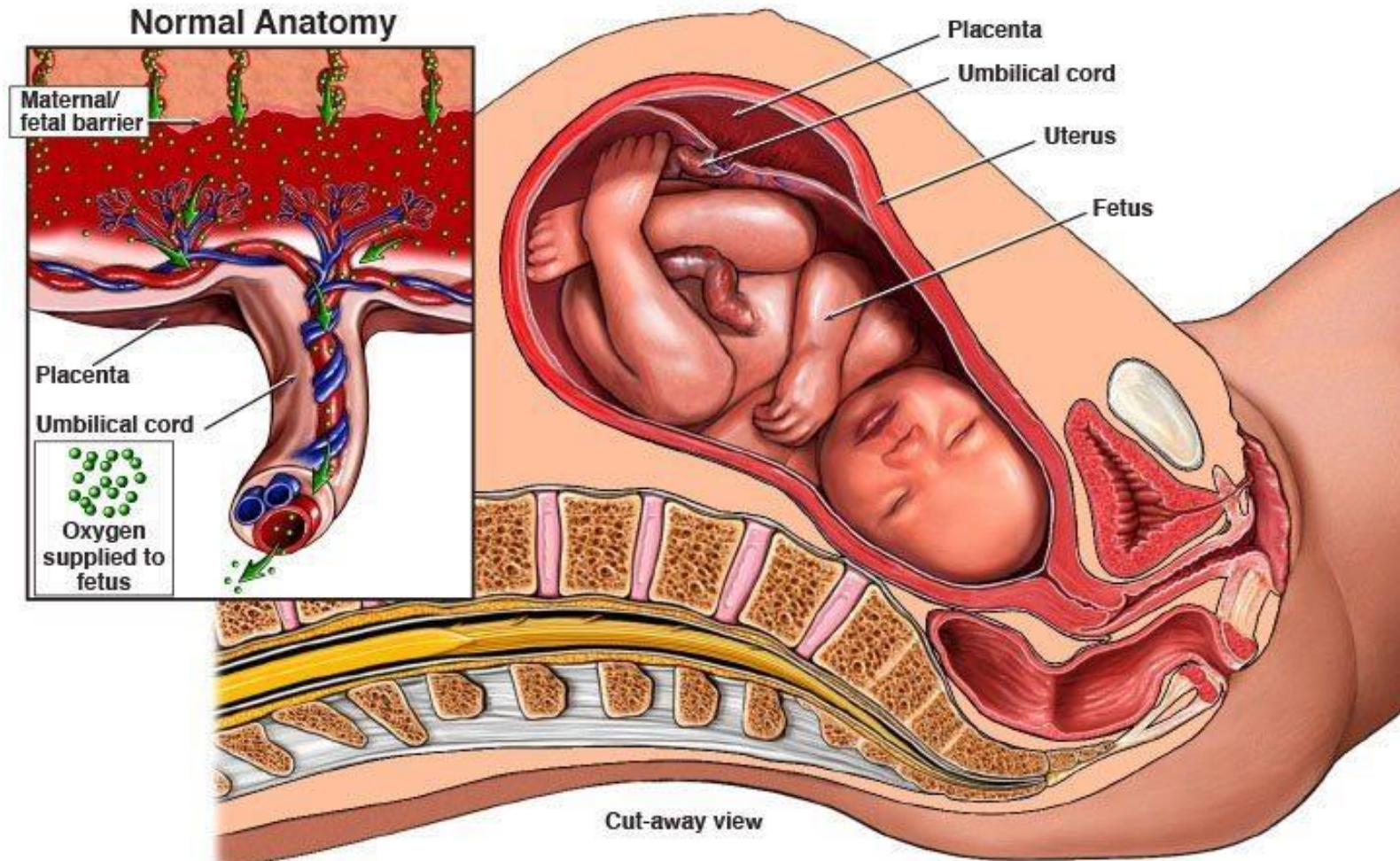
- **delivery of oxygenated blood from the placenta to the fetus is impeded**

(eg, placental abruption, cord compression).

**When adequate fetal oxygenation does not occur, metabolism proceeds along an anaerobic pathway with production of organic acids, such as lactic acid and keto acids.**

# Buffers:

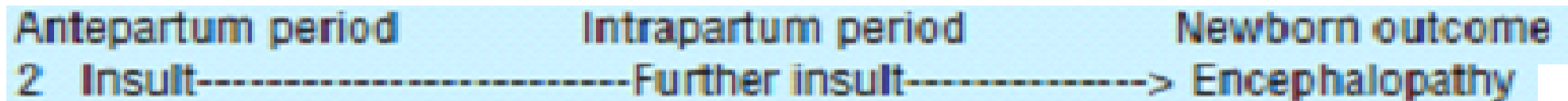
- **The placenta** also plays a significant role in helping to maintain a bicarbonate pool and buffering the fetus against changes in maternal pH or blood gas status.
- In a study using a perfused human placental model, **acidification of the maternal side of the circulation** did not significantly alter fetal acid-base status.
- A **base deficit** (or negative base excess) exists when the fetal serum bicarbonate concentration is below normal.
- *A **base excess exists** when the fetal bicarbonate concentration is above normal; however, alkalemia at birth is rare and always secondary to maternal abnormalities.*



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# Isolated fetal respiratory acidosis:

- Short time impairment of uteroplacental or fetoplacental circulation
- **The time of insult is no more than 20 -30 min.**
- Seldom is associated with adverse outcomes
- For each 10 mmHg increment in PCO<sub>2</sub> from normal neonatal PCO<sub>2</sub> at time of birth ( 50) PH rises 0.08 unit.



## Respiratory Acidemia

Acute interruption in placental gas exchange is accompanied by subsequent CO<sub>2</sub> retention and respiratory acidemia. The most common antecedent factor is transient umbilical cord compression. Generally, respiratory acidemia is not harmful to the fetus (Low, 1994).

The degree to which pH is affected by pCO<sub>2</sub>—the respiratory component of the acidosis—can be calculated. First, the upper normal neonatal pCO<sub>2</sub> of about 50 mm Hg is subtracted from the cord blood gas pCO<sub>2</sub> value. Each additional 10 mm Hg pCO<sub>2</sub> increment will lower the pH by 0.08 units (Eisenberg, 1987). Thus, in a mixed respiratory–metabolic acidemia, the benign respiratory component can be calculated. As an example, acute cord prolapse during labor prompts cesarean delivery of a neonate 20 minutes later. The umbilical artery blood gas pH was 6.95 and the pCO<sub>2</sub> was 90 mm Hg. The degree to which the cord compression and subsequent impairment of CO<sub>2</sub> exchange affected the pH is calculated using the relationship given earlier and shown below.

$$90 \text{ mm Hg} - 50 \text{ mm Hg} = 40 \text{ mm Hg excess CO}_2$$

$$\text{To correct pH: } (40 \div 10) \times 0.08 = 0.32; 6.95 + 0.32 = 7.27$$

Therefore, the pH before cord prolapse was approximately 7.27, well within normal limits. Thus, the low pH resulted from respiratory acidosis.

- **Acute interruption of oxygen supply = Intrapartum asphyxia**



- **CO<sub>2</sub> retention and respiratory acidosis**



- **Mixed acidosis** (low pH with low bicarbonate concentration and **high PCO<sub>2</sub>**)



- Pure **metabolic acidemia** (low pH and low bicarbonate concentration **with normal PCO<sub>2</sub>**)

develops when **accumulation of organic acids** depletes the buffer system to critically low levels of buffers.

# INDICATIONS FOR FETAL ACID-BASE ANALYSIS

- There is no consensus about when to perform umbilical cord blood acid-base analysis and no evidence that routinely measuring pH and blood gases at birth is cost-effective.
- The **ACOG & AAP** recommend performing umbilical artery blood acid-base analysis after any delivery in which a fetal metabolic abnormality is suspected [[7](#)].

# INDICATIONS FOR FETAL ACID-BASE ANALYSIS

- **Low Apgar score (at  $\geq 5$  minutes)**
- **Category III fetal heart rate pattern** an abnormal fetal heart rate tracing
- **Assisted vaginal delivery (vacuum, forceps)**
  - All non elective cesareans
  - Intrauterine growth restriction
  - Intrapartum fever
  - Multiple pregnancy

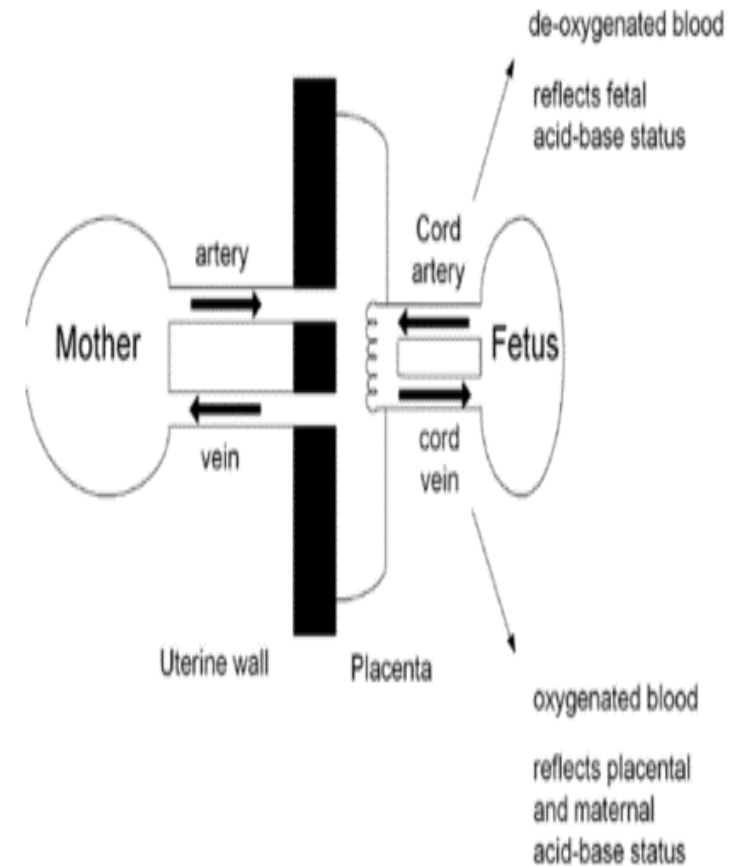
# TECHNIQUE:

- Sampling umbilical artery blood is preferable
  - umbilical arterial blood primarily reflects fetal metabolism while venous blood primarily reflects placental functions .
  - A 10 to 20 cm segment of umbilical cord
  - a 1 to 2 mL syringe (preferably glass), which has been flushed with heparin,
  - immediately transported on ice to the laboratory.
  - **Ideally**, the test is performed as soon as possible after delivery
  - stable for assessment of **both pH and base deficit for 60 minutes**





BG Parameter	Umbilical Artery	Umbilical Vein
pH	7.12 - 7.35	7.23 - 7.44
pO <sub>2</sub>	6.2 - 27.6	16.4 - 40.0
pCO <sub>2</sub>	41.9 - 73.5	28.8 - 53.3
Bicarbonate	18.8 - 28.2	17.2 - 25.6
Base Deficit	+9.3 to -1.5	+8.3 to -2.6



## Reference range for umbilical artery blood gas values in term newborns

Umbilical arterial blood	Mean	5th to 95th percentile
pH	7.27	7.15 to 7.38
PCO <sub>2</sub> (mmHg)	50.3	32 to 68
HCO <sub>3</sub> (mEq/L)	22	15.4 to 26.8
Base excess (mEq/L)	-2.7	-8.1 to 0.9

Values represent findings from umbilical artery cord blood analysis after vaginal delivery of 3522 unselected term infants delivered at Shands Hospital, University of Florida, 1992-1993.

*Data from: Riley RJ, Johnson JWC. Collecting and analyzing cord blood gases. Clin Obstet Gynecol 1993; 36:13.*

# Can umbilical venous blood be used?

- A sample from the umbilical vein should be sent if an umbilical artery sample cannot be obtained.

- In one study, :

over 50 percent of newborns with cord venous pH  $\geq 7.07$  had cord arterial pH  $> 7.0$

and

over 90 percent with cord venous pH  $\geq 7.14$  had cord arterial pH  $> 7.0$ .

# Sampling both the umbilical artery and vein

Some clinicians prefer to obtain two samples. If both vessels are sampled, **the median arteriovenous pH difference** is 0.09 (range 0.02 to 0.49).

- **One advantage** to sampling both vein and artery is that the ability to compare both sets of values *makes it clearer which set of values reflects* the vein versus the artery.
- If only one sample from one vessel is collected, it is not necessarily readily apparent from the values whether the sample reflects the artery or the vein.

# Sampling both the umbilical artery and vein

- In cases of sudden catastrophic events, **such as acute abruption or cord occlusion, the arterial value best represents the neonate's blood gas at **delivery** whereas the venous sample reflects the status just before the event.**
- Therefore, in such cases, clinicians are encouraged to obtain both umbilical artery and venous blood gas samples to provide a better index of the fetal acid-base status before an often unpredictable event.

## TEST RESULTS:

- The pH,  $\text{PCO}_2$ ,  $\text{PO}_2$ ,  $\text{CO}_2$ , hemoglobin, and oxygen content **of the blood are measured,**
- whereas bicarbonate concentration, percentage oxygen saturation, and base excess (or deficit) are **calculated.**
- The most useful values for interpretation of fetal-newborn condition and prognosis are **the pH and base excess (or deficit)**
- **Fetal pH is normally 0.1 unit lower than maternal pH.**

# TEST RESULTS:

- The mean umbilical arterial blood pH, base deficit, and gas values for preterm infants and term infants are almost identical.
- **Base deficit slowly increases during active labor and the second stage [37],**
- the mean umbilical cord blood gas values obtained at cesarean birth for term pregnancies not in labor were similar to those described in the table for vaginal deliveries.

# Acidosis

- A practical pH threshold for defining pathologic fetal acidemia that is used by the author and others is **umbilical artery pH <7.00** ,  
**which occurs in 3.7 per 1000 non anomalous term births .**
- Umbilical artery pH >7.00 and <7.20 or <7.10 has been proposed **as the threshold for identifying fetuses with abnormal fetal heart rate tracings who might benefit from intervention prior to the development of pathologic fetal acidosis and fetal injury .**

# Acidosis

- Although the **umbilical artery pH** can be used alone to classify the presence or absence of acidosis,
- **the base deficit** is helpful in distinguishing whether umbilical artery acidemia is respiratory or metabolic .
- **Umbilical artery acidosis with a metabolic component**, especially if persistent after delivery, is a **strong predictor of an increased risk of neonatal morbidity or mortality**;
- **respiratory acidosis** is not usually associated with complications in the newborn.

## Base deficit (negative base excess)

- The decreased concentration of buffers (primarily bicarbonate) associated with metabolic acidosis is reported as the base deficit or negative base excess.
- the **base deficit is useful for interpretation of umbilical artery pH** because an increase in base deficit distinguishes acidosis with a **metabolic component** (low pH, low bicarbonate concentration) from **respiratory acidosis** (low pH, normal bicarbonate concentration).

# Base deficit (negative base excess)

- The base deficit has a linear relationship with lactic acid accumulation and correlates with the risk of neonatal neurologic morbidity [\[7\]](#).
- An umbilical artery base deficit  $\geq 12$  mmol/L, which is  $>2$  standard deviations above the mean [\[35\]](#), is commonly accepted as **a reasonable threshold for predicting an increased risk of moderate or severe newborn complications**.
- **A base deficit of 12 to 16 mmol/L is associated with an**
  - **increase in newborn mortality,**
  - **moderate to severe neonatal encephalopathy,**
  - **multiorgan failure, and**
  - **long-term neurologic dysfunction.**

# Base deficit (negative base excess)

- In one study,

moderate or severe complications occurred in :

**-10 percent of newborns with umbilical artery base deficit 12 to 16 mmol/L**

and in - **40 percent of those >16 mmol/L** [\[58\]](#).

- base deficit in academic newborn at term is an independent marker for neonatal morbidity and mortality has been questioned.

# Base deficit (negative base excess)

- It has been estimated that fetal stress characterized by repetitive moderate or severe variable decelerations may increase the BD by 1 mmol/L per 30 minutes;
- repetitive late or severe atypical variable decelerations (subacute fetal compromise) may increase the BD by 1 mmol/L per 6 to 15 minutes; and
- terminal bradycardia (eg, from ruptured uterus, major abruption, or complete cord occlusion) may increase the BD by as much as 1 mmol/L per two to three minutes.
- an uncomplicated labor results in a 3 mmol/L change in BD over many hours ( the average umbilical artery BD at vaginal delivery is 5 mmol/L).

# Short or long lasting hypoxia

- High BD in artery and normal BD in vein – short lasting hypoxia

E.g	Art pH 7.01	Vein pH 7.27
	CO2 8.82	5.14
	<u>BD 12.8</u>	<u>8.0</u>

- High BD in artery and vein – long lasting hypoxia

E.g.	Art pH 7.01	Vein pH 7.12
	CO2 8.82	6.65
	<u>BD 12.8</u>	<u>11.5</u>

# Base deficit (negative base excess)

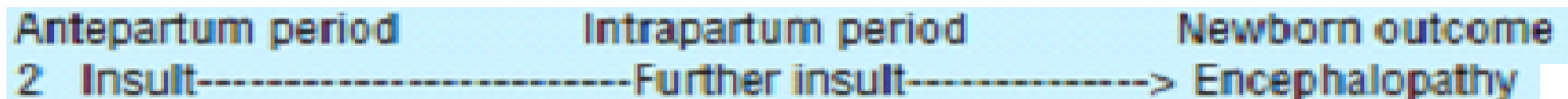
- **It is important to note that base deficit is calculated from pH and  $\text{PCO}_2$  using an algorithm and that blood gas analyzers do not use a universal standard algorithm for this calculation.**
- Studies have shown that the base deficit value reported by a laboratory is impacted by :
  1. the fetal **fluid compartment sampled** (blood, extracellular fluid),
  2. **choice of algorithm**, and
  3. **brand of blood gas analyzer** [[59,63](#)].

# Lactate levels

- Routine assessment of umbilical artery lactate levels is not recommended given the poor predictive value of newborn outcome.
- The threshold lactate concentration predictive of adverse short-term neonatal outcome is controversial and depends on the specimen (hemolyzed or whole blood) and the lactate meter used

# Damaging acidosis

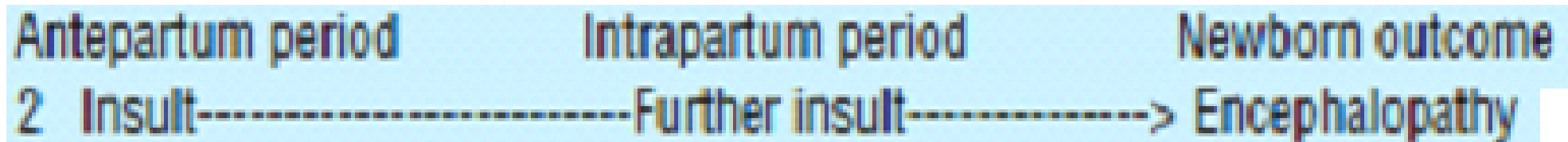
- PH less than 7
- BASE D. more than : -12 ( -16 )
- PH is not an ideal parameter for estimating the cumulative exposure to hypoxia because it does not give a linear measure of acid accumulation
- Base D. is better and has more linear relation with degree of hypoxia
- In mixed acidosis we can estimate PH before acute insult



# Umbilical cord blood gases and birth injury litigation

- Umbilical cord blood gases are frequently used in [birth injury](#) litigation.
- **There are many reasons why a fetus who suffered asphyxia or hypoxia can have a normal cord gas.**
- the results may be invalid due to
  - error in drawing,
  - storing or
  - analyzing the blood.

**A study suggested that up to 19 percent of umbilical cord blood samples may be invalid due to technical errors .**



# Prior ABG is NL. BUT second ABG is ABNL.

- **Acute near-total asphyxia** : usually lasts 5 to 30 minutes, and causes complete or near-complete cessation of blood flow to the fetus.
- **Etiologies** include :
  - **uterine rupture**
  - **complete placental abruption,**
  - **severe cord compression.**

May without providing the opportunity to document in utero acidosis at the end of parturition.

- **(reperfusion acidosis)** As the baby is resuscitated, circulation improves and tissue lactic acid is cleared into the central circulation.

من یک نوزادم: برایم دعا کن، روحم را در می یابم

