



# **Umbilical blood gas analysis**

**Dr Razavi**  
**Perinatology conference**  
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# How and when umbilical cord gas analysis can justify your obstetric management

Three cases illustrate how umbilical cord gas values can provide insight into a newborn's status

Michael G. Ross, MD, MPH

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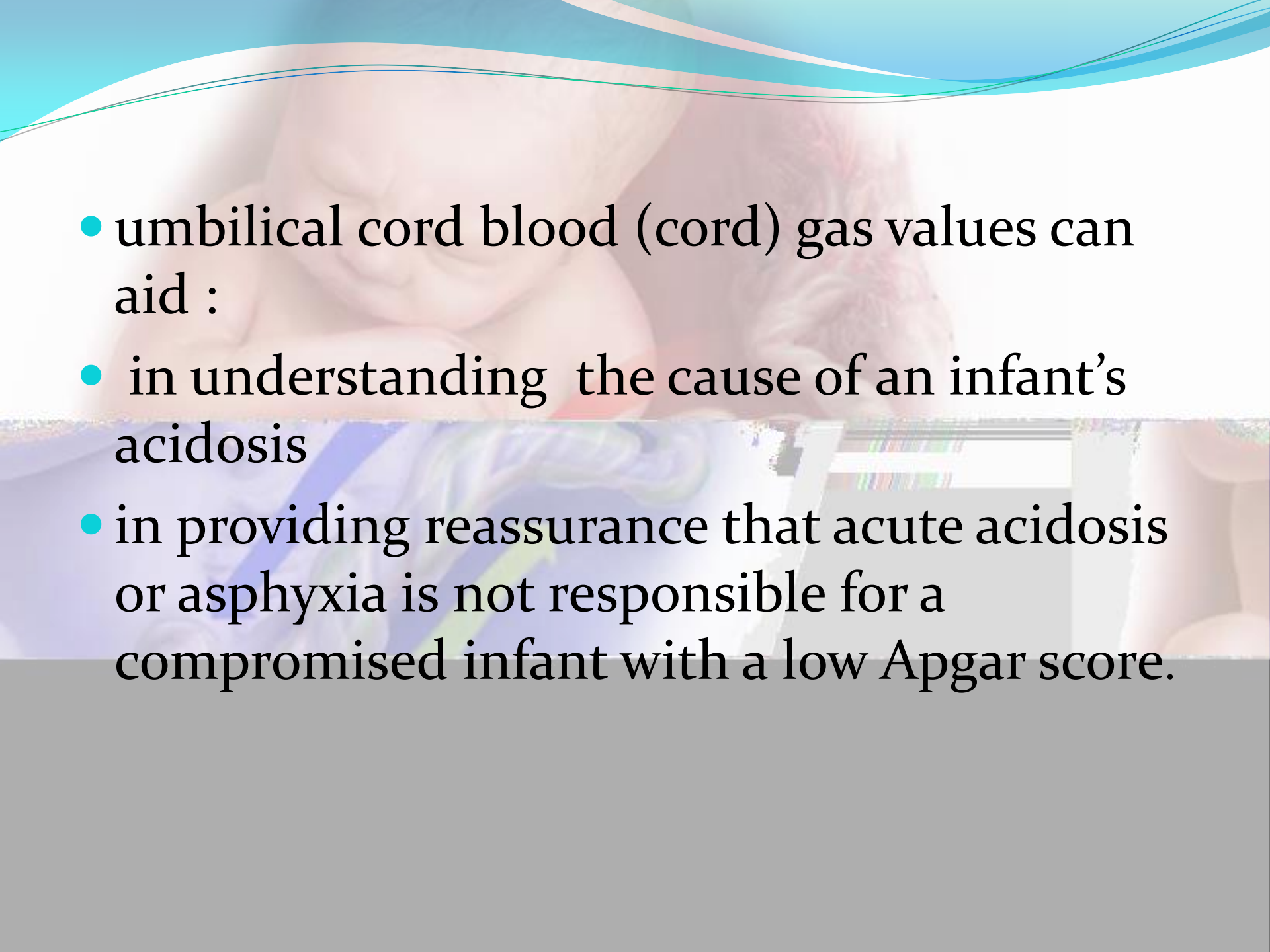
Dr. Ross is Distinguished Professor of Obstetrics and Gynecology and Public Health, Geffen School of Medicine at UCLA, Fielding School of Public Health at UCLA, Department of Obstetrics and Gynecology, Harbor/UCLA Medical Center, Torrance, California.

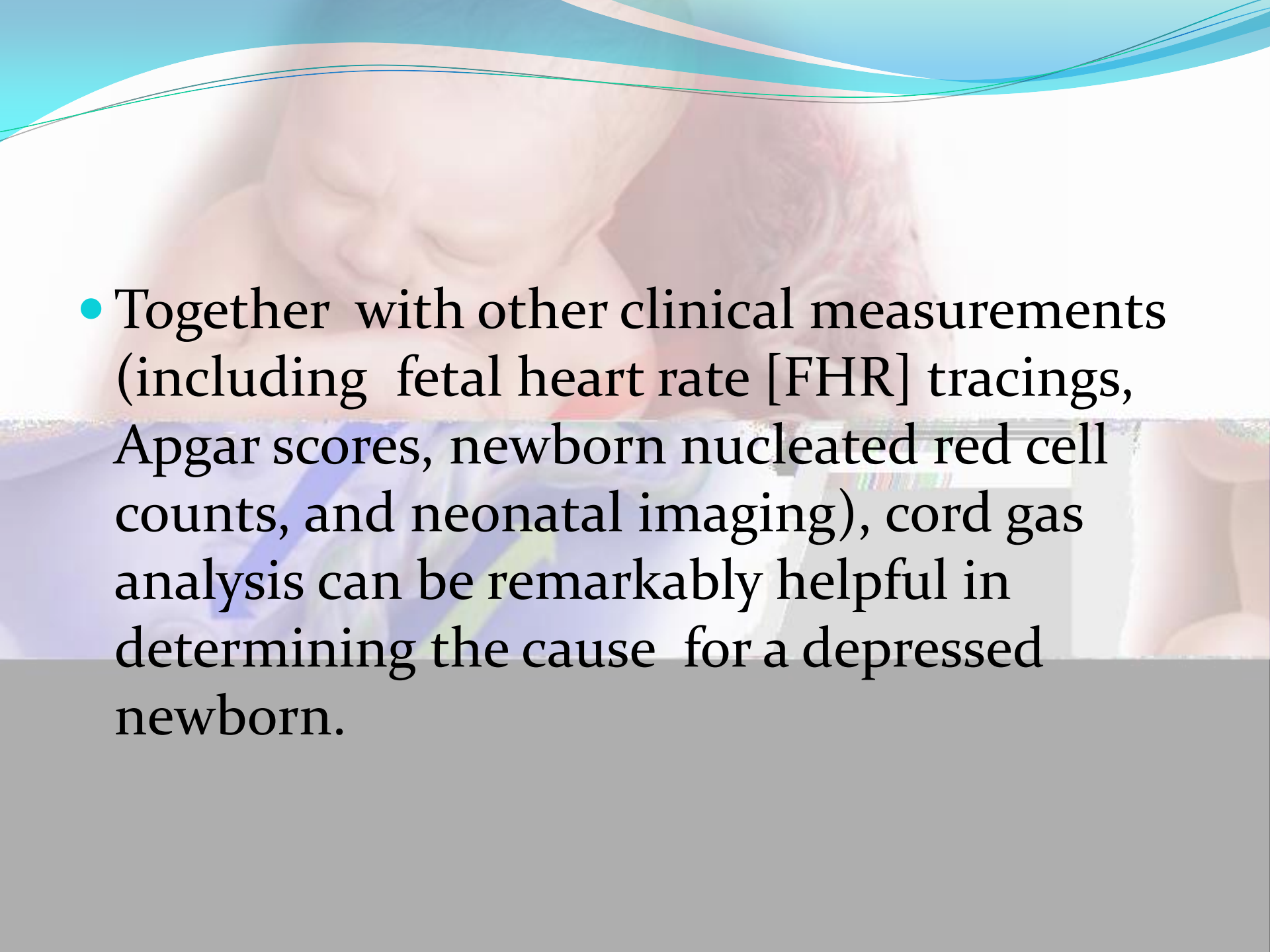
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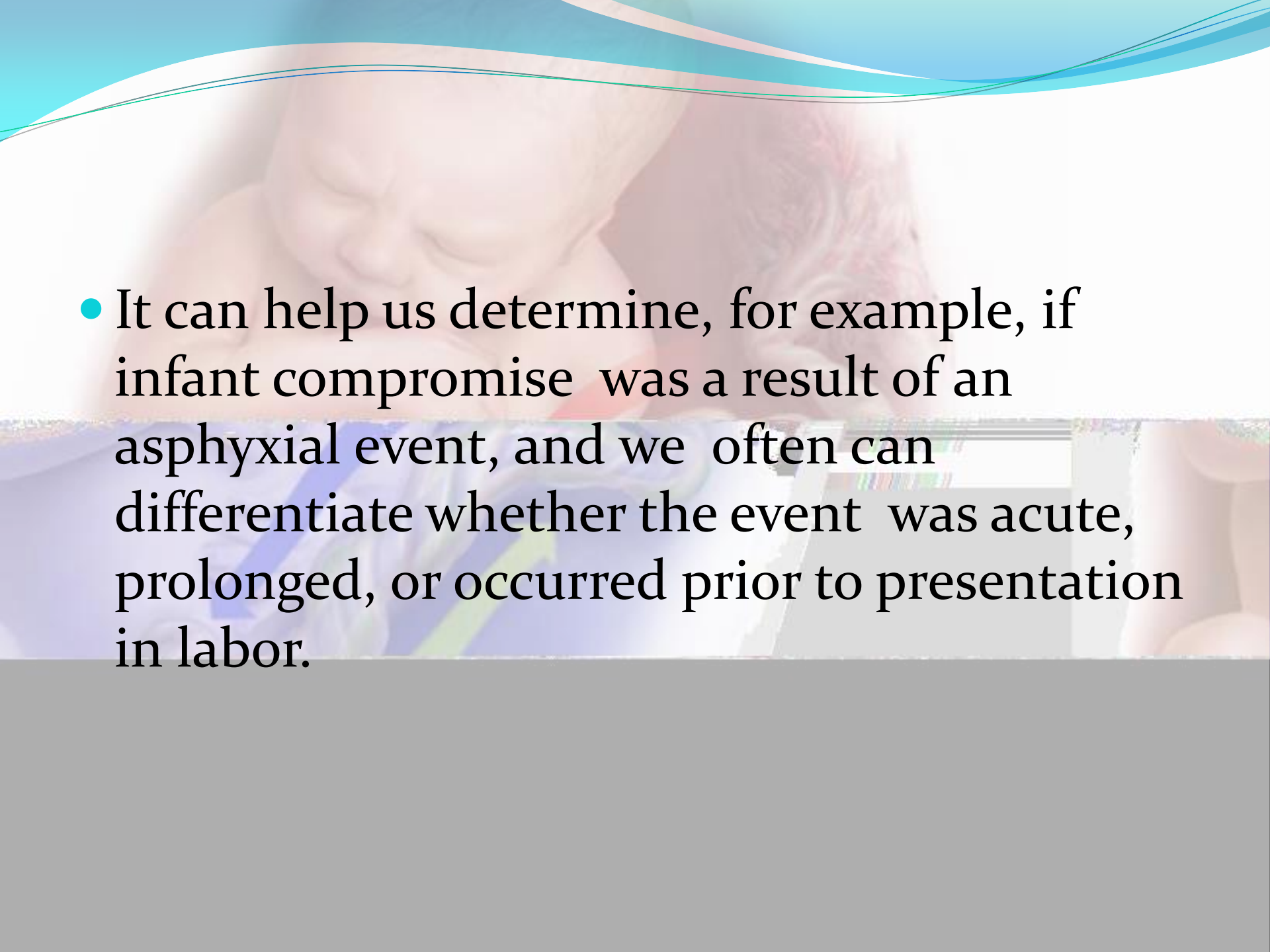
*The author reports no financial relationships relevant to this article.*

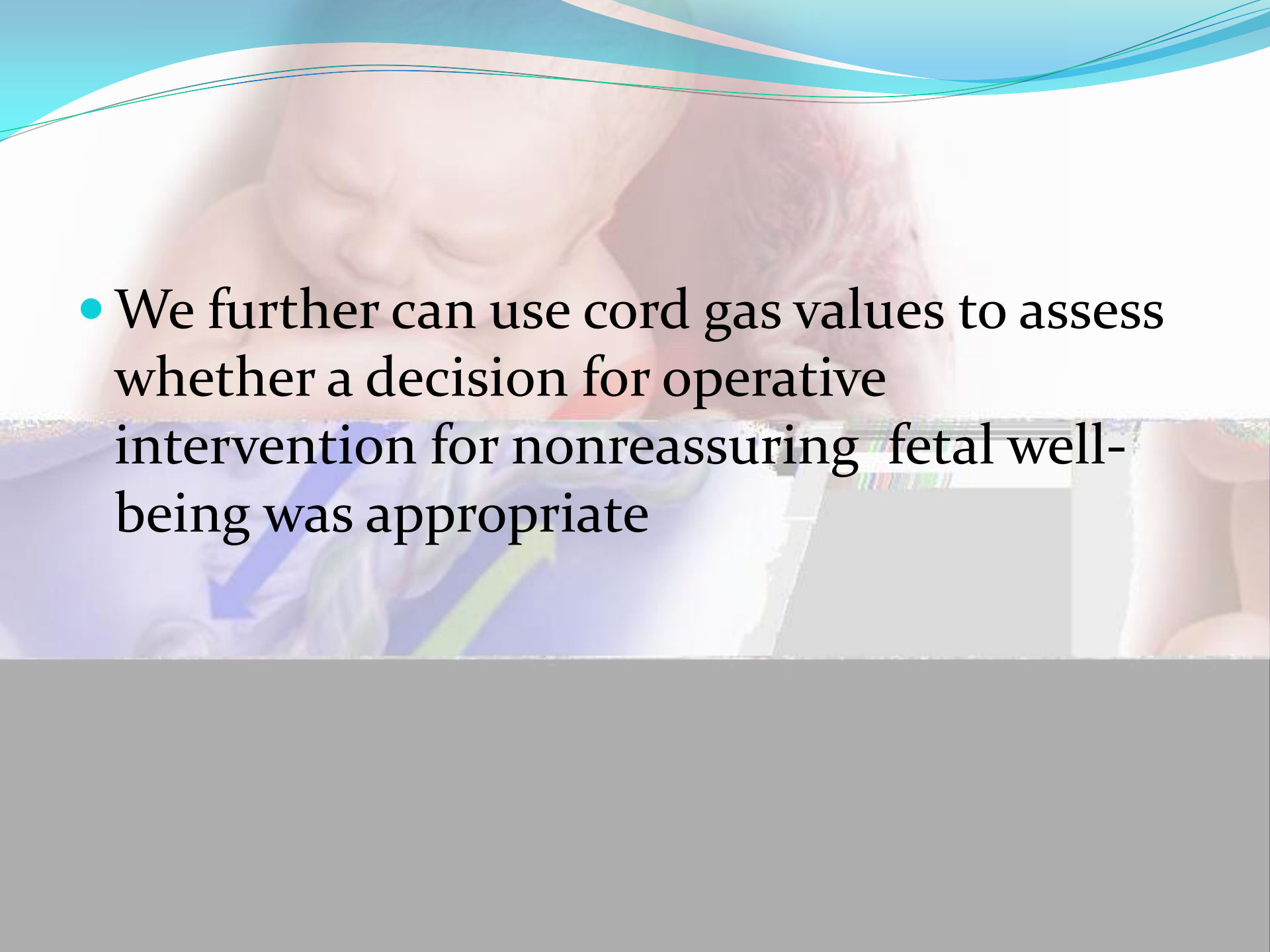




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- A newborn baby is lying in a hospital bed, partially covered by a blue blanket. A heart rate monitor is visible on the right side of the bed. The background is a soft, out-of-focus image of the baby's face and the hospital room.
- umbilical cord blood (cord) gas values can aid :
  - in understanding the cause of an infant's acidosis
  - in providing reassurance that acute acidosis or asphyxia is not responsible for a compromised infant with a low Apgar score.

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- Together with other clinical measurements (including fetal heart rate [FHR] tracings, Apgar scores, newborn nucleated red cell counts, and neonatal imaging), cord gas analysis can be remarkably helpful in determining the cause for a depressed newborn.

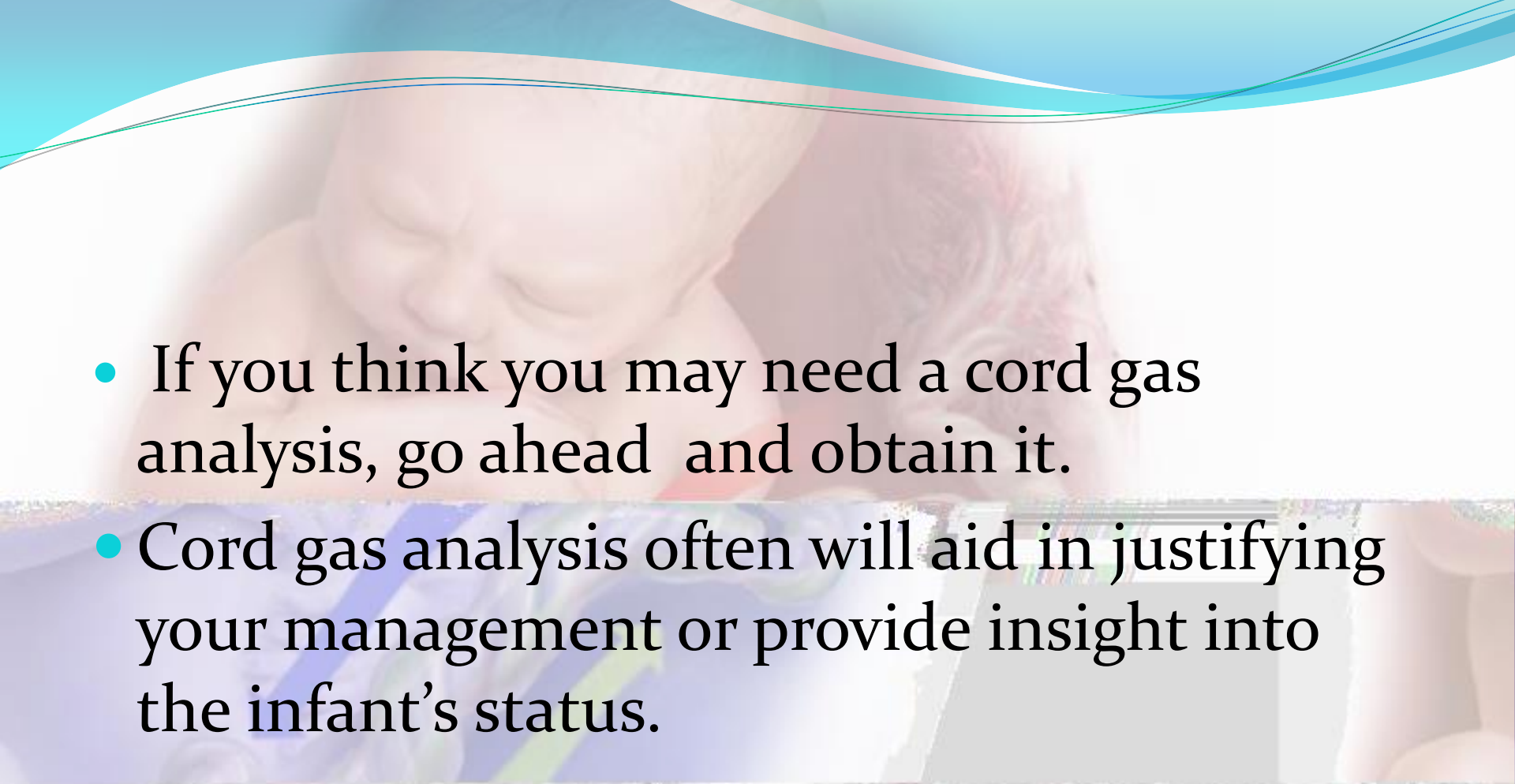
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- It can help us determine, for example, if infant compromise was a result of an asphyxial event, and we often can differentiate whether the event was acute, prolonged, or occurred prior to presentation in labor.

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- We further can use cord gas values to assess whether a decision for operative intervention for nonreassuring fetal well-being was appropriate



## checking umbilical cord blood gas values on:

- all operative vaginal deliveries,
- cesarean deliveries for fetal concern,
- abnormal FHR patterns,
- clinical chorioamnionitis
- , multifetal gestations,
- premature deliveries,
- and all infants with low Apgar scores at 1 or 5 minutes.

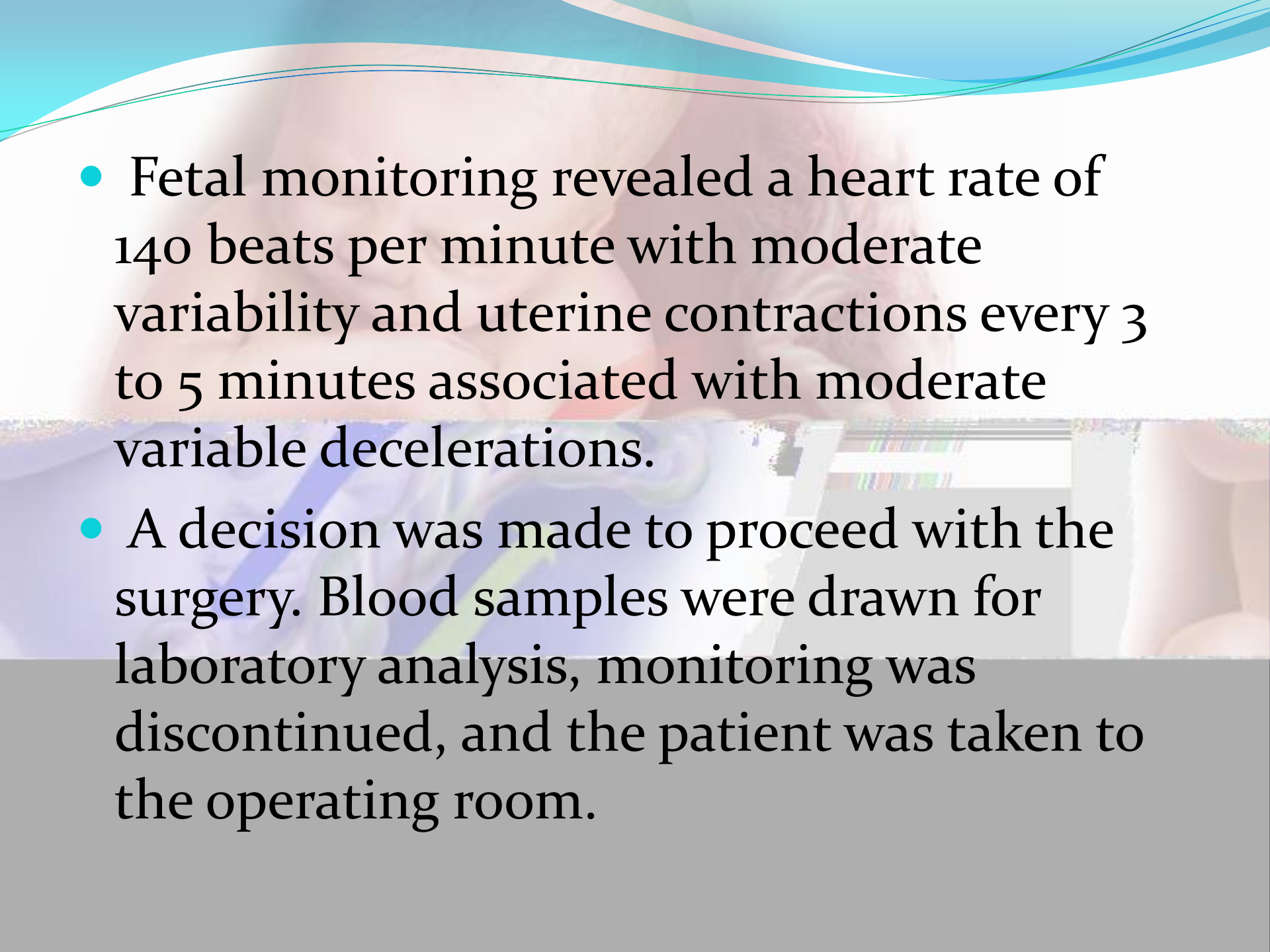
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- If you think you may need a cord gas analysis, go ahead and obtain it.
  - Cord gas analysis often will aid in justifying your management or provide insight into the infant's status.

## Controversy remains as to the benefit of universal cord gas analysis

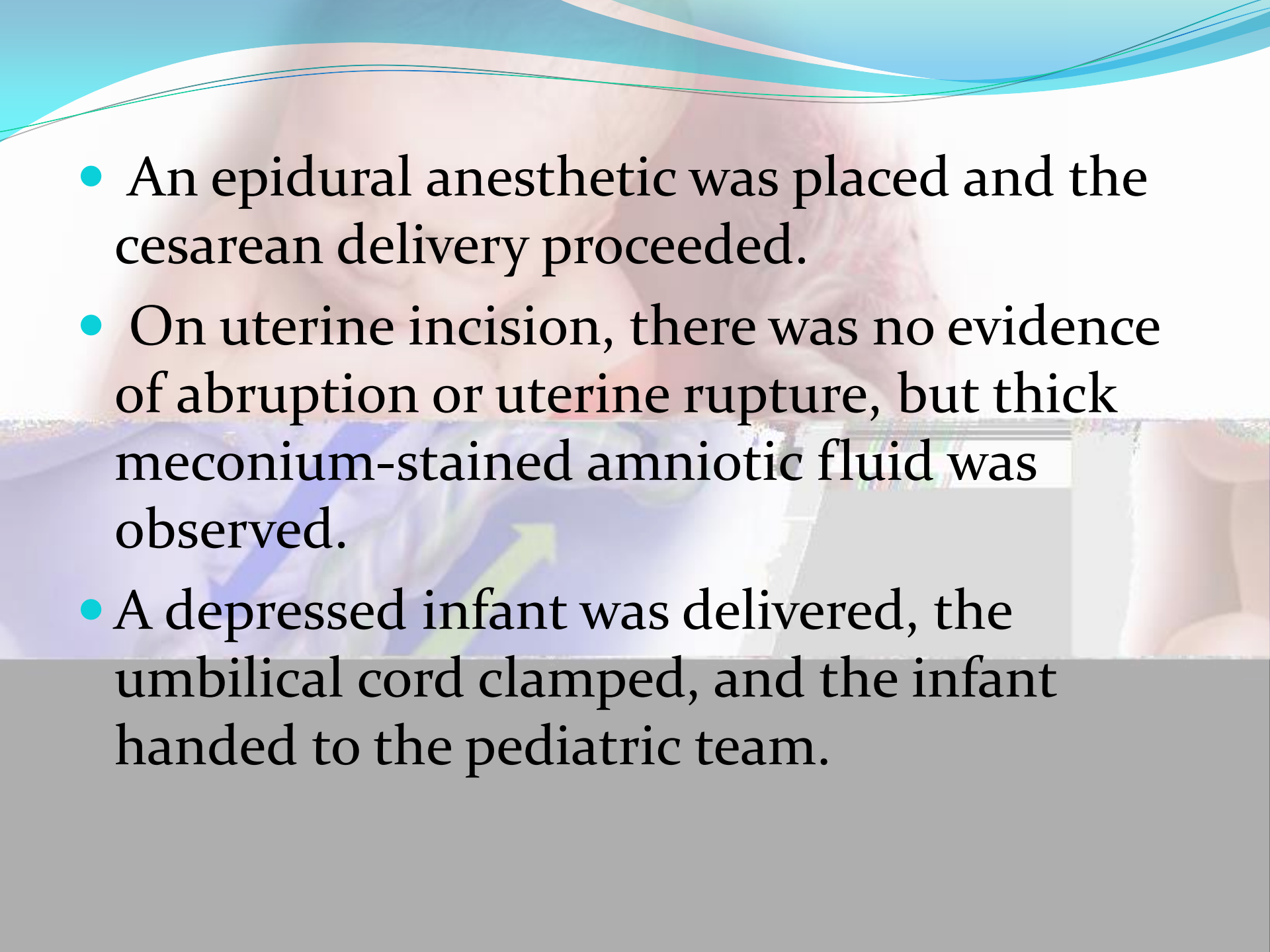
- . Assuming a variable cost of \$15 for 2 (artery and vein) blood gas samples per neonate,
- the annual cost in the United States would be approximately \$60 million.
- This would likely be cost effective as a result of:
- medico legal and educational benefits
- potential improvements in perinatal outcome
- reductions in special care nursery admissions.
- Blood gas in Iran 120000 rials

## CASE 1 A newborn with unexpected acidosis

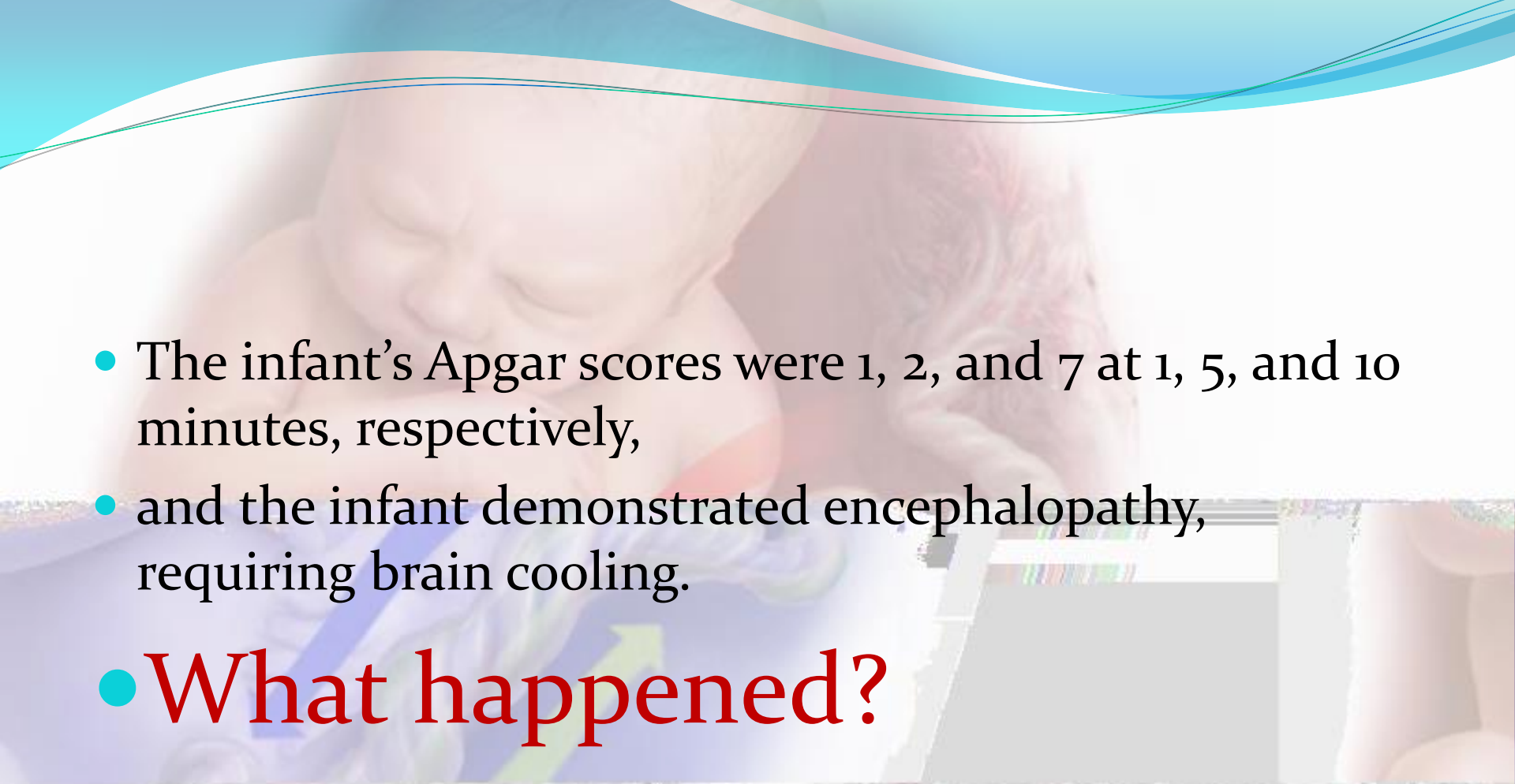
- A 29-year-old woman (G2P1) at 38 weeks' gestation
- was admitted to the hospital following an office visit during which oligohydramnios (amniotic fluid index, 3.5 cm) was found.
- The patient had a history of a prior cesarean delivery for failure to progress, and she desired a repeat cesarean delivery.

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- Fetal monitoring revealed a heart rate of 140 beats per minute with moderate variability and uterine contractions every 3 to 5 minutes associated with moderate variable decelerations.
  - A decision was made to proceed with the surgery. Blood samples were drawn for laboratory analysis, monitoring was discontinued, and the patient was taken to the operating room.



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- An epidural anesthetic was placed and the cesarean delivery proceeded.
  - On uterine incision, there was no evidence of abruption or uterine rupture, but thick meconium-stained amniotic fluid was observed.
  - A depressed infant was delivered, the umbilical cord clamped, and the infant handed to the pediatric team.

- Cord samples were obtained
- values from the umbilical artery were as follows: pH, 6.80; Pco<sub>2</sub>, 120 mm Hg; Po<sub>2</sub>, 6 mm Hg; and base deficit extracellular fluid (BDECF), 13.8 mmol/L.
- Values from the umbilical vein were: pH, 7.32; Pco<sub>2</sub>, 38 mm Hg; Po<sub>2</sub>, 22 mm Hg; and BDECF , 5.8 mmol/L.

- 
- A newborn baby is lying in a hospital bed, appearing to be asleep. The baby is wearing a blue hospital gown. To the right of the baby, there is a piece of medical equipment, possibly a monitor or a ventilator, with a screen and various tubes. The background is a soft, out-of-focus light blue and white. The top of the image has a decorative blue and white wavy border.
- The infant's Apgar scores were 1, 2, and 7 at 1, 5, and 10 minutes, respectively,
  - and the infant demonstrated encephalopathy, requiring brain cooling.
  - **What happened?**

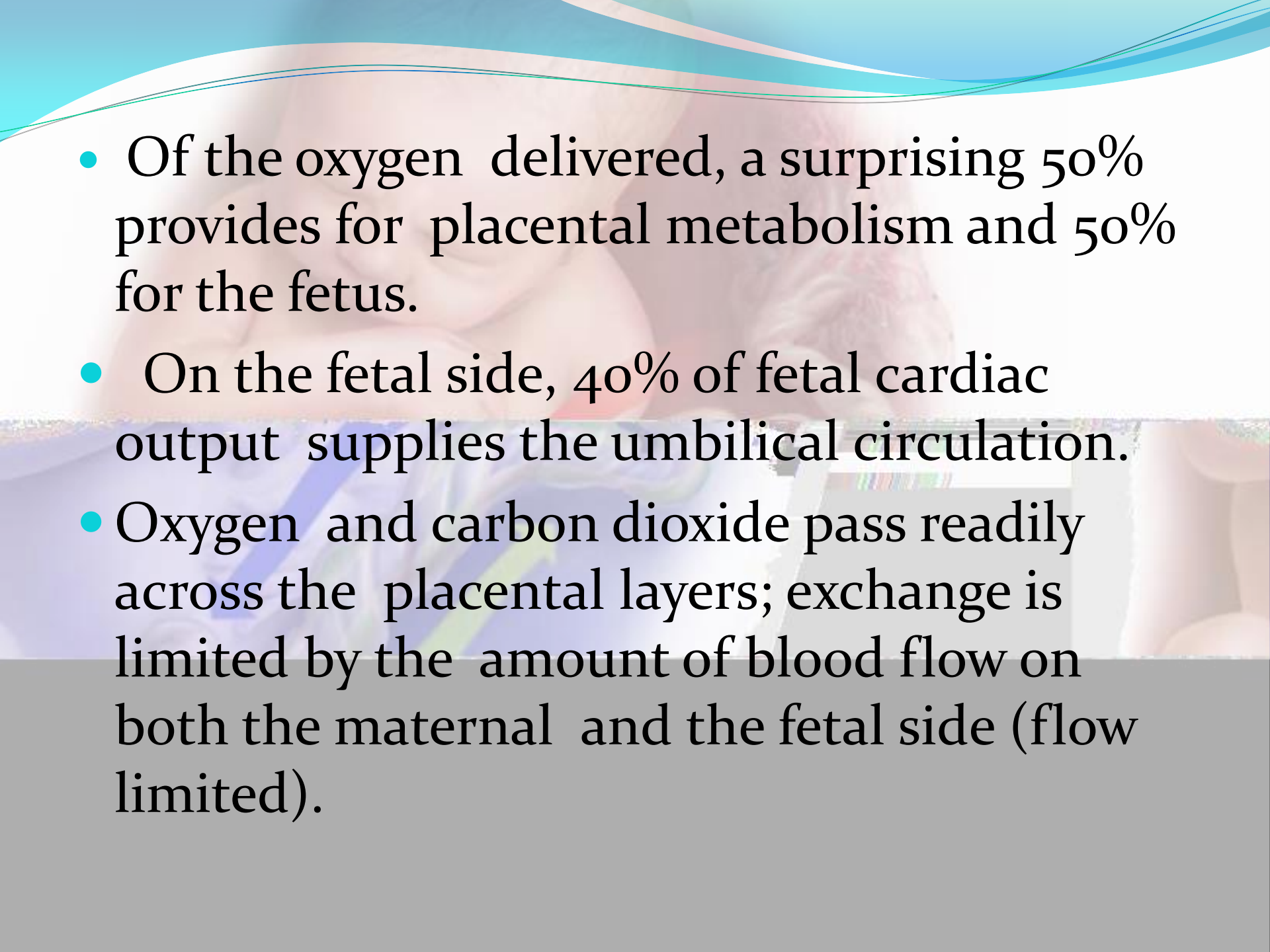
## Before analyzing cord gas values

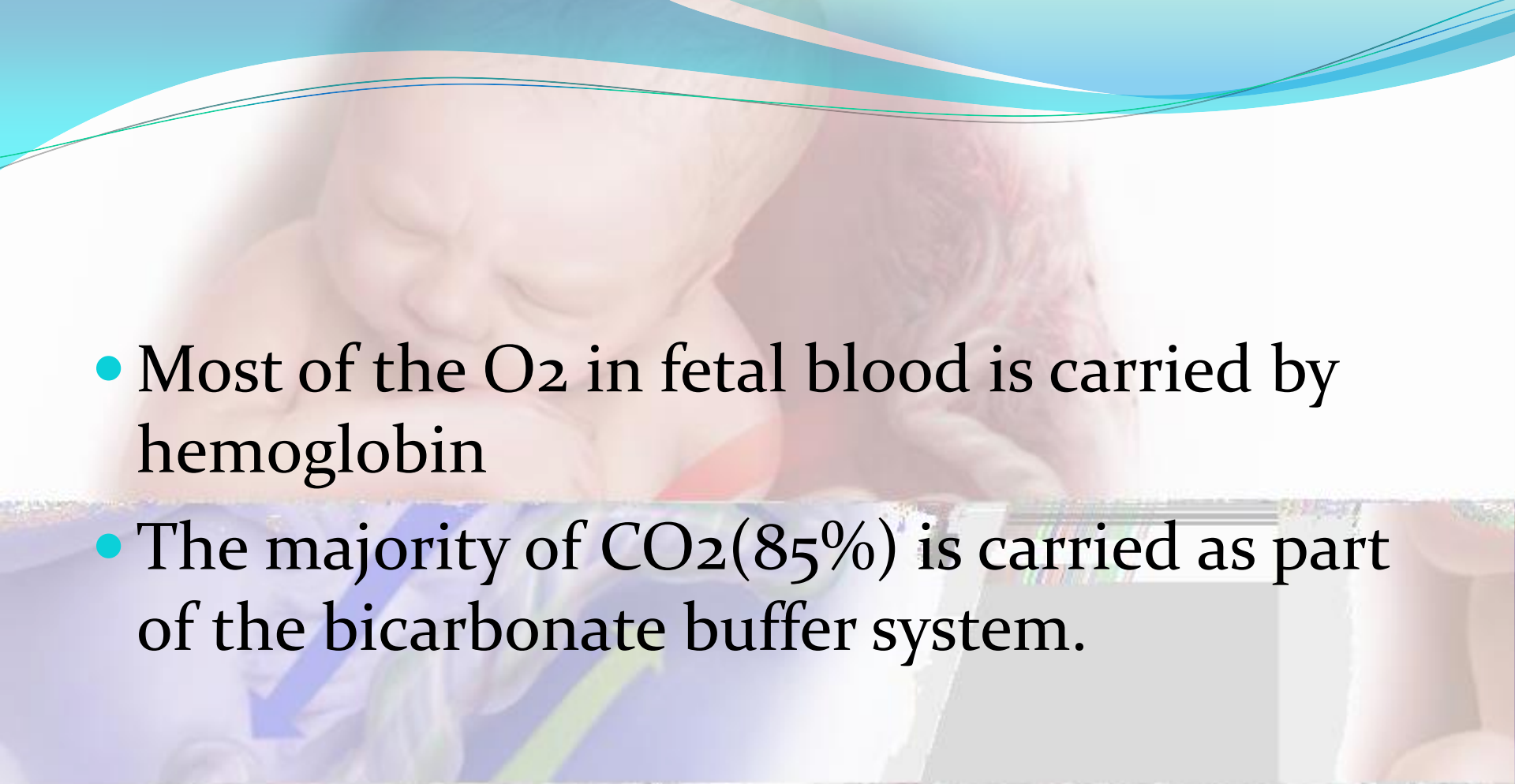
- it is important to consider several key questions, including:
- What are the normal levels of cord pH, O<sub>2</sub>, CO<sub>2</sub>, and base deficit (BD)?
- How does cord gas indicate what happened during labor?
- What are the preventable errors in cord gas sampling or interpretation?

## A rapid review of basic fetal cord gas physiology

- Fetal cord gas values result from the rapid transfer of gases and the slow clearance of acid across the placenta.
- Approximately 10% of maternal blood flow supplies the uteroplacental circulation, with the nearterm placenta receiving approximately 70% of the uterine blood flow.



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- Of the oxygen delivered, a surprising 50% provides for placental metabolism and 50% for the fetus.
  - On the fetal side, 40% of fetal cardiac output supplies the umbilical circulation.
  - Oxygen and carbon dioxide pass readily across the placental layers; exchange is limited by the amount of blood flow on both the maternal and the fetal side (flow limited).

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- Most of the  $O_2$  in fetal blood is carried by hemoglobin
  - The majority of  $CO_2$  (85%) is carried as part of the bicarbonate buffer system.

**TABLE 1** Normal values for fetal umbilical cord gases<sup>6,7</sup>

	<b>Umbilical artery</b>	<b>Umbilical vein</b>
pH	7.18–7.38	7.25–7.45
Po <sub>2</sub>	5.6–30.4 mm Hg	17.4–41.0 mm Hg
Pco <sub>2</sub>	32.4–66.0 mm Hg	27.0–49.4 mm Hg
BD <sub>cor</sub> , mean (SD)	4.79 (3.46) mmol/L	-4.0 (3.5) mmol/L

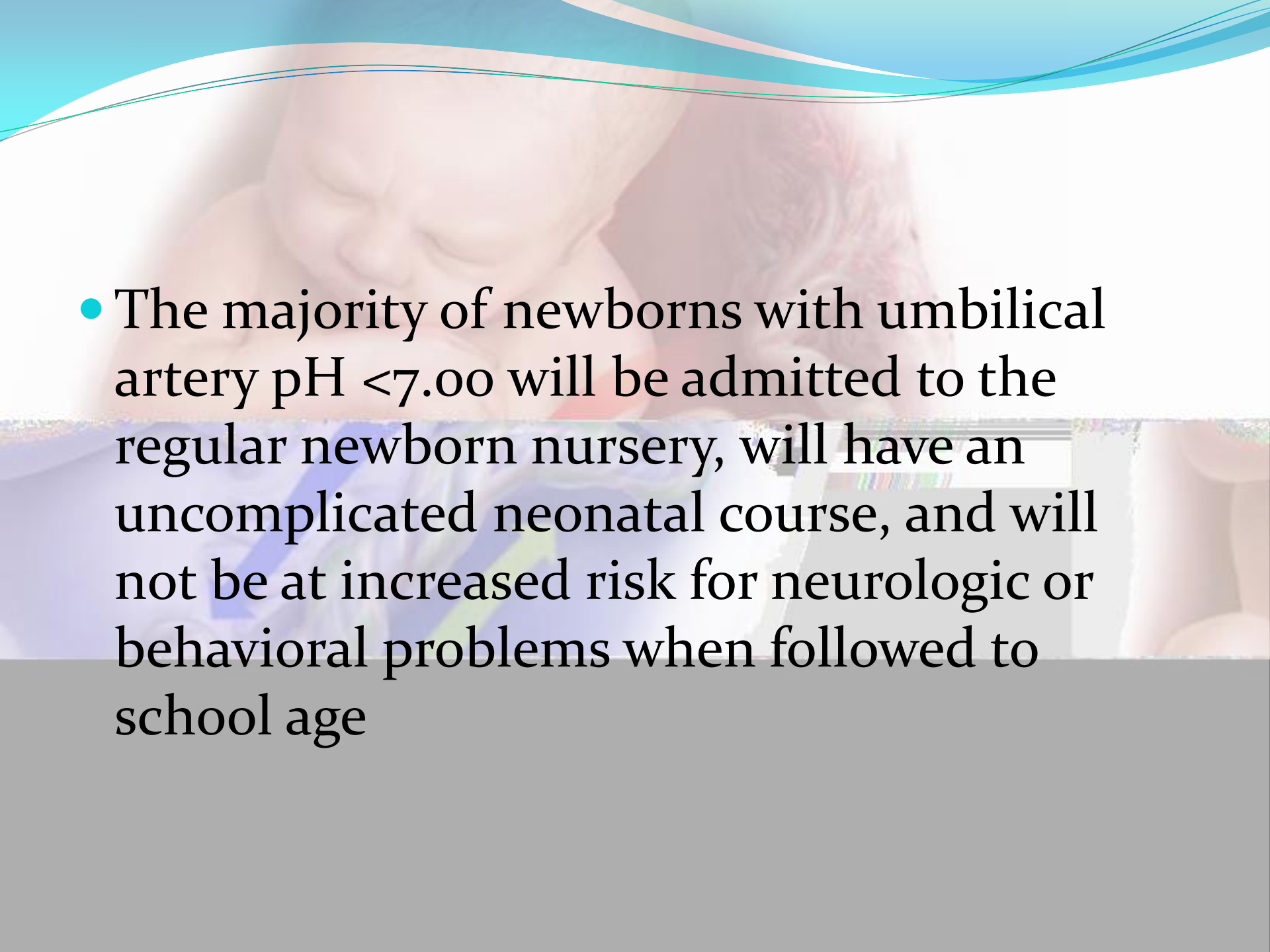
Ranges based on mean  $\pm$  2 SD.

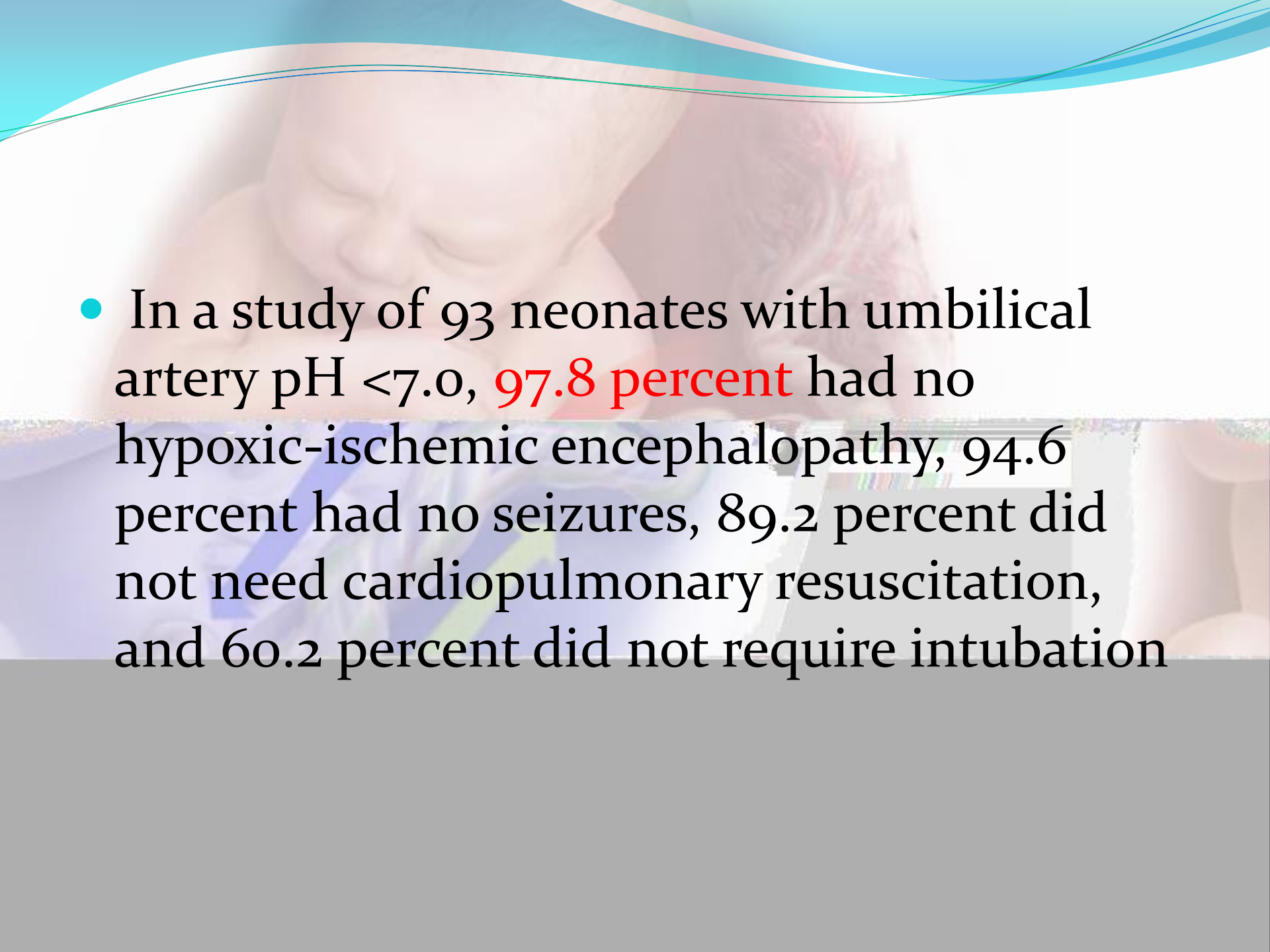
**TABLE 2** Fetal umbilical cord gases:  
The “20, 30, 40, 50 rule”

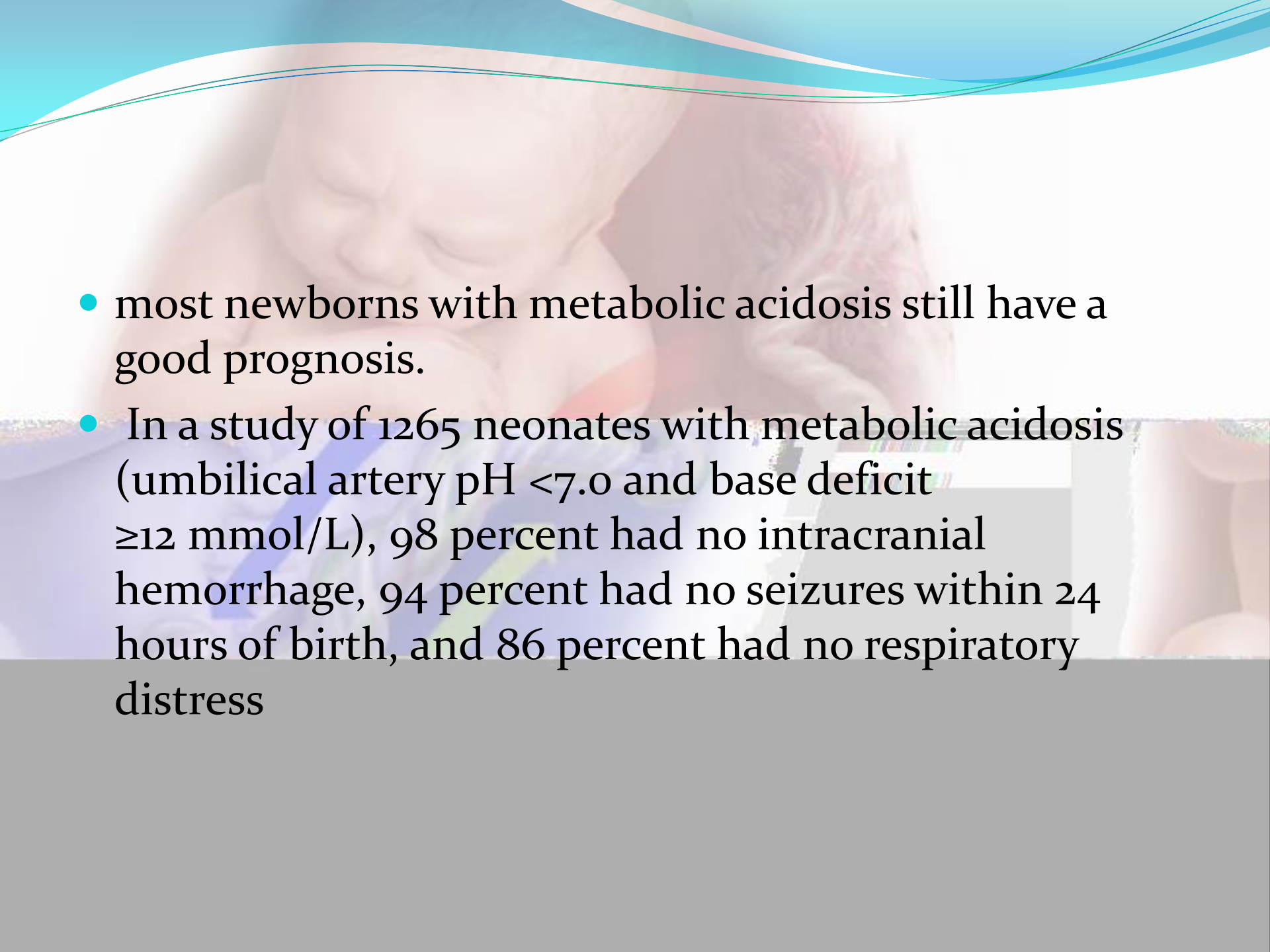
<b>Value, mm Hg</b>	<b>Cord gas measured</b>
20	Umbilical artery $PO_2$
30	Umbilical vein $PO_2$
40	Umbilical vein $PCO_2$
50	Umbilical artery $PCO_2$

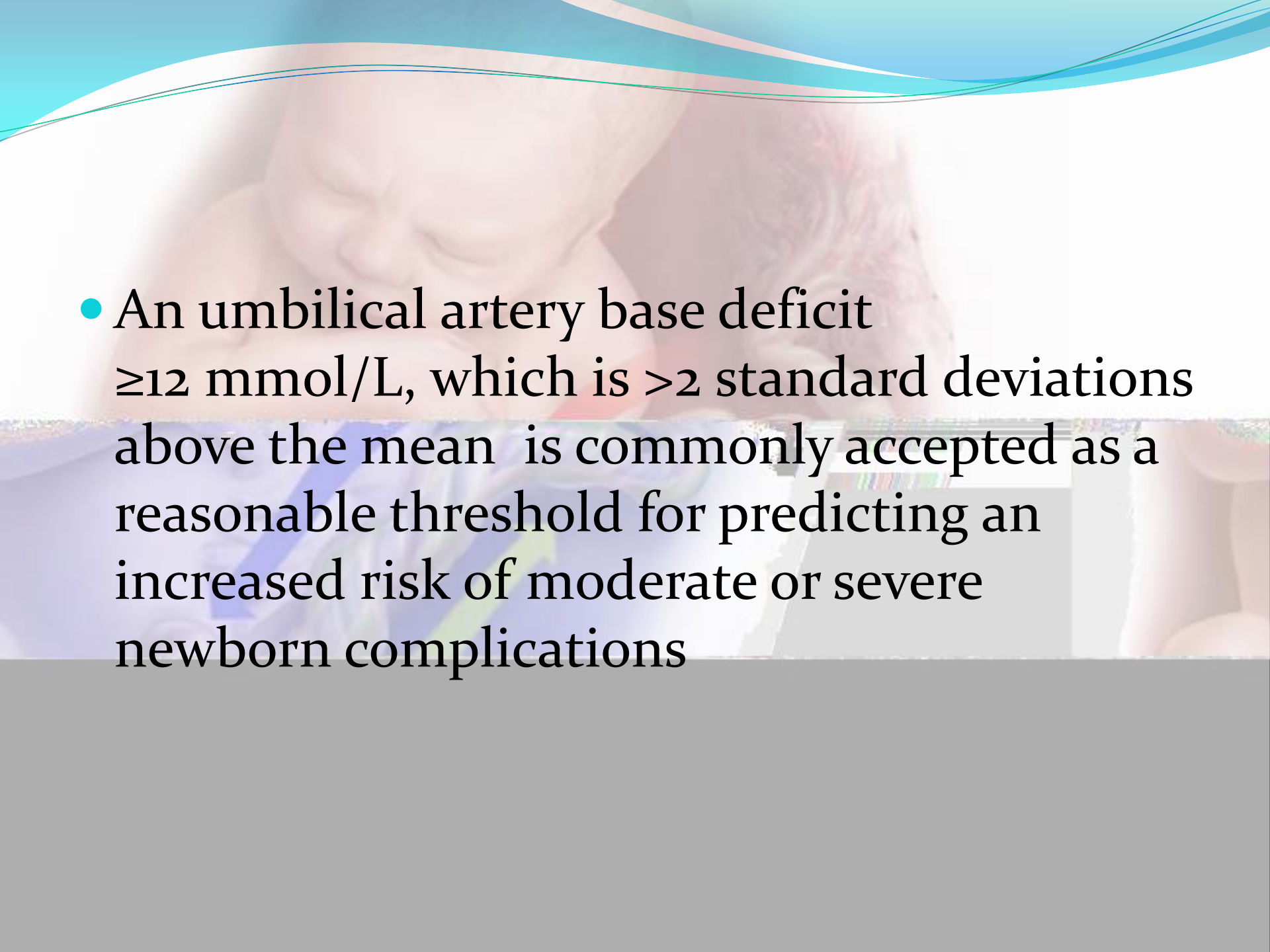
- In a cohort study of over 8700 singleton nonanomalous infants at term (520 with umbilical artery pH <7.1 and 84 with umbilical artery pH <7.0), umbilical artery pH was a strong predictor of all adverse outcomes
- Encephalopathy or death occurred in 2.3 percent of all acidemic infants and 8.5 percent of infants with severe acidemia.

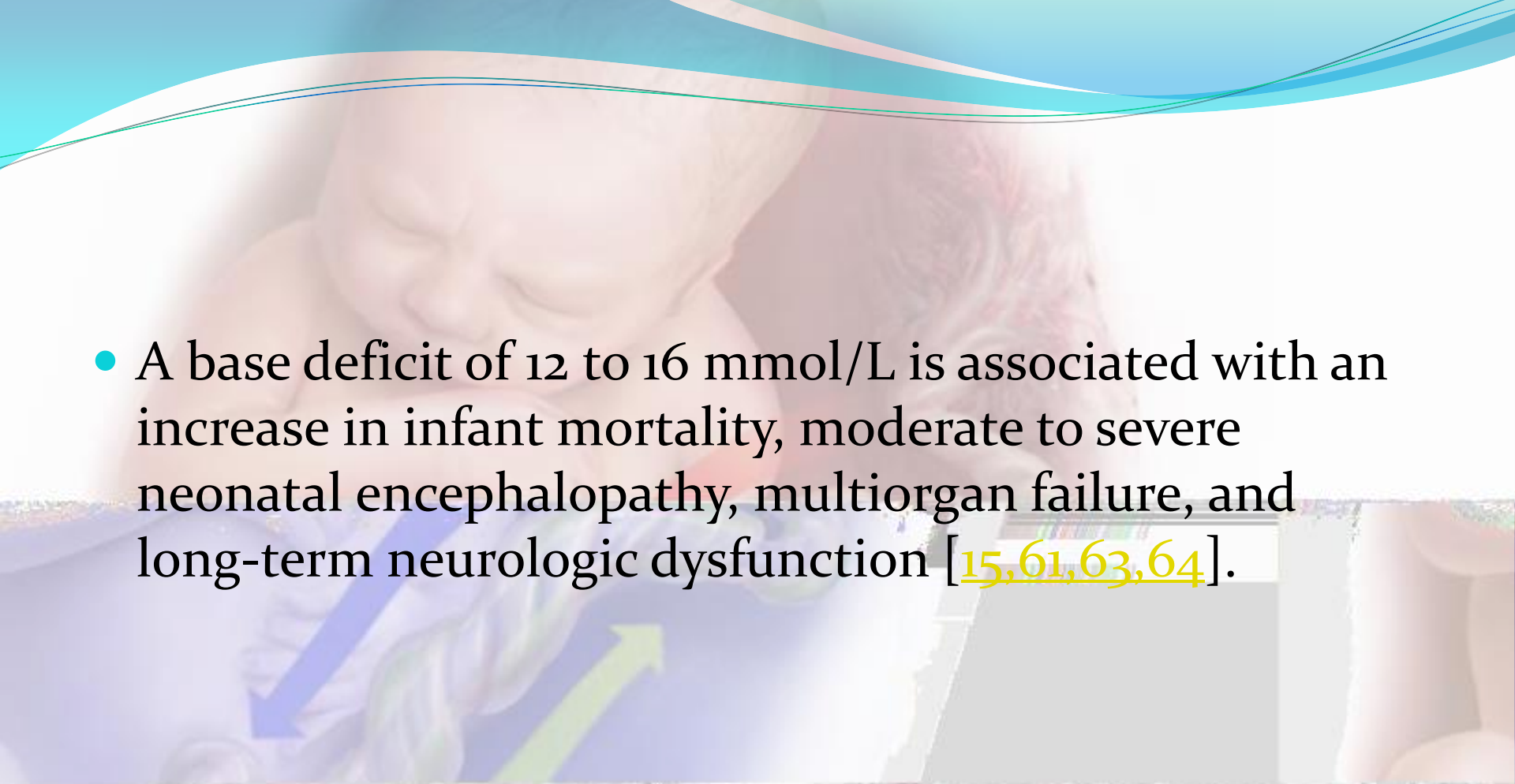


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- The majority of newborns with umbilical artery pH <7.00 will be admitted to the regular newborn nursery, will have an uncomplicated neonatal course, and will not be at increased risk for neurologic or behavioral problems when followed to school age

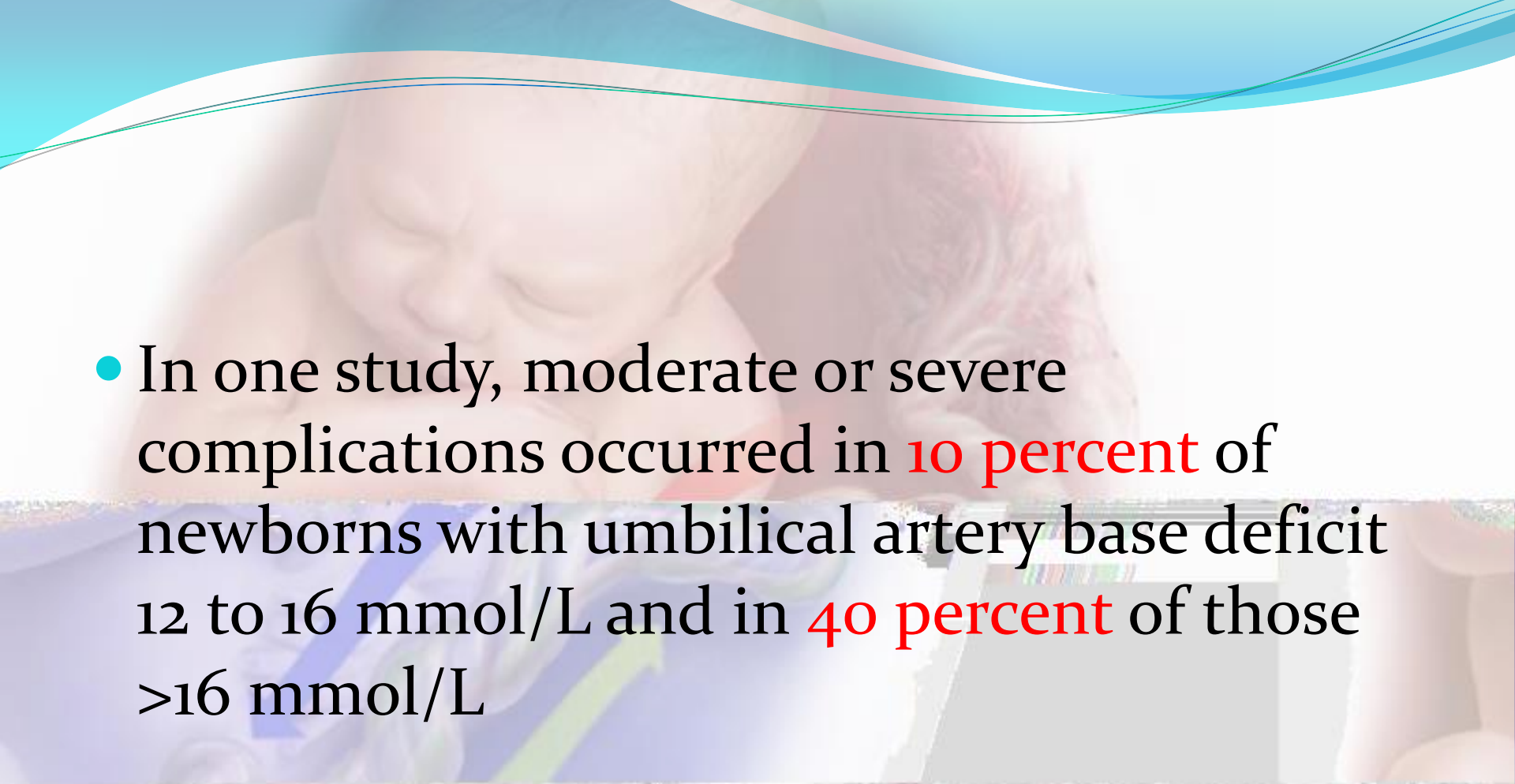
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- In a study of 93 neonates with umbilical artery pH <7.0, **97.8 percent** had no hypoxic-ischemic encephalopathy, 94.6 percent had no seizures, 89.2 percent did not need cardiopulmonary resuscitation, and 60.2 percent did not require intubation

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- most newborns with metabolic acidosis still have a good prognosis.
  - In a study of 1265 neonates with metabolic acidosis (umbilical artery pH <7.0 and base deficit  $\geq 12$  mmol/L), 98 percent had no intracranial hemorrhage, 94 percent had no seizures within 24 hours of birth, and 86 percent had no respiratory distress

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- An umbilical artery base deficit  $\geq 12$  mmol/L, which is  $>2$  standard deviations above the mean is commonly accepted as a reasonable threshold for predicting an increased risk of moderate or severe newborn complications

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- A base deficit of 12 to 16 mmol/L is associated with an increase in infant mortality, moderate to severe neonatal encephalopathy, multiorgan failure, and long-term neurologic dysfunction [[15,61,63,64](#)].

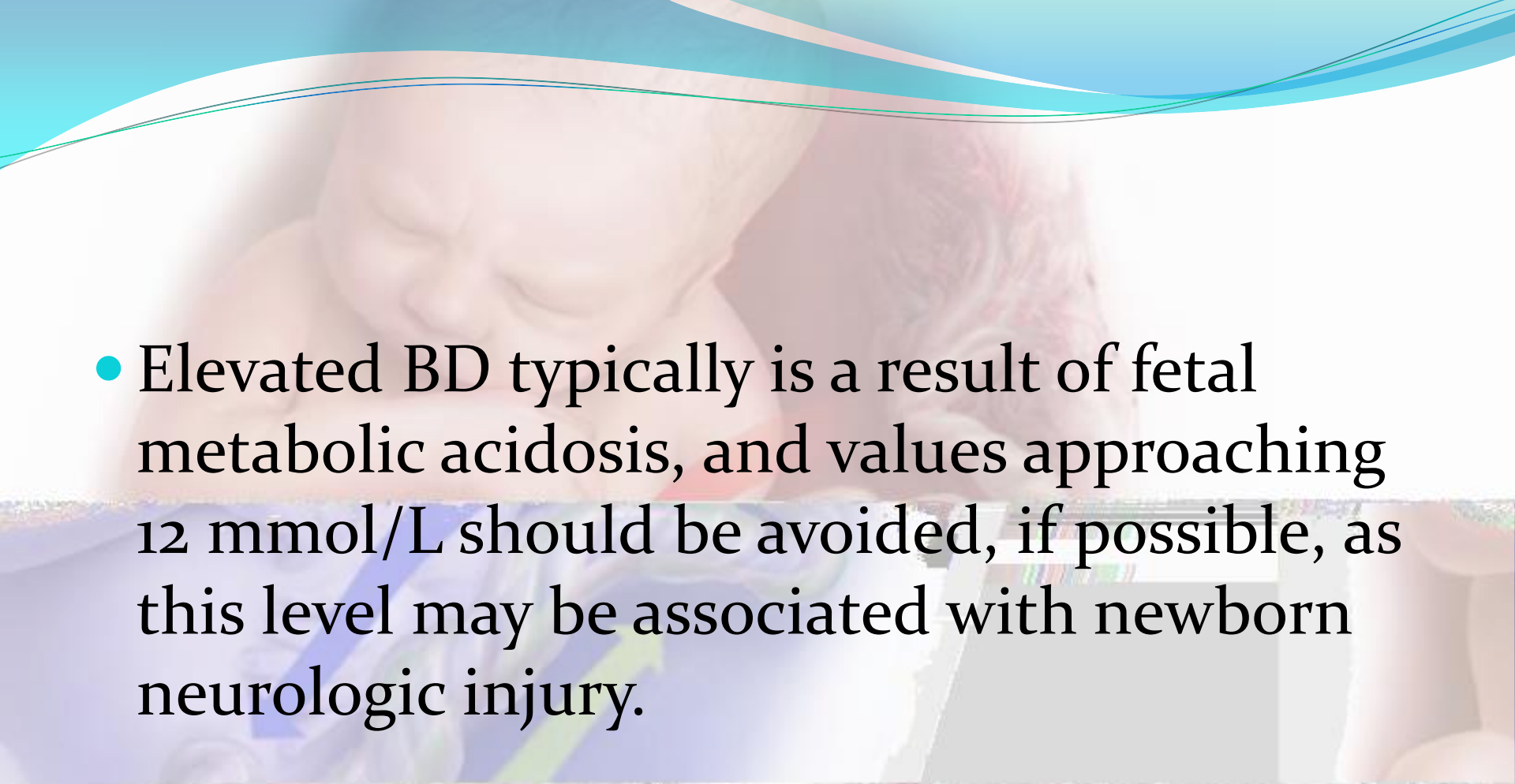


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- In one study, moderate or severe complications occurred in **10 percent** of newborns with umbilical artery base deficit 12 to 16 mmol/L and in **40 percent** of those >16 mmol/L

## Umbilical cord BD values change in relation to labor and FHR decelerations

- Prior to labor, the normal fetus has a slight degree of acidosis (BD, 2 mmol/L).
- During the latent phase of labor, fetal BD typically does not change.
- With the increased frequency of contractions, BD may increase 1 mmol/L for every 3 to 6 hours during the active phase
- up to 1 mmol/L per hour during the second stage, depending on FHR responses.

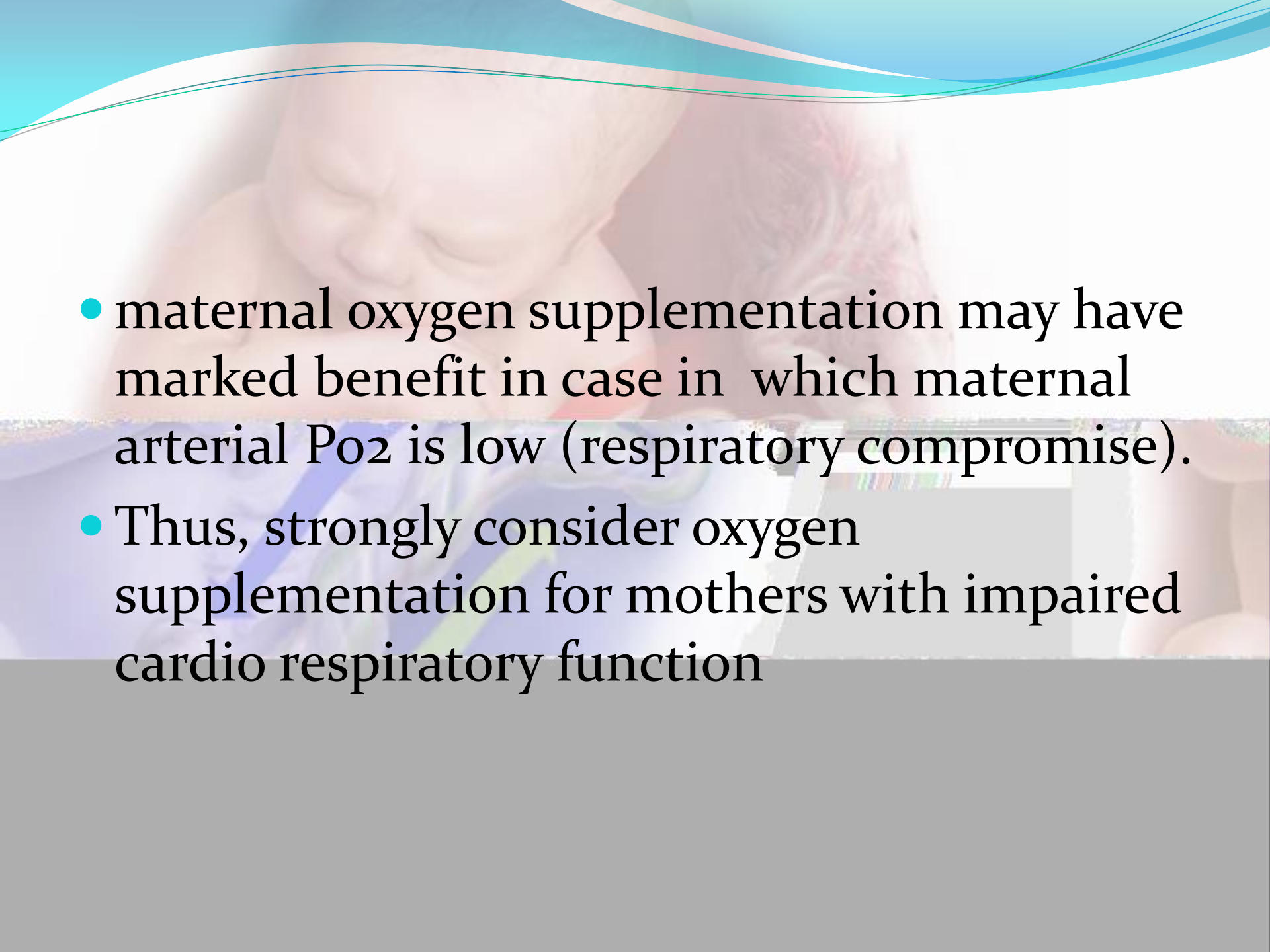
- following vaginal delivery the average umbilical artery BD is approximately 5 mmol/L and the umbilical vein BD is approximately 4 mmol/L.
- As lactate crosses the placenta slowly, BD values are typically only 1 mmol/L less in the umbilical vein than in the artery,
- unless there has been an obstruction to placental flow (see Case 1).

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- Elevated BD typically is a result of fetal metabolic acidosis, and values approaching 12 mmol/L should be avoided, if possible, as this level may be associated with newborn neurologic injury.

## Effect of maternal oxygen administration on fetal oxygenation

- Although maternal oxygen administration is commonly used during labor and delivery, controversy remains as to the benefit of oxygen supplementation.
- In a normal mother with oxygen saturation above 95%, little change in the maternal arterial  $O_2$  content or maternal uterine venous  $Po_2$  level, there is minimal change in fetal oxygenation.



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- maternal oxygen supplementation may have marked benefit in case in which maternal arterial  $P_{O_2}$  is low (respiratory compromise).
  - Thus, strongly consider oxygen supplementation for mothers with impaired cardio respiratory function

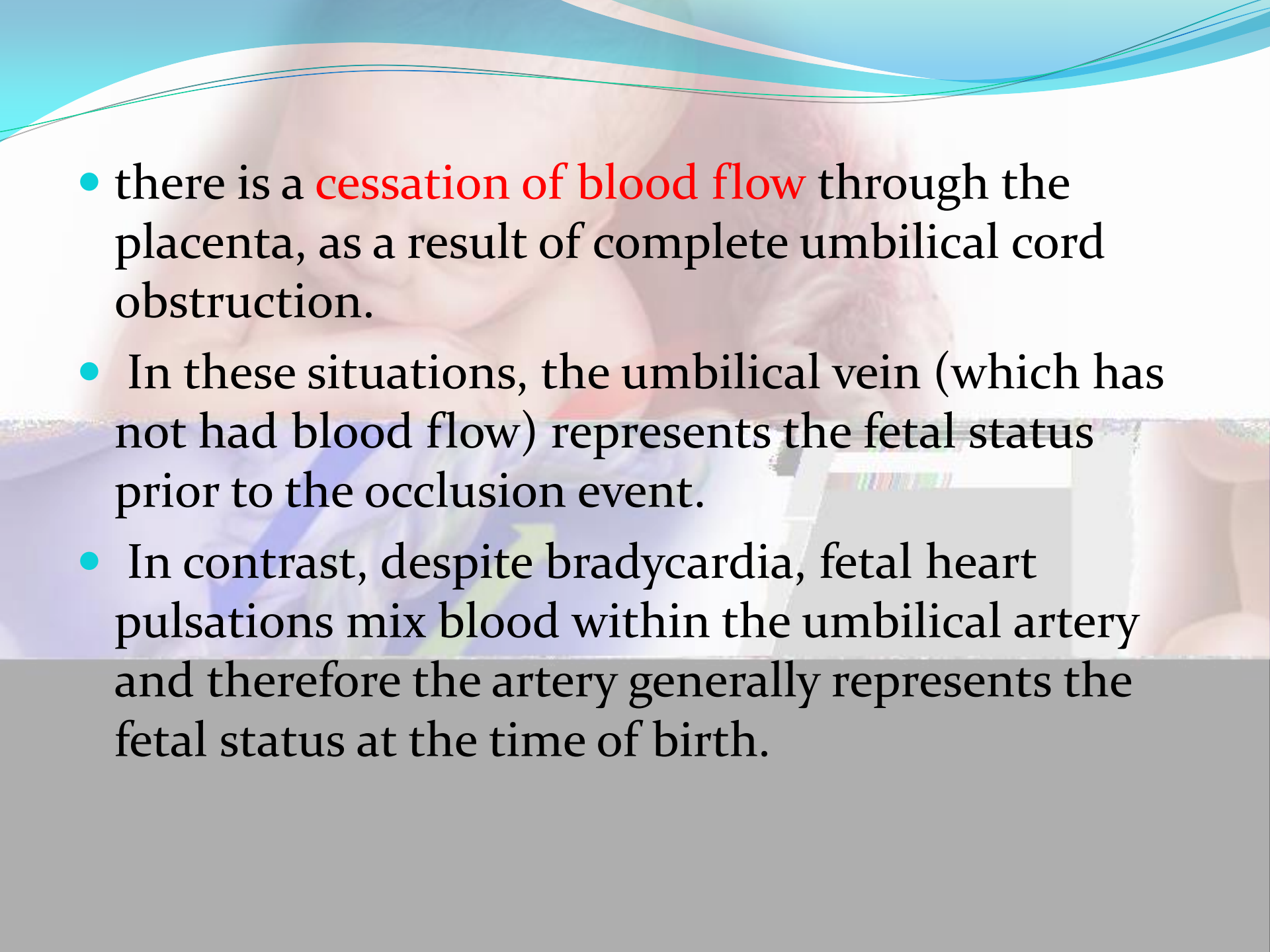


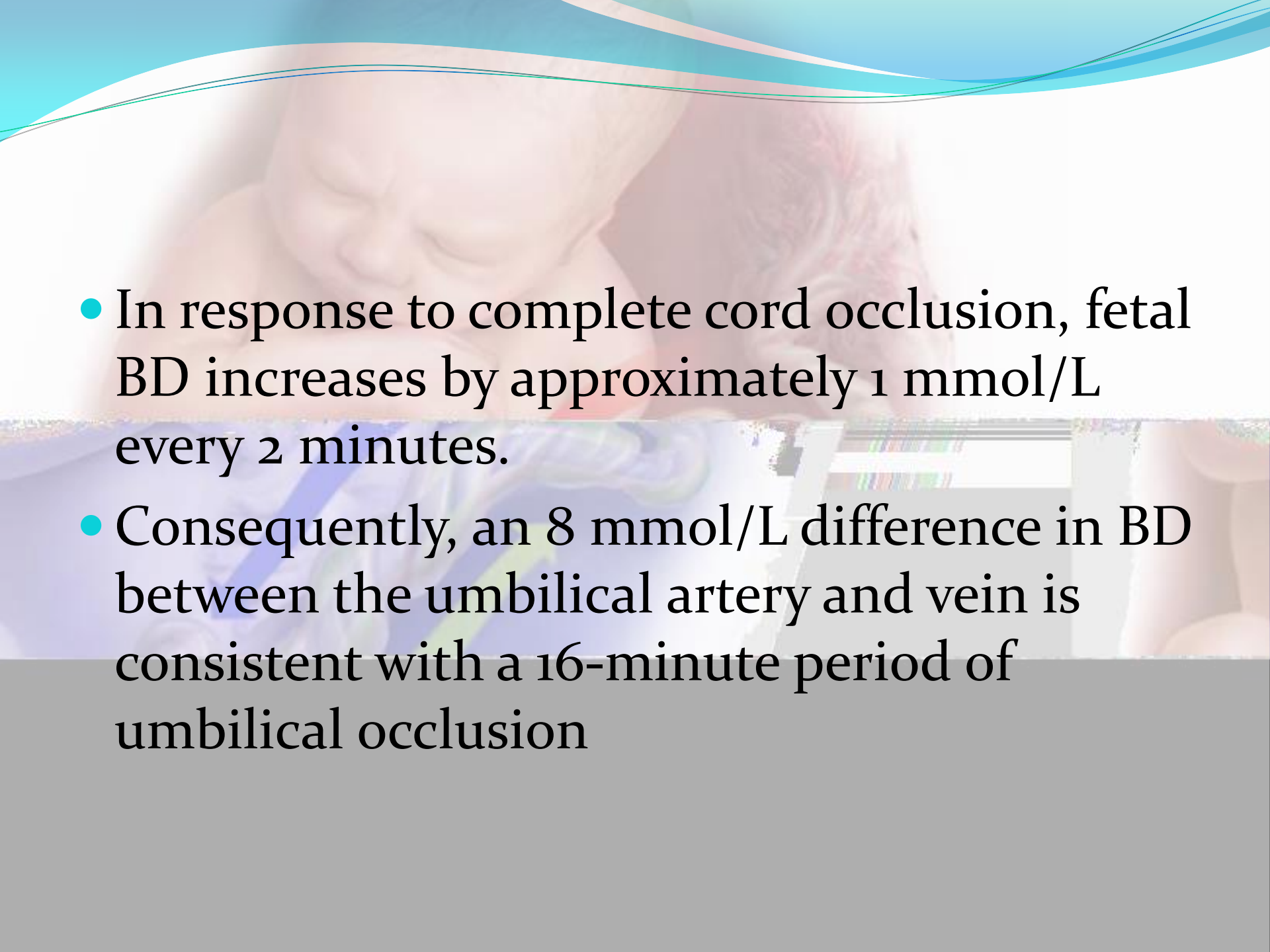
How did the Case 1 circumstances lead to newborn acidosis?

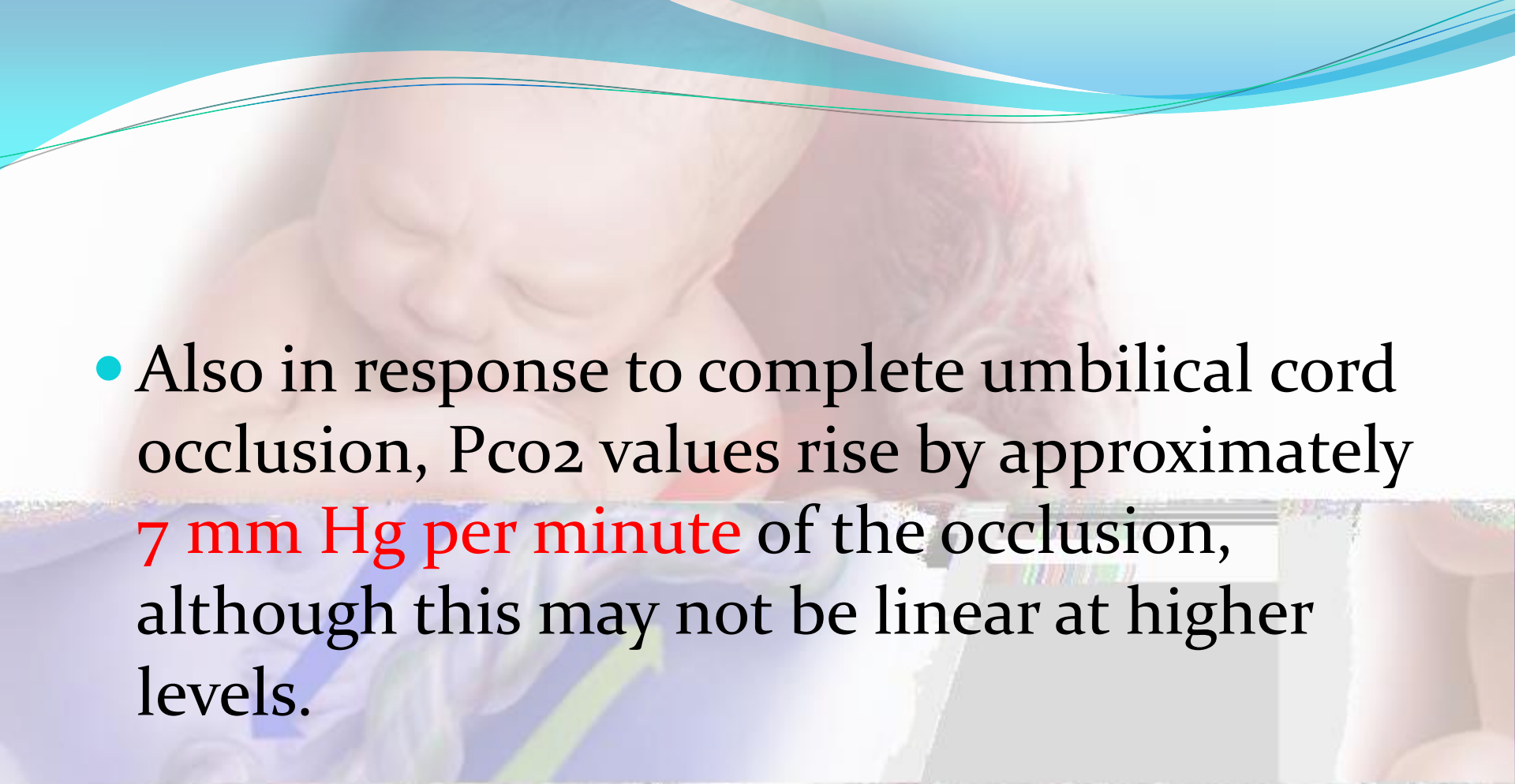


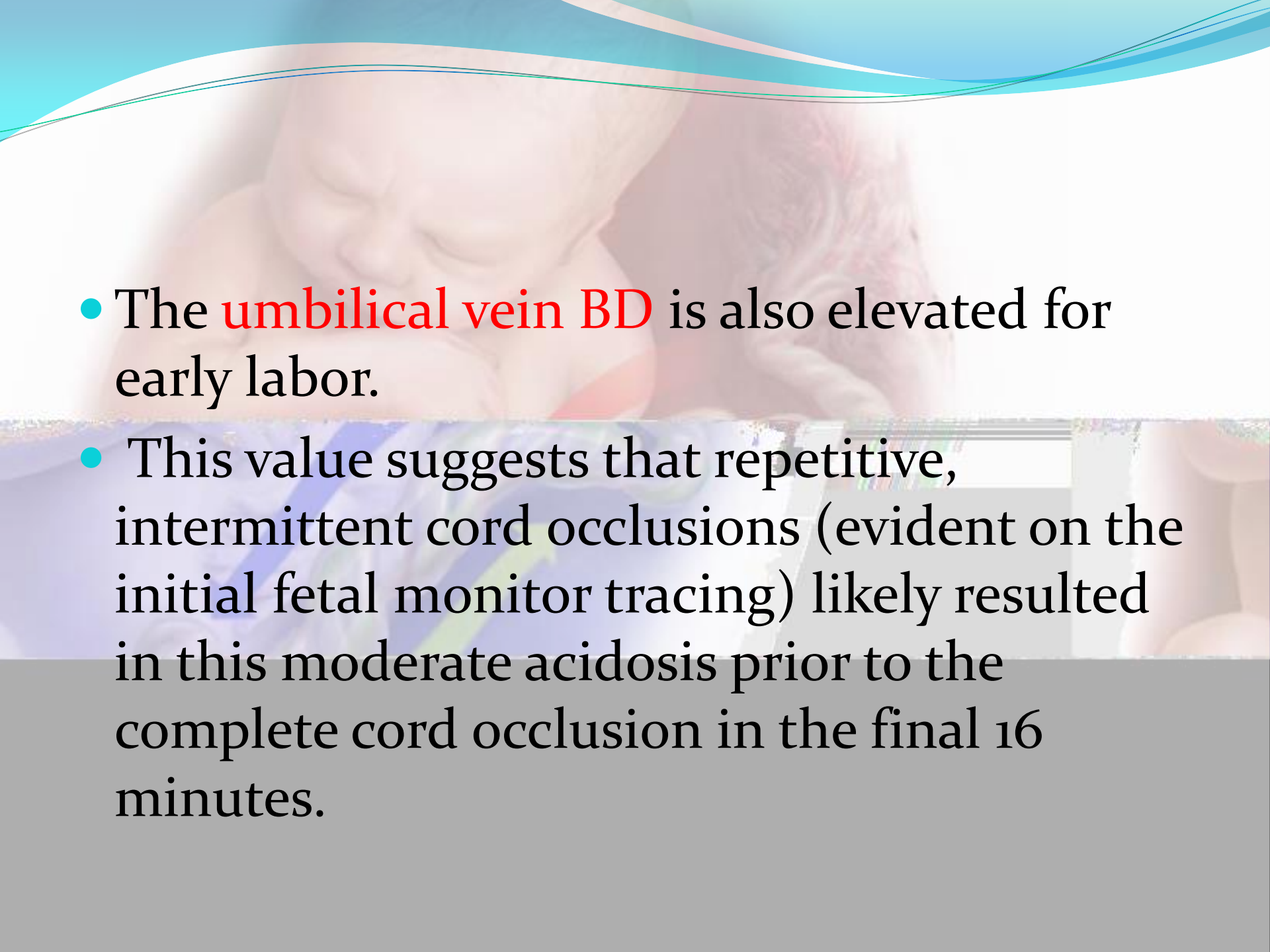
# How did the Case 1 circumstances lead to newborn acidosis?

- Cord samples were obtained
- values from the umbilical artery were as follows:  
pH, 6.80; Pco<sub>2</sub>, 120 mm Hg; Po<sub>2</sub>, 6 mm Hg; and base deficit extracellular fluid (BDECF), 13.8 mmol/L.
- Values from the umbilical vein were:  
pH, 7.32; Pco<sub>2</sub>, 38 mm Hg; Po<sub>2</sub>, 22 mm Hg; and BDECF , 5.8 mmol/L.

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- there is a **cessation of blood flow** through the placenta, as a result of complete umbilical cord obstruction.
  - In these situations, the umbilical vein (which has not had blood flow) represents the fetal status prior to the occlusion event.
  - In contrast, despite bradycardia, fetal heart pulsations mix blood within the umbilical artery and therefore the artery generally represents the fetal status at the time of birth.

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- In response to complete cord occlusion, fetal BD increases by approximately 1 mmol/L every 2 minutes.
  - Consequently, an 8 mmol/L difference in BD between the umbilical artery and vein is consistent with a 16-minute period of umbilical occlusion

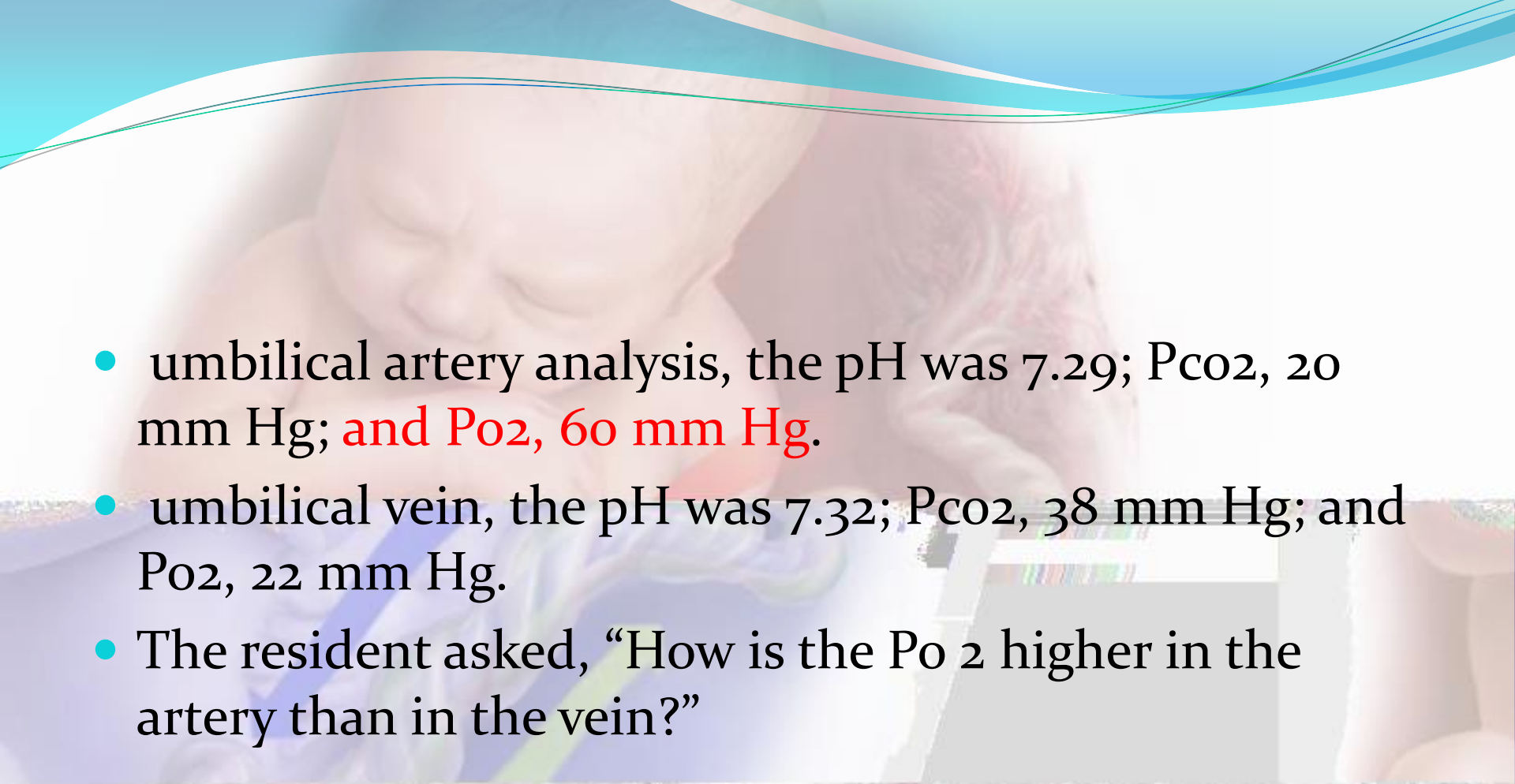
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- Also in response to complete umbilical cord occlusion,  $P_{CO_2}$  values rise by approximately **7 mm Hg per minute** of the occlusion, although this may not be linear at higher levels.

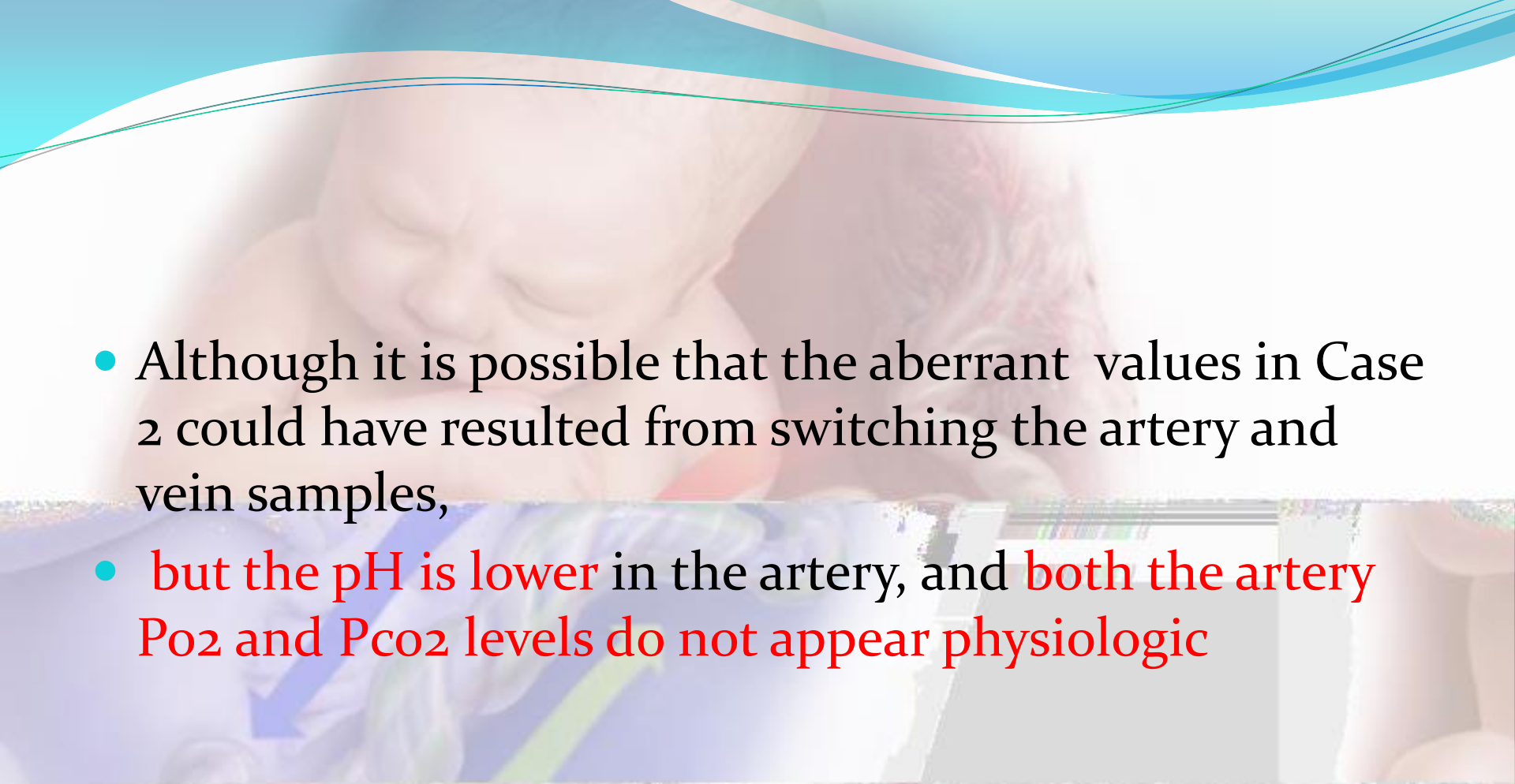
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- The **umbilical vein BD** is also elevated for early labor.
  - This value suggests that repetitive, intermittent cord occlusions (evident on the initial fetal monitor tracing) likely resulted in this moderate acidosis prior to the complete cord occlusion in the final 16 minutes.

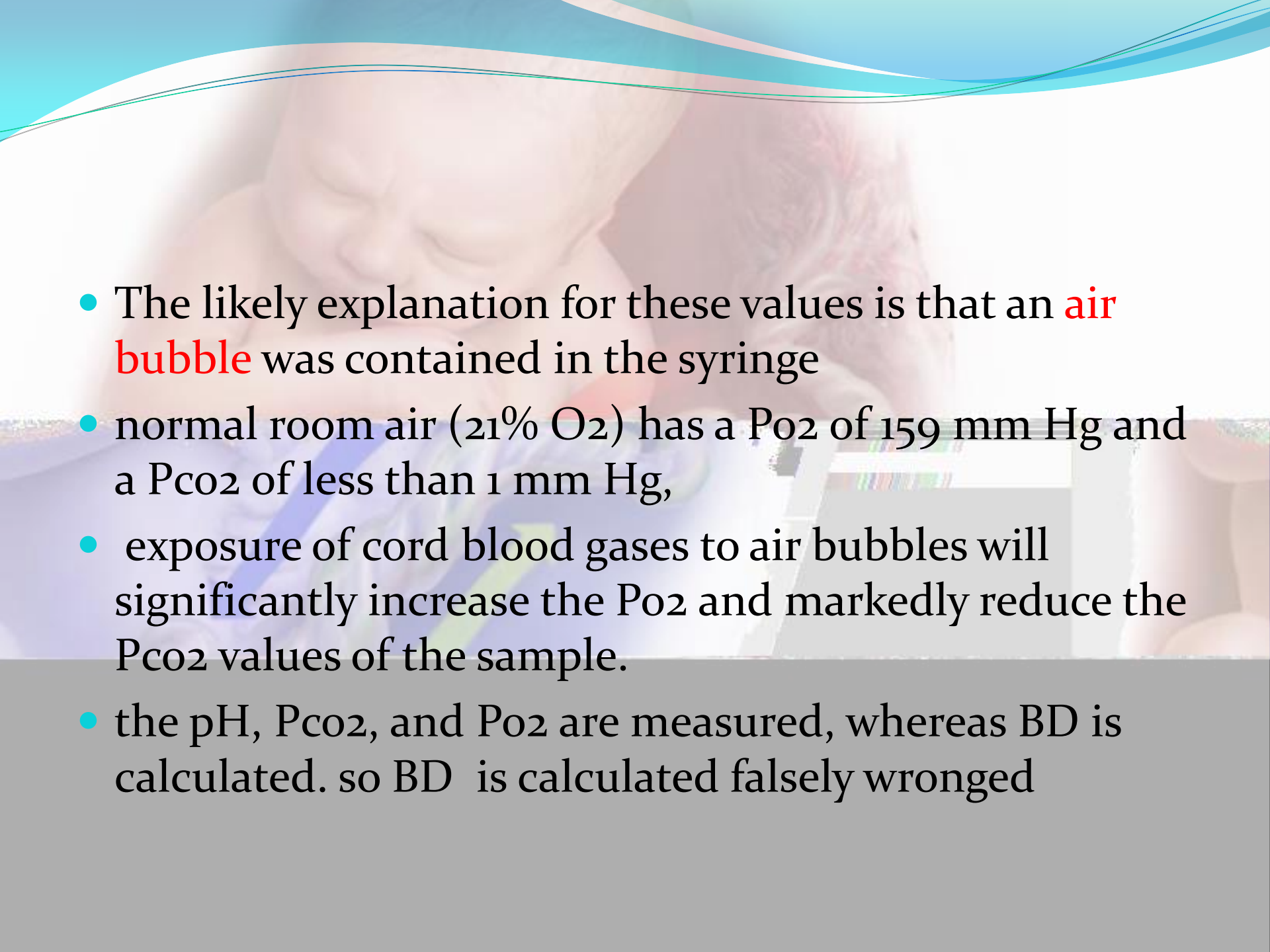


# CASE 2 An infant with unusual umbilical artery values

- An infant born via vacuum delivery for a prolonged second stage of labor
- had 1- and 5-minute Apgar scores of 8 and 9, respectively.
- umbilical artery analysis, the pH was 7.29; Pco<sub>2</sub>, 20 mm Hg; and Po<sub>2</sub>, 60 mm Hg.
- umbilical vein, the pH was 7.32; Pco<sub>2</sub>, 38 mm Hg; and Po<sub>2</sub>, 22 mm Hg.

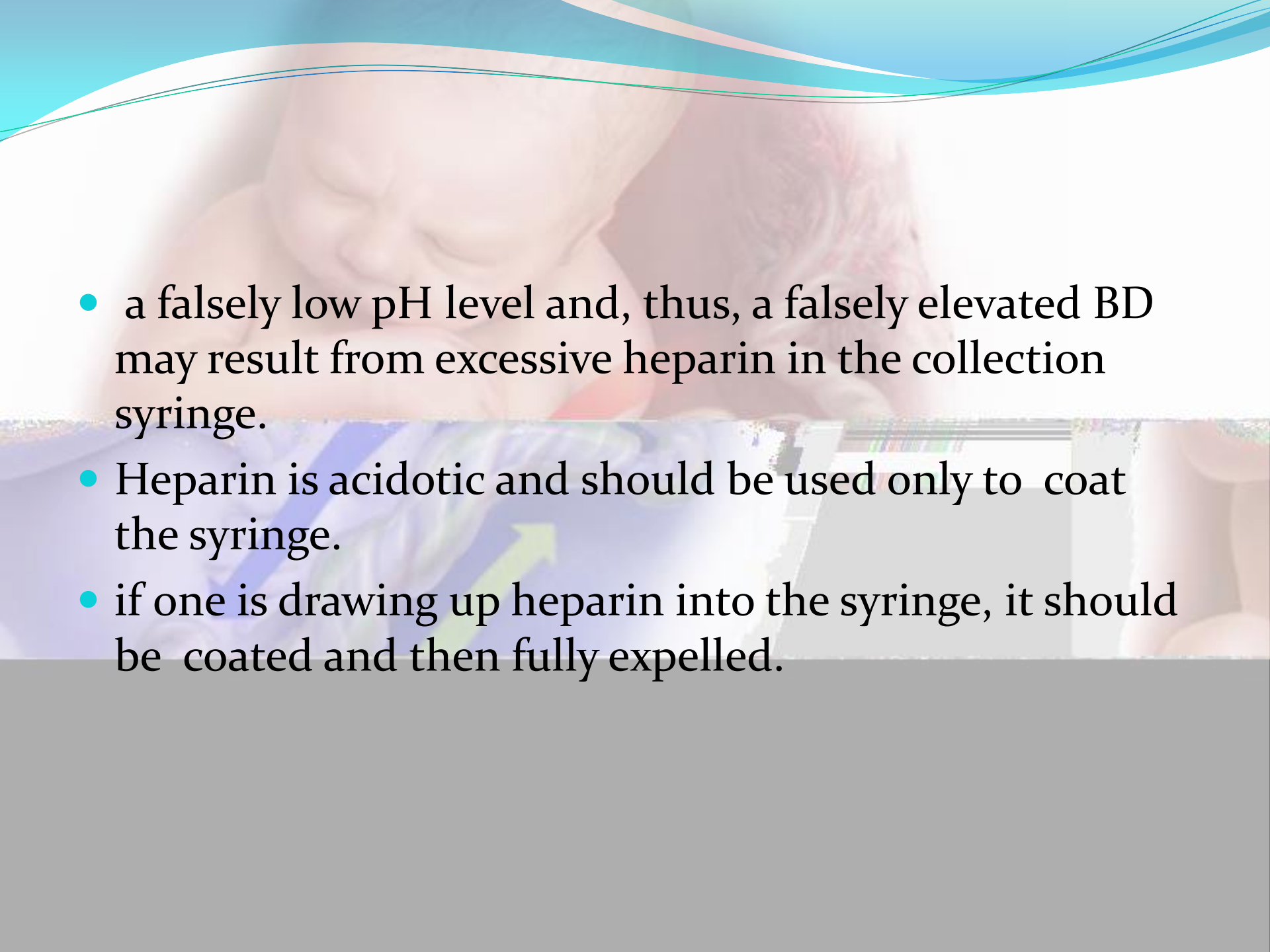
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- A newborn baby is lying in a hospital bed, appearing to be asleep. The baby is wearing a blue hospital gown. Medical equipment, including a white monitor with a colorful display and various tubes, is visible around the baby. The background is a soft, out-of-focus light blue and white. The top of the image features a decorative blue and white wave-like graphic.
- umbilical artery analysis, the pH was 7.29; Pco<sub>2</sub>, 20 mm Hg; **and Po<sub>2</sub>, 60 mm Hg.**
  - umbilical vein, the pH was 7.32; Pco<sub>2</sub>, 38 mm Hg; and Po<sub>2</sub>, 22 mm Hg.
  - The resident asked, “How is the Po<sub>2</sub> higher in the artery than in the vein?”

- 
- Although it is possible that the aberrant values in Case 2 could have resulted from switching the artery and vein samples,
  - **but the pH is lower in the artery, and both the artery Po<sub>2</sub> and Pco<sub>2</sub> levels do not appear physiologic**

- 
- The likely explanation for these values is that an **air bubble** was contained in the syringe
  - normal room air (21% O<sub>2</sub>) has a P<sub>O<sub>2</sub></sub> of 159 mm Hg and a P<sub>CO<sub>2</sub></sub> of less than 1 mm Hg,
  - exposure of cord blood gases to air bubbles will significantly increase the P<sub>O<sub>2</sub></sub> and markedly reduce the P<sub>CO<sub>2</sub></sub> values of the sample.
  - the pH, P<sub>CO<sub>2</sub></sub>, and P<sub>O<sub>2</sub></sub> are measured, whereas BD is calculated. so BD is calculated falsely wronged

## CASE 3 A vigorous baby with significant acidosis

- A baby with 1- and 5-minute Apgar scores of 9 and 9 was delivered by cesarean and remained vigorous. Umbilical cord analysis revealed an umbilical artery pH level of 7.15, with normal  $P_{O_2}$  and  $P_{CO_2}$  values. What could be the explanation?

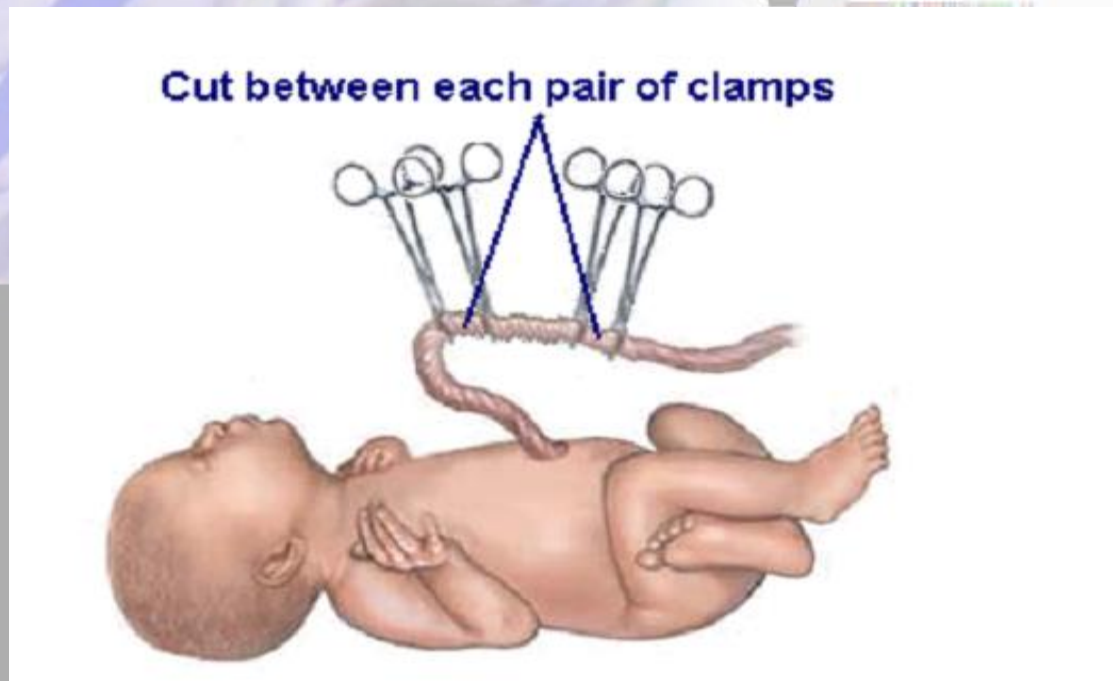
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- a falsely low pH level and, thus, a falsely elevated BD may result from excessive heparin in the collection syringe.
  - Heparin is acidotic and should be used only to coat the syringe.
  - if one is drawing up heparin into the syringe, it should be coated and then fully expelled.





Umbilical cord sampling:  
Procedures and equipment

- Ideally, a doubly clamped section of the cord promptly should be sampled into **glass** syringes that can be placed on **ice** and **rapidly** measured for cord values.



Easy to “get”

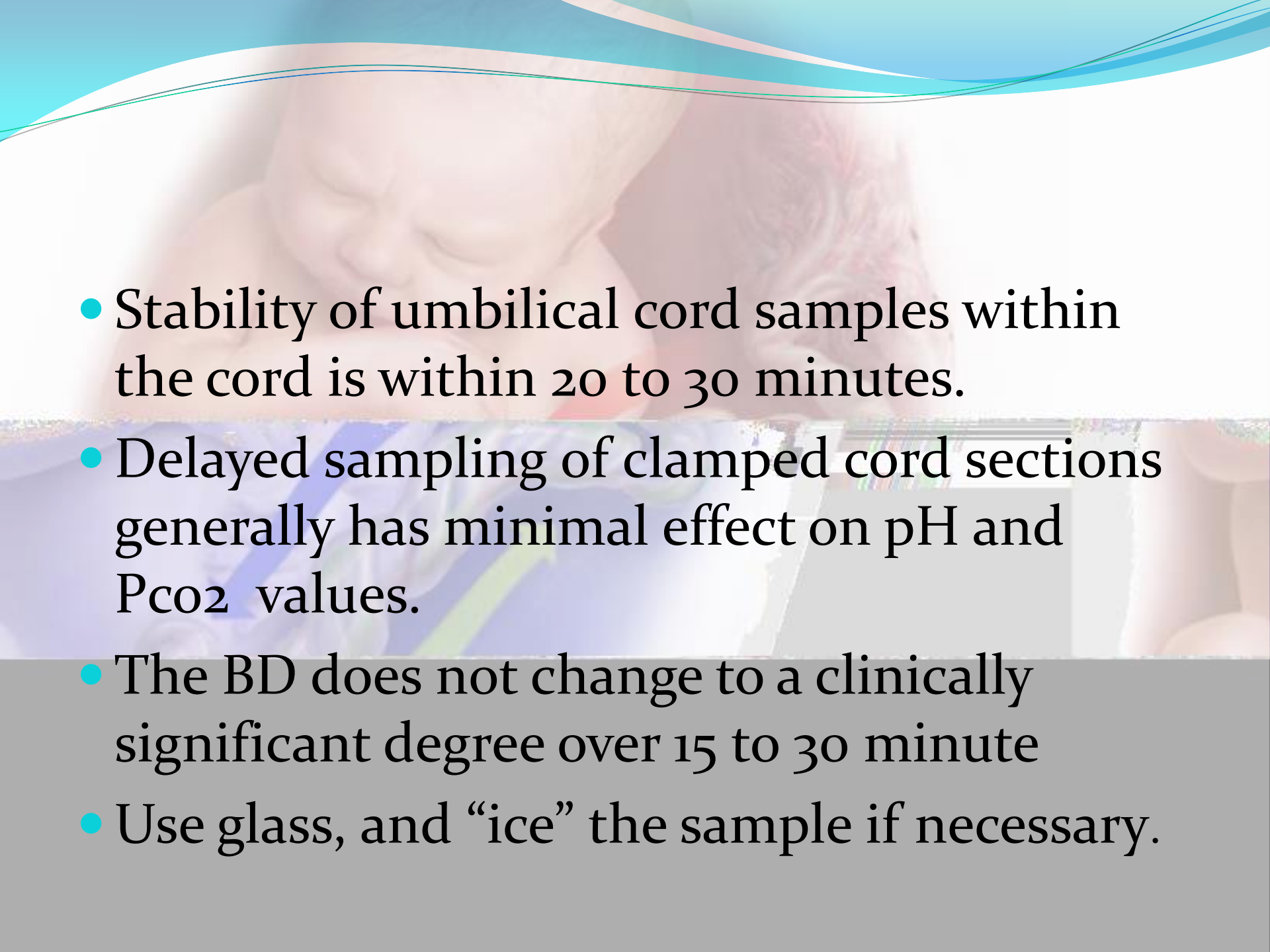


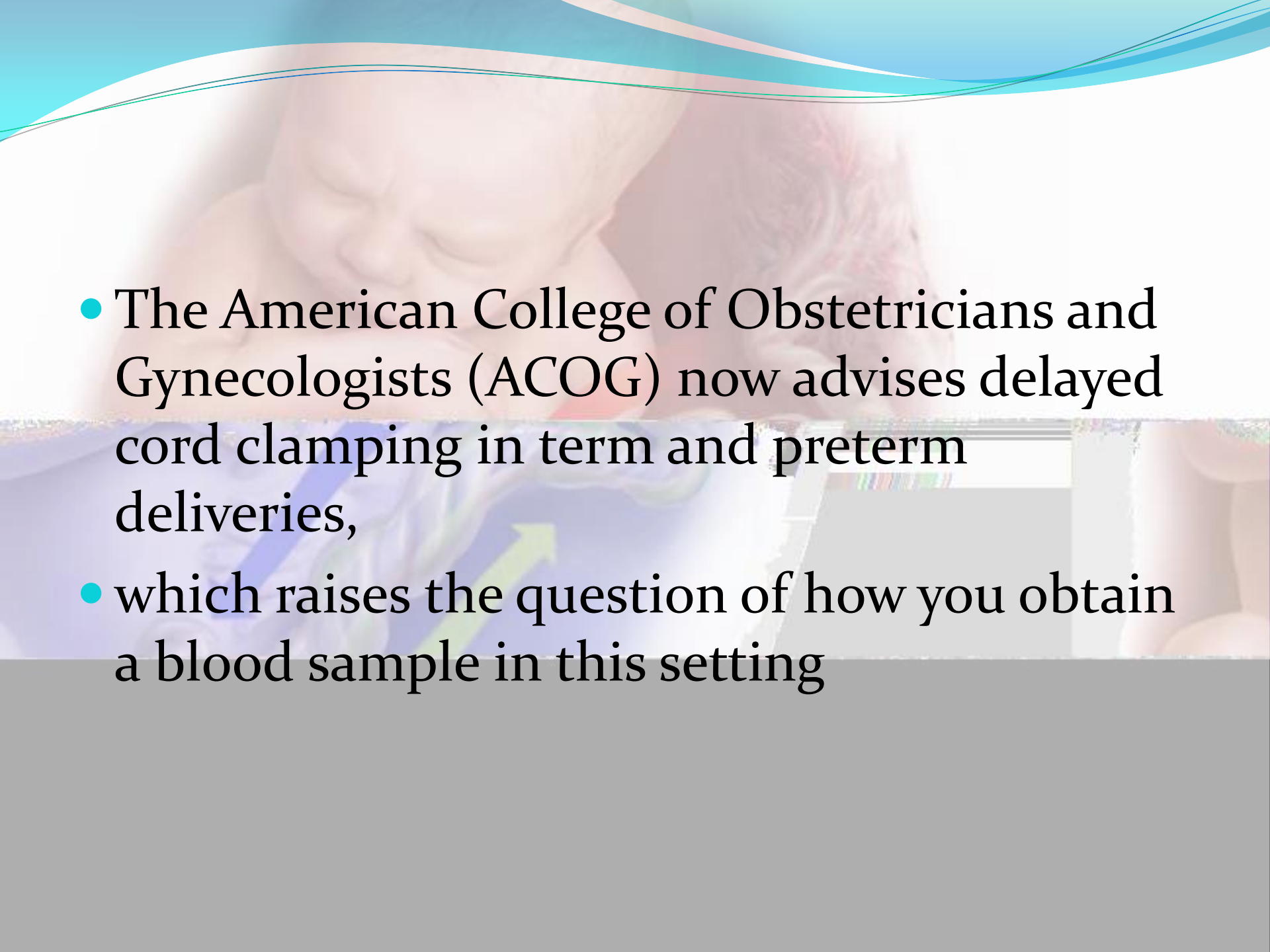
Hard to “get”

- **Always draw two samples**
- **From different but closely adjacent blood vessels**
- **One inevitably will be the artery**
- **The big easy-to-draw-from vessel is always the vein**
- **The differences in PCO<sub>2</sub> (always higher in the artery) and pH (always lower in the artery) will indicate from which vessel the samples were obtained, regardless of how the sample may be erroneously labeled**
- **Obtain the umbilical artery sample first, then the umbilical vein sample**

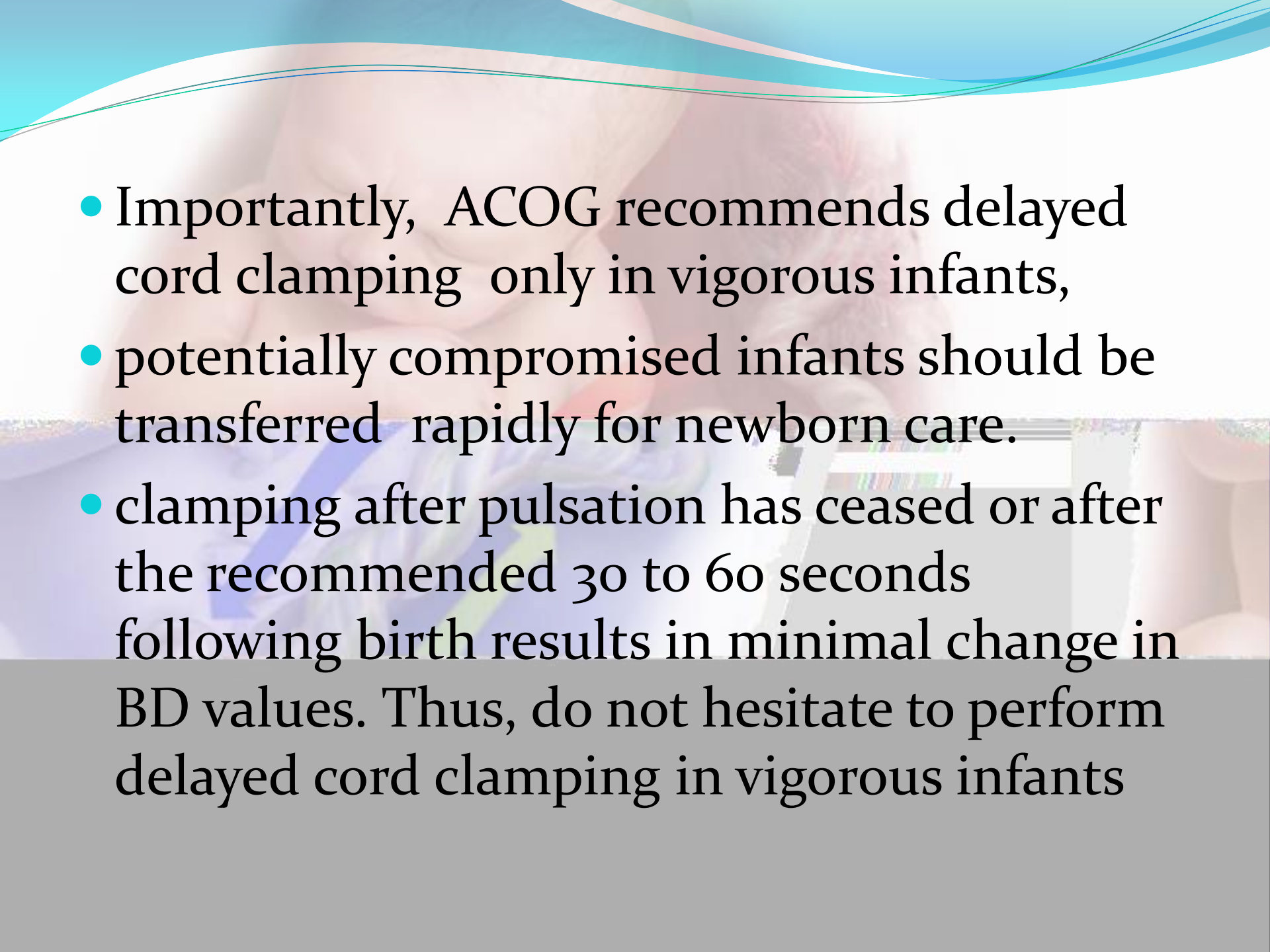




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- Stability of umbilical cord samples within the cord is within 20 to 30 minutes.
  - Delayed sampling of clamped cord sections generally has minimal effect on pH and Pco<sub>2</sub> values.
  - The BD does not change to a clinically significant degree over 15 to 30 minute
  - Use glass, and “ice” the sample if necessary.

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- The American College of Obstetricians and Gynecologists (ACOG) now advises delayed cord clamping in term and preterm deliveries,
  - which raises the question of how you obtain a blood sample in this setting



- 
- Importantly, ACOG recommends delayed cord clamping only in vigorous infants,
  - potentially compromised infants should be transferred rapidly for newborn care.
  - clamping after pulsation has ceased or after the recommended 30 to 60 seconds following birth results in minimal change in BD values. Thus, do not hesitate to perform delayed cord clamping in vigorous infants

Thank you

