Fetal capillary blood pH (fetal blood sampling)

June 2002

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Electronic fetal monitoring (EFM) during labor has been performed for 40 years. However, the specificity in diagnosing asphyxia is still insufficient. The combination of EFM and fetal scalp-blood sampling was introduced shortly after the introduction of EFM.

Although this monitoring ensures a better sensitivity and specificity, it is still not standard procedure in all obstetrical departments. The physiological background for the acid-base changes during asphyxia, the blood sampling procedure, and the benefits of pH measurement during labor are described in this paper. A troubleshooting guide is presented.

During labor the fetus is extremely at risk as compromised oxygen supply from the placental circulation to the fetus may develop either gradually or suddenly. Such a situation can result in severe organ damage, especially cerebral damage, or death of the fetus if not treated adequately.

It is therefore of major importance to monitor the fetus during labor to detect any sign of compromised fetal health demanding therapeutic intervention. During the last century the fetal heart rate has been used as an indicator of intrauterine well-being.

A continuous simultaneous recording of fetal heart rate and uterine activity (CardioTocoGraphy, CTG) is based on studies performed by Hon (1958) [1], and this method eliminates the human error in counting the heart beats, and both short-term and long-term variability are more strictly evaluated.

Nevertheless, these methods have proven an insufficient sensitivity and specificity in diagnosing fetal asphyxia.

In the 1970s and 1980s several randomized studies concerning fetal monitoring with cardiotocography as the only monitoring equipment were performed, and in most cases the results showed only a very modest decrease in morbidity of the newborn, while the rate of instrumental delivery (especially Cesarean section) increased.

Therefore, it is obvious that another or a supplementary fetal monitoring is necessary to diagnose fetal asphyxia.

Fetal asphyxia

The term asphyxia is not exactly defined in the literature, although the condition is well known by obstetricians and neonatologists. To most obstetricians the condition means a state of the fetus with depressed vital functions, usually defined by a fetal acidosis combined with hypoxia/anoxia.

Signs of asphyxia during labor are abnormal heart rate, pathological CTG readings, green meconium-stained amniotic fluid, and low scalp-blood pH.

Acid-base changes during fetal hypoxia

During the first stage of fetal hypoxia, caused by partial compression of the umbilical cord, by a decreased fetal cardiac output, or by placental insufficiency, the most evident change is an increasing pCO_2.

The hypoxia is at this stage not compromising the aerobic metabolism of carbohydrate to CO_2 and H_2O. An acid-base evaluation of the blood will show a respiratory acidosis with normal base excess value.

During the second and more dangerous stage of fetal hypoxia, the oxygen delivery to the fetus becomes insufficient, and the metabolism of carbohydrate changes to an anaerobic metabolism with the production of lactic acid.

A distinct decrease of pH occurs during oxygen deficiency, until the low pH itself stops all further metabolic activities. Consequently, the acidosis will only be progressive for a short time, the slope of the pH decrease being an indicator of the oxygen deficiency.

Usually the fetal asphyxia develops during the described two-step mechanism. In some cases, the first stage is prolonged, and it may eventually be interrupted, if normal oxygen exchange between the fetus and the mother is reestablished.

However, in other cases, with a sudden total occlusion of the umbilical cord or a total placental abruption, the hypoxia may be so evident that the anaerobic metabolism starts immediately after the obstetric complication.

Normal values of fetal pH

Initially during the first stage of labor the pH decreases slowly (0.016 pH units per hour) while during the second stage of an even normal labor the pH value decreases faster (0.12 pH unit per hour) [2]. Therefore, normal fetal capillary-blood pH ranges from 7.25 to 7.45 during labor.

Fetal blood sampling

The method of fetal blood sampling was described by Saling in 1961 [3]:

1. The membranes must be ruptured and the cervical os dilated more than 3-4 cm.
2. The presenting part of the fetus is visualized by an amnioscope. The amnioscope should be pressed gently against the skin to avoid leak of amniotic fluid into the area but still permitting normal vascularization of the skin.
3. The skin is cleaned and dried with swaps. Rubbing several times will assure increased blood flow to the area. To avoid the blood drops from spreading, silicone is placed on the swap and spread over the area.
4. An incision is made in the upper part of the area with a 2-mm blade. In some cases 2 or 3 incisions are necessary to produce adequate bleeding.
5. The blood drops are collected into a preheparinized capillary tube. The capillary tube tip should be placed directly in the drop and the tube tilted slightly with the external end lower than the internal to facilitate the filling of the tube. Suction on the tube should be avoided.
6. The blood is transferred to the pH meter and the value measured.

The volume of blood obtained performing fetal scalp-blood sampling is usually limited and in many cases not large enough to perform a total acid-base evaluation

including pH, pCO_2 and base excess. Measurement of blood pH alone can be performed in small blood samples, and in clinical practice this monitoring procedure is preferred during labor. Furthermore, a pH decrease will always initiate the decrease in base excess, and this early warning is of importance for the obstetrician.

Clinical application of intrapartum fetal capillary pH

Fetal capillary-blood pH values above 7.25 indicate that the fetus at the time of the sampling does not suffer from hypoxia. Labor should be allowed to progress, but if the heart rate or the cardiotocogram indicates pathological changes, the blood sampling should be repeated.

pH values between 7.20 and 7.25 are signs of prepathological condition. Measures should be taken to improve fetal oxygenation (change of maternal position, oxygen mask). If the fetus is not delivered 15 min after the pH measurement was performed, a subsequent fetal blood sampling must be performed. If the new pH value is still between 7.20 and 7.25, new blood sampling should be done every 15-30 min.

A capillary-blood pH value below 7.20 indicates a pathological fetal acidosis, and the fetus should be delivered immediately.

Benefits of pH measurement during labor

Continuous electronic monitoring with the cardiotocograph alone and electronic monitoring supplemented with fetal blood sampling and pH measurements have been evaluated in randomized studies.

The rate of instrumental deliveries (Cesarean sections, forceps and vacuum extractions) was lower when fetal blood sampling was performed, and the number of newborns with asphyxia was equal in both groups [4].

The reduction of Cesarean-section rate causes a decrease in the maternal complications following delivery. From an economical point of view, the costs of introducing pH measurements on fetal blood sampling are low in relation to the savings from a lower Cesarean-section rate [5].

Complications from fetal blood sampling

Very few complications following fetal blood sampling have been reported. Prolonged bleeding after blood sampling may be caused by a fetal coagulation disorder or an extensive laceration.

Lacerations were described previously, but with the use of new smaller knifes, these complications are rare. The incision site should, however, be inspected during the following two uterine contractions to ensure that the bleeding has stopped.

In the case of bleeding, compression with a swab will usually stop the bleeding. Infection in the incision wound may happen, but all complications are seldom, in most materials much lower than 1 per cent.

Trouble shooting		
Problem	Possible cause	Solution
1. Not sufficient bleeding to fill the capillary tube	• Too small incision	• Larger incision
	• Insufficient blood flow in the skin	• Rubbing the skin before incision
2. Clotting of the blood in the capillary tube	• Too slow filling of tube	• See point 1
	• Tissue tromboplastin in sample	• Use a sharp pointed knife for incision to minimize tissue contusion
	• Insufficient heparinization	• Use correct preheparinized capillary tube • If not immediately analyzed, mix the blood sample with magnet
3. Air bubbles in the blood sample	• Incorrect sampling procedure	• Do not remove the tip of the tube from the blood drop before the capillary is sufficiently filled

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