

The merit of routine cord blood measurement at birth

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Cord blood pH measurement at birth, using relatively simple and non-invasive methods, provides obstetricians and perinatologists with an objective and sensitive measure for the condition of the infant during the final stage of birth. As long as certain criteria are observed, the reported values are reliable. Routine measurement can be of benefit to obstetricians and perinatologists who value critical assessment of their performance.

Introduction

Fetal blood sampling during pregnancy and during labor are both rather complicated procedures, requiring specialized skills on the part of the doctors. They are also unpleasant for the mother, and involve risks for the fetus. Cord blood sampling at birth, on the other hand, is safe and easy. When the pH analyzer is located near the labor ward, very little time, effort, and supplies are required for this measurement. There is, of course, a discrepancy between the actual costs of measurement and what is charged for it. American studies report that patients are charged between USD 22 and 79 for cord blood measurement at birth [1]. These charges often play a prominent role in discussions of whether cord blood pH should be routinely tested at birth. A survey on the use of cord blood pH measurement at birth showed that only 27 % of university obstetric units performed the measurement routinely [2].

The American College of Obstetricians and Gynecologists has addressed the issue of cord blood measurement at birth in several guidelines. In recent guidelines, it is advised that a segment of the cord be clamped immediately after birth. This segment can later be discarded if the five-minute Apgar score is satisfactory. If, however, serious problems with the neonate's condition persist beyond the first five minutes, the College advises that blood be drawn from the cord segment and sent for blood gas analysis. In Germany and the United Kingdom, the Societies of Obstetricians and Gynecologists advise to measure arterial cord blood pH at each birth. In the Netherlands, it is advised to measure cord blood pH at each hospital birth.

In this paper, we present the arguments for and against routinely measuring cord blood pH at birth. For clinicians, however, the main issue regarding cord blood pH measurement at birth, whether it is measured routinely or only in selected cases, remains the correct interpretation of

the results. This relates not only to the clinical significance of normal and abnormal values, but also to the reliability of the measurement, the factors that influence it and the chosen cutoff points between normal and abnormal pH at birth.

Sampling and measurement

Arterial and venous samples from the cord vessels can be taken immediately after birth, even before clamping and cutting off the cord. It is recommended, though, to clamp the cord first and to use two extra clamps to isolate and remove a 10-20 cm long segment from which samples can be taken later. When clamping is started from the newborn end, the umbilical arteries probably to some extent empty towards the placenta before the next clamp is fixed. It is therefore better to place the first clamp at the placental end.

Isolating a section of the cord between clamps offers several advantages. Cord blood can be taken at ease by another person. Measurements can be repeated when there is doubt about the samples; for example, when arterial and venous measurements provide nearly identical pH values. Most importantly, the sampling is less likely to intervene with the emotional and medical aspects of childbirth, either in the delivery room or at the operating table. A clamped cord segment can remain at room temperature for 15-30 minutes, without sampling and measurement being affected [3]. When the measurement is to be postponed for longer than 30 minutes, samples should be taken in heparinized syringes and kept on ice [4]. The (acid) heparin concentration in these syringes should not exceed 50 IU/mL of blood [5].

It is important that blood samples are taken from both artery and vein. This will provide convincing evidence that the arterial pH was actually derived from an artery. If only one vessel is sampled, it can readily be argued that the pH reflects the venous pH, because sampling the vein is usually easier [6]. Obviously, correct sampling also requires appropriate measurement and reporting of values. Instructions of the manufacturer for calibration and quality control of the analyzer should be followed. Presently, most analyzers indicate whether a certain measurement is reliable. There should be adequate safeguards to ensure that cords and pH results are not erroneously assigned to other patients.

Validation and interpretation

If the two pH values diverge sufficiently, one may conclude that both arterial and venous pH have been obtained. How large the difference between the samples should be to ensure this is somewhat arbitrary. It is reasonably well-accepted, though, that venous pH should exceed arterial pH by at least 0.03 units to give credence to the results [6]. Data that do not meet this criterion are suspect of representing only venous pH.

Differences between repeated arterial blood pH measurements obtained from the same cord have been reported in a number of studies. These differences result from imprecision of the pH analyzer, biological variation among samples and variations in obtaining and handling the samples. Standard deviations (SD) of the differences between two samples were from 0.024 to 0.033 in studies that compared two measurements immediately after birth, and from 0.024 to

0.045 in studies comparing immediate measurements with delayed ones [3,7,8]. The 95 % confidence limit is therefore roughly the measured value \pm 0.06 for an individual arterial cord blood pH measurement.

For clinical interpretation of umbilical artery pH some consideration is necessary of what is normal or not. Fetal and neonatal blood pH usually remain fairly constant. During pregnancy, arterial cord blood pH has a mean value of 7.37, with 95 % of measurements being within the range of 7.43 and 7.31 [9]. Immediately after birth, mean arterial cord blood pH is lower, with a much larger spread around its mean, attesting both to the challenge of birth and its variation from one person to another. Blood of a deceased fetus or baby is usually around 6.8 and always below 7. Such low pH values in a live fetus or baby are indicative of asphyxia.

In a group of women with normal pregnancy and labor, excluding, for example, those with abnormal fetal heart rate tracings, mean arterial cord blood pH varied between 7.24 and 7.31, while lower limits of statistical normality (mean $-$ 2 SD) varied from 7.07 to 7.22 [10]. In women with normal pregnancies having cesarean section before the onset of labor, mean arterial cord pH varied between 7.26 and 7.29 with lower limits of statistical normality between 7.16 and 7.21 [10].

A cutoff point for abnormality should be fairly sensitive (80-90 %) while having a positive predictive value of at least 5-10 % in detecting infants who contracted asphyxial damage during (rather than before or after) labor. Several studies indicate that cutoff values of 7.00 or 7.05 comply with these expectations [6,11,12]. However, as the 95 % confidence interval of an individual measurement is relatively broad ($+0.06$ to -0.06), the use of a single cutoff value is unrealistic. Therefore, the following classification of arterial cord blood pH values in three categories seems more realistic: normal (when $>$ 7.11), borderline (when H 7.11 and I 6.99) and abnormal (when $<$ 6.99). There is statistical and physiological evidence in support of this classification. However, many authors set cutoff points between normal and abnormal arterial cord blood pH at birth at unrealistically high levels, varying between 7.10 and 7.20.

Clinical significance of normal and abnormal values

Cord blood pH values at birth do not provide a highly sensitive and specific indication of permanent damage. There are several obvious reasons for this. Fetuses and neonates may recover more or less quickly from an asphyxial episode, and such an episode may or may not result in permanent organ damage. Thus, the majority of infants born with low cord blood pH enjoy normal psychomotor development [11,12]. On the other hand, unrecorded asphyxial episodes in utero or in early infancy may engender permanent damage. This explains why many brain-damaged infants were born with normal cord blood pH. In addition, permanent damage may follow genetic or infectious disease without any history of disturbed fetal homeostasis.

If umbilical pH cannot predict long-term outcome, what, if any, is its significance? A normal cord blood pH indicates that the fetus was in good condition at birth. When it corresponds with the clinical appearance, the obstetrician can conclude that the baby does not need immediate

specialized care. Umbilical pH also provides an important element in the evaluation of intrapartum care, both in cases with good and with worrying outcome. Normal cord blood pH at birth provides evidence that the management of birth did not harm the fetus. It may also indicate in retrospect that emergency obstetric intervention was either effective or superfluous. A normal cord blood pH at birth will, with reasonable certainty, exclude oxygen deficiency during labor. This is also true for neonates born with normal umbilical pH, but clinically depressed. The cause for these low Apgar scores should then be sought in factors such as maternal medication, birth trauma, congenital anomalies, etc.

An abnormal cord blood pH indicates that the fetus was in a state of biochemical decompensation at the time of birth. If this is accompanied by a low Apgar score, resuscitation procedures will have been initiated before the abnormal pH result was available. Adequate ventilation will usually suffice to overcome the acidemia. However, documentation of perinatal asphyxia indicates that the neonate should be cared for in an intensive care unit, because of the increased risk of hypoxic ischemic encephalopathy. When an infant is born with abnormal cord blood pH but normal Apgar scores, the outlook is more favorable, but full examination is necessary, including observation at least until the blood pH has returned to normal. Abnormal cord blood pH values should aid obstetricians and perinatologists to critically evaluate their care during pregnancy and labor, for instance in considering whether and when fetal blood sampling should have been performed or what signs of impending problems were inadequately acted upon.

Finally, parents may expect a prognosis on the future development of their baby. Such prognosis cannot be given on the basis of cord blood pH or Apgar score. Careful observation of the neonate during the first days of life will be necessary. If signs of moderate or serious encephalopathy (Sarnat II or III) develop, the risk of death or permanent disability is considerable, and a causal relationship with perinatal asphyxia will be likely [13]. Absence of these signs is associated with good prognosis. Residual neurological abnormalities as a result of perinatal asphyxia are then unlikely [11,12,14,15].

Advantages of routine cord blood pH measurement

An arterial cord blood pH, correctly sampled, measured, validated and interpreted, provides the most objective and sensitive index for asphyxia during labor. Its measurement is non-invasive and also inexpensive, provided that the delivery room is equipped, as it should be, with a pH analyzer for testing fetal blood samples taken during labor. The major advantage of routine measurement is that caregivers receive immediate feedback on their care during childbirth, and can learn from that information. Many neonates with grave acidemia will be detected earlier, leading to a more timely reaction and, in some instances, prevention of further complications. In addition, routine measurement offers new opportunities for audit. Regular discussion of cases with abnormal cord blood pH at birth will add to the quality of hospital policies and their application. With regard to later claims or complaints, a normal cord pH practically excludes asphyxia during labor. Finally, routine collection of cord blood pH offers reliable outcome measures for retrospective studies.

Disadvantages of routine cord blood pH measurement

About 98 % of routinely measured arterial cord blood pH will turn out to be normal or borderline, while about 90 % of infants with abnormal results will not suffer permanent consequences. In many cases, perinatal asphyxia can be ascertained without routine pH measurement. Routine measurement means extra costs and extra workload. Despite this extra effort, cord blood pH will remain unreported in at least 10 % of births. Moreover, if only validated measurements are accepted, around 25 % of cord blood values will remain unreported or dubious in terms of whether they reflect arterial or venous pH [10]. The lack of universally agreed cutoff points between normal and abnormal pH leaves room for conflicting interpretations. Moreover, in case of litigation, adequate documentation of unexpected acidemia at birth may well have negative consequences for obstetricians who seek to document and audit their practice.

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译文 （非专业人士翻译仅供参考）

新生儿常规测量脐带血的价值

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在出生时测量脐带血 pH，是相对简单的和非侵入的方法，为产科医生提供客观的和敏感的测量条件的婴儿出生状态的情况。只要遵守一定的标准，报告的值是可靠的。常规检测对产科医来说是有利的。

介绍

在怀孕期间和分娩时胎儿血液采样都是相当复杂的程序，需要有专门的医生。在出生时脐带血采样，在另一方面，是安全和容易。当 pH 值分析仪在产房，节省时间，精力，但这种测量均需要电源。当然，有实际成本计量，收取此费用的标准是什么。美国的研究报告说，患者脐带血测量的收费是 22 和 79 美元之间 [1]。这些费用往往扮演着重要的角色，讨论在出生时是否应常规检测脐带血 pH。出生时的脐带血 pH 测量使用的一项调查显示，只有 27% 的大学产科进行常规的测量[2]。

美国妇产科医师学院的脐带血解决了这个问题。在最近的指导方针，它是表示在出生后立即被夹住脐带。这部分可以在以后 5 分钟 Apgar 评分是令人满意的。但是，如果严重的问题，在 5 分钟前就应送血气分析。在德国和英国，社团妇产科医师提醒，在每个出生的新生儿测量动脉脐带血 pH 值。在荷兰，我们建议在各医院出生的脐带血 pH 值来衡量。

在本文中，我们提出出生时赞成和反对脐带血 pH 值在常规测量。然而，做为临床医师，出生时的脐带血 pH 测量的主要问题，无论是常规测量或仅在选定的情况下，保持正确的解释的结果。这不仅涉及到正常和异常值的临床意义，但还测量的可靠性，影响因素，它和所选择的截止在出生点之间的正常和不正常的 pH 值。

采样和测量

在出生后钳夹脐带血管的动脉和静脉的样品可以立即采取。我们建议，脐带夹紧，使用两个止血钳钳夹 10-20 厘米长，可以采取。从新生儿端开始夹紧时，脐动脉空朝着下一钳位之前胎盘某种程度上可能是固定的。因此，最好将钳头的胎盘端。

钳夹脐带的截面提供了几个优点。脐带血可以采取由另一端。当有疑问时，可重复测量的样品，例如，当动脉和静脉的测量提供了几乎相同的 pH 值。最重要的是，采样是不太可能受到分娩的干预。一个钳夹段可以在室温下保持 15-30 分钟，不包括采样和测量的影响[3]。当测量被推迟超过 30 分钟，样品应在肝素化的注射器，并保存在冰水中[4]。在这些注射器肝素浓度不应超过 50 IU / mL [5]。

重要的是，采取血液样本从动脉和静脉。这将提供令人信服的证据表明，动脉血 pH 值实际上是来自一个动脉。如果只有一个容器被采样时，它可以很容易地被认为，将 pH 反映静脉的 pH 值，因为采样静脉通常更容易[6]。显然，正确的采样，也需要有适当的测量报告的值。制造商的说明进行校准和质量控制应遵循分析仪。目前，大多数分析仪显示是否有一定的测量是可靠的。应该有足够的保障措施。

验证和解释

如果两个 pH 值出现明显的偏离，人们可以得出这样的结论：动脉和静脉的 pH 混合。味确保值的准确要明确样本之间的差异。虽然，这是合理接受的，静脉的 pH 值应超过动脉血 pH 值至少为 0.03 个单位给的结果[6]。数据不符合本标准是仅相当于静脉 pH。

重复动脉血 pH 值测量之间的差异获已报道了一些研究。这些差异导致的 pH 值不准确，生物样本之间的差异和变化，在获取和处理样本。标准偏差 (SD) 的两个样本之间的差异是 0.024 到 0.033，比较了两种测量出生后立即直接测量比较的研究为 0.024 到 0.045 [3,7,8]。95% 动脉线血液的 pH 值测量的可信限大致是测量值的 ± 0.06 。

临床解释脐动脉血 pH 需要考虑的是什么是正常什么是不正常。胎儿及新生儿血液的 pH 值一般保持不变。在怀孕期间，动脉脐带血 pH 平均值为 7.37，在 95% 的测量范围为 7.43 和 7.31[9]。在出生后立即，平均动脉脐带血 pH 值低，一个更大的传播围绕其平均值，证明出生的变化从一个人到另一个。死的胎儿或婴儿的血液是通常在 6.8 和总是低于 7。如此低的 pH 值在现场的胎儿或婴儿窒息表示。

胎儿心脏异常率描线，平均动脉血液的 pH 值在 7.24 和 7.31 之间变化，而下限统计正常（平均 - 2 SD）从 7.07 至 7.22 之间变化[10]。在妇女与正常妊娠，剖宫产临产前，动脉线的 pH 值在 7.26 和 7.29 之间，与下限之间的统计正常 7.16 和 7.21[10]。

在产生窒息损伤时应该是有相当敏感的截止点（80-90%），同时具有检测婴儿中至少有 5% 至 10% 的预测值期间（而非之前或之后）。一些研究表明，临界值 7.00 到 7.05 符合这些标准 [6,11,12]。然而，由于 95% 置信区间的单独的测量是相对宽（0.06 至 0.06），使用一个单一的截止值是不现实的。因此，动脉脐带血 pH 值在 3 以下的分类类似于更现实：正常（>7.11），边界（H 7.11，L 6.99）和异常（<6.99）。有统计和生理上的证据支持这一分类。然而，许多学者之间的分界点，正常和异常的动脉脐带血出生时 pH 值在 7.10 和 7.20 之间变化。

正常和不正常的值临床意义

出生时的脐带血 pH 值提供一个高度敏感的和具体的指示，永久性的伤害。有几个明显的原因。胎儿和新生儿可能恢复或多或少的从窒息的情节，这样一个小插曲可能会或可能不会导致永久性器官损伤。因此，大多数的婴儿出生时脐带血 pH 低精神运动发育正常[11,12]。在另一方面，未记录窒息发生在子宫内或在婴儿早期可能使人产生永久性的伤害。这就解释了为什么许多脑损伤的婴儿出生时有正常脊髓血液的 pH 值。此外，永久损害可以按照遗传或感染性疾病的干扰胎儿没有任何历史动态平衡。

如果脐 pH 值不能预测长期结果，如果有的话，它的意义是？一个正常的脐带血 pH 表明，胎儿出生时是在良好的条件。当它与产科医生的临床表现，可以得出这样的结论：宝宝并不需要立即专业的护理。脐 pH 值还提供了一个重要的元件中的评价产时监护，都具有良好的情况下。pH 值在正常脐带血出生提供的证据表明，出生的管理并不会伤害胎儿。它也可以在回顾的指示，'紧急产科干预是有效的或多余的。一个正常的出生时的脐带血 pH 值，以合理的确定性，排除在分娩时氧气不足。与正常出生的新生儿脐血 pH 值，这也是真实的。这些低 Apgar 评分的原因，然后在寻找因素，如产妇用药，出生创伤，先天畸形等。

脐带血液 pH 值异常，表示在出生的时候胎儿的状态在 失代偿期。如果这是伴随着低 Apgar 评分，复苏程序已经启动前的 pH 值异常结果是可利用的。充足通气通常会足以克服低氧血症的。但是，围产期窒息，新生儿应在重症监护病房

照顾，因为缺氧缺血性脑病的危险性增加。当一个婴儿出生异常脐带血 pH 值，但正常 Apgar 评分，前景是比较有利的，但全面检查必要时，包括观察，至少要等到血液的 pH 值已恢复正常。异常脐带血 pH 值的值应该有助于的产科医生和 perinatologists 到批判性地评价他们的照顾，例如在怀孕和分娩过程中考虑是否及何时胎儿血液采样应该已经完成或即将出现问题的迹象没有得到充分采取行动时。

最后，父母期望他们的孩子的未来发展的预后。脐带血 pH 值或 Apgar 评分的基础上给予必要的评估。仔细观察新生儿在第一天的生活是必要的。如果迹象，中度或严重性脑病（Sarnat II 或 III），永久性残疾或死亡的风险是相当大的，这与围生期窒息有必要的因果关系[13]。缺席这些迹象与预后良好。

常规的脐带血 pH 测量的优势

一个动脉脐带血 pH 值，正确的取样，测量，验证和解释，提供了分娩时窒息最客观，最敏感的指标。它的非侵入性测量便宜，只要配备产房，因为它应该是，与 pH 值分析仪用于测试在分娩时胎儿的血液样本。的主要优点常规测量是照顾者获得即时反馈对他们的照顾在分娩过程中，可以从这些信息中得到。许多严重酸血症的新生儿及早发现，导致更及时的反应，并在某些情况下，防止进一步的并发症。此外，常规测量的审计提供了新的机遇。定期讨论血液的 pH 值在出生时脐带异常的情况下，将增加医院的政策的质量和他们的应用程序。考虑到以后的索赔或投诉，实际上排除了正常的 pH 值窒息分娩。最后，定期收集脐带血 pH 提供了可靠的结果回顾性研究的措施。

常规的脐带血 pH 测量的缺点

约 98% 的常规测量动脉脐带血 pH 值会变成正常或边缘，而约 90% 的婴幼儿不正常的结果不会受到永久的后果。在许多情况下，围产期窒息常规 pH 值，可确定不测量。常规的测量意味着额外的成本和额外的工作量。尽管这些额外的努力，脐血 pH 值将保持未申报出生的婴儿中至少有 10%。此外，如果只验证测量被接受，脐带血值将保持 25% 左右未报告或可疑的方面，是否反映动脉或静脉 pH 值[10]。缺乏正常和不正常的 pH 值普遍同意的截止点之间留出了空间相互冲突的诠释。此外，在案件诉讼，足够的文档的很可能产生消极后果的产科医生寻求记录审核他们的做法。

文献概述：

一：新生儿出生后常规测定脐带血的价值，建议出生后钳夹脐带动静脉血管立即采取，并介绍了优势，介绍了脐带血不正常的原因；还分享了常规测量动脉脐带血的优势和缺点；

关键词：脐动脉血气、PH 值