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# Acid–base balance of umbilical artery blood of liveborn piglets at birth and its relation with factors affecting delivery of individual piglets

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**Abstract**

In the limited number of studies that reported on the relation between factors affecting birth of individual piglets and acid–base balance values at birth, predominantly simple correlation coefficients have been used. The aim of the present study was to analyse the relation between factors affecting delivery of individual liveborn piglets and acid–base balance values (pH, $p_{CO_2}$, $HCO_3^-$ and $BE_{ecf}$) at birth. In total 201 piglets originating from 44 litters were used for the collection of blood samples from the umbilical artery immediately after birth, preferably in the period of apnea. Blood samples were analysed with the iStat® Portable Clinical Analyser.

Significantly lower pH, $HCO_3^-$, $BE_{ecf}$ and significantly higher $p_{CO_2}$ levels were found in posteriorly presented piglets, independently of the condition of the umbilical cord, birth weight and cumulative birth interval/rank. Independently of presentation, birth weight and rank, piglets born with ruptured umbilical cords showed significantly lower pH values. Next to that, increasing birth weights resulted in increasing $HCO_3^-$ and $BE_{ecf}$ values at birth, independently of presentation, condition of the umbilical cord and cumulative birth interval/rank. Both an increase in cumulative birth interval and in rank was associated with a significant decrease of pH, $HCO_3^-$, $BE_{ecf}$ and increase of $p_{CO_2}$ levels in umbilical cord blood at birth.

Together these results demonstrate for the first time that a clear relation exists between (factors affecting) the progress of delivery and acid–base balance values in a polytocous species like the pig.


*Keywords:* Piglet; Presentation; Birth weight; Birth interval; Acid–base balance

## 1. Introduction

Analysis of acid–base balance (pH, $p_{O_2}$, $p_{CO_2}$, $HCO_3^-$ and base excess values ($BE_{ecf}$)) in the blood of newborns is used, among others, to evaluate the physiological condition immediately after spontaneous birth and to analyse the impact of obstetrical measures on neonatal outcome [3,22,27,28]. In this respect polytocous species, such as the pig, are of specific interest because a broad range of acid–base values can be expected at birth in different members of the same (large) litter [4,10]. Several studies performed with piglets not only focussed on the establishment of

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reference values for acid–base parameters in healthy individuals at birth, but also aimed to relate these values to clinical viability scores of the neonates [10,19,34].

Particularly the degree of acidosis (resulting from acid–base balance analysis) is considered to be an important factor in determining neonatal outcome [14,20]. Acidosis can be of respiratory or metabolic origin (respiratory or metabolic acidosis, respectively) or of mixed respiratory-metabolic origin [20]. In human babies it has been demonstrated that metabolic acidosis (and not respiratory acidosis), resulting from the excessive formation and subsequent accumulation of metabolic acids like lactate during a period of hypoxemia, is responsible for more or less severe complications in newborns [14]. Although some studies in pigs point to the importance of metabolic parameters [2,10,13,33] in the evaluation of the condition of newborns, others neglected to incorporate metabolic parameters such as $BE_{ecf}$ or lactate concentrations [18,34].

In studies published so far, great variety exists as to the site where blood sampling of newborn piglets took place. Blood samples have been taken from the carotid artery [1,15], vena cava cranialis [2,7,13,33], umbilical artery [18,19], umbilical cord (mixed blood) [4,10] but also suborbital blood [34,35] has been collected. Next to that, the time of sample collection in relation to the moment of birth of the piglet differed considerably, ranging from the period of apnea immediately after birth [4,7,9,10,15,18,19,33] to several minutes or even hours after birth [1,2,34,35]. Furthermore, blood sampling has been performed under a variety of conditions, such as from chronically catheterized fetuses in laboratory experiments [15], and from newborn piglets after induced [9,15,35] or spontaneous farrowings on commercial farms [1,2,7,13,18]. Finally, several studies only reported data from a limited number of samples used for acid–base measurements [2,7,15,18].

As already mentioned, the acid–base balance in blood samples collected at birth reflects the degree of metabolic and/or respiratory acidosis of the neonate. Although the severity of the acidosis at birth can be affected by, for example, the duration of farrowing [10], data on factors related to delivery of piglets and that may affect their acid–base balance at birth are rare. We recently demonstrated that presentation of piglets at birth, birth weight and birth order each significantly affects individual birth intervals between piglets [30]. Herpin et al. [10] showed that blood pH decreased and $p_{CO_2}$ increased slightly with an increasing position in the birth order and similar findings were reported by Brenner and Gürtler [2]. Furthermore, it has been found that posteriorly presented piglets showed significantly lower pH values at birth than anteriorly presented piglets [10]. However, in these studies variables that may be related to the acid–base balance at birth were analysed independently of each other.

The present study provides acid–base balance values (pH, $p_{CO_2}$, $HCO_3^-$ and $BE_{ecf}$) in umbilical artery blood, collected at birth from liveborn piglets delivered during spontaneous farrowings under commercial conditions. Our main aim was to analyse whether the acid–base balance at birth is related to factors affecting delivery of individual liveborn piglets. For this purpose the variables presentation at birth, condition of the umbilical cord at birth (intact or ruptured), birth weight and cumulative birth intervals (interval between birth of a piglet relative to birth of the first piglet) or relative position in the birth order (rank, defined as (position in birth order − 1)/(total number born − 1)) of liveborn piglets were considered simultaneously.

## 2. Materials and methods

These experiments were approved by the Ethical Committee of the Veterinary Faculty of Utrecht University (The Netherlands).

### 2.1. Animals

Sows and gilts used in this study originated from three different (genetic) lines (pure- or crossbred): Dutch Landrace (D), Dutch Landrace × Large White crossbreds (X) and synthetic Dumeco α-line (Dumeco breeding company: a crossbred based on three different lines, abbreviated as DUM). Data were collected in three different experiments (batches), see Table 1.

The animals were housed at the experimental pig farm The Tolakker, Faculty of Veterinary Medicine, Utrecht. Approximately 3–6 days before the expected date of farrowing, the pregnant sows were transported to individual farrowing crates in the farrowing unit. The average ambient temperature was maintained at about 20 °C. Pregnant sows were fed 1.15–1.75 kg of a commercial diet for pregnant sows twice daily (at 07:30 and 16:00 h). Piglets were provided with a separate bedding consisting of wood-shavings, heated by a 150-W infrared lamp.

### 2.2. Data collection

The animals were monitored for signs of an impending farrowing. All farrowings occurred sponta-