CONTINUOUS TRANSCUTANEOUS CARBON DIOXIDE MONITORING DURING HUMAN LABOUR

C. Nickelsen

Department of Obstetrics and Gynecology, Rigshospitalet, University of Copenhagen, Denmark

T. Weber

Department of Obstetrics and Gynecology, Hvidovre Hospital, University of Copenhagen, Denmark

Introduction

Fetal transcutaneous carbon dioxide tension is the only possible method for non-invasive monitoring of the fetal acid base state during labour. During fetal respiratory acidosis the carbon dioxide tension is elevated. At least temporarily this is also found during fetal metabolic acidosis (1).

By the transcutaneous technique the gas tension of the extra cellular fluid in the upper layer of the skin is measured. This value reflects the gas tension of arterial blood but it is modified by the capillary blood flow and the production or consumption of gas in the area. Heating of the skin produces dilatation of the capillaries. This is necessary when transcutaneous oxygen is monitored. However, during transcutaneous carbon dioxide monitoring this is not quite as essential because of a much higher transmissibility of the carbon dioxide though the epidermal layers.

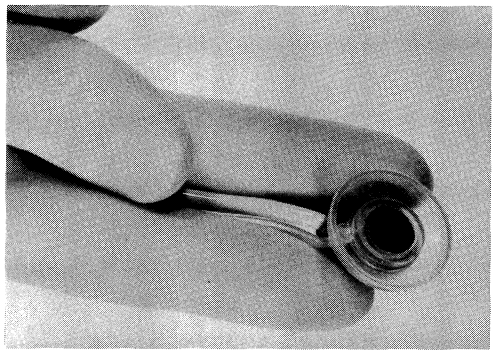
Heating of the skin - and the blood - will cause an elevation of the transcutaneous carbon dioxide tension in relation to the

capillary value, which usually is measured at 37°C. The transcutaneous carbon dioxide tension should be corrected for this temperature difference. Additionally, the carbon dioxide production in the skin between the capillaries and the electrode on the skin surface will cause an elevation of the transcutaneous carbon dioxide tension. In previous studies this "metabolic" contribution to the transcutaneous carbon dioxide tension is estimated to be approximately 0.5 kPa (2).

The electrode used in our studies is a modified Severinghaus carbon dioxide electrode (Radiometer E 5230).

Sterilization implies change of electrode membrane, mechanical cleaning with alcohol and sterilization in fluid aldehydes. The electrode is calibrated at a 5% and 10% carbon dioxide gas mixture immediately before the final sterilization with aldehydes. No drift or change in electrode sensitivity has been observed during the final sterilization procedure (3).

Application of the electrode to the fetal scalp can be performed using either a glue fixation technique or a suction fixation technique. The glue fixation is performed through an amnioscope, using cotton swaps to clean and dry the fetal skin before applying the electrode with a specially designed forceps. In contrast, the suction fixation is performed without amnioscopy and without cleaning during a vaginal examination, holding the electrode in the suction ring between the two exploring fingers (Fig. 1). The electrode is kept in the position by a vacuum of 20



kPa produced by an electrical pump. We have compared the two methods by simultaneously monitoring a fetus with two electrodes applied by the two different methods (4). No difference in the measured carbon dioxide tension was found. Compression of the electrode on the other hand causes an elevation of the measured pCO2. This was demonstrated in a study in which one electrode was placed under the cervical edge. This electrode measured higher tc-pCO2 values which fluctuated with the uterine contraction compared to lower stable values measured by another electrode, which was not compressed (5). The suction fixation method makes it possible during a vaginal examination to move the electrode to a position without compression.

Results

We have performed monitoring with an electrode temperature of 44 ^{o} C (80 cases) and with an electrode temperature of 41^{o}C (42 cases). When correlating the last measured transcutaneous carbon dioxide value just before delivery to the carbon dioxide tension of umbilical artery blood we found significant correlations using both electrode temperatures. The regression line was close to the identity line, but the intercept on the Y-axis was much higher when using the 41^{o} C temperature than when using the 44^{o}C temperature. This intercept is an indication of the mean difference between the umbilical artery blood value and the transcutaneous value. This could be explained by the lower temperature causing less dilatation of the capillaries of the skin and a subsequent lower blood flow and accumulation of carbon dioxide in the tissue.

The mean values of tc-pCO2 are calculated according to the dilatation of the cervical os, slightly higher values being found using the low electrode temperature (Table 1). The values were slightly increasing during the first stage and more distinctly increasing during the second stage of labour.

During our studies only six newborns were delivered with umbilical artery blood pH below 7.15 following transcutaneous pCO2 monitoring. Using the above mentioned mean values + 2SD as upper limit for normal pCO2 only 4 out of these 6 newborns had values exceeding this limit. In all 6 cases there was a distinct increase of pCO2 before delivery.

Table 1. Mean ± SD of fetal transcutaneous carbon dioxide tension according to the cervical dilatation, measured at different elecde temperatures.

	4 cm	5 cm	6 cm	7 cm	8 cm	9 cm	10 cm	PF
41°	6.16 ± 1.17	6.84 ± 1.67	7.07 ± 1.72	7.01 ± 1.42	7.15 ± 1.66	7.23 ± 1.40	7.33 ± 1.47	7.86 ± 2.06
n=	21	28	31	34	35	36	37	34
44°	5.82 ± 0.80	5.97 ± 0.75	6.01 ± 0.88	5.96 ± 0.89	6.18 ± 1.11	6.20 ± 1.05	6.37 ± 1.05	7.17 ± 1.13
n=	18	34	47	52	63	68	66	48

However, if all six acidotic fetuses (Umbilical artery pH < 7.15) should be detected by a fixed tc-pCO2 limit the upper limit of tc-pCO2 should be as low as the mean value of tc-pCO2 according to our material.

Conclusion

Concluding, our studies indicate that if tc-pCO2 monitoring is used as a screening method to exclude fetal acidosis, 50% of all fetuses would need further evaluation by fetal scalp blood sampling. This implies that in high risk cases - and at least

following a pathological CTG - tc-pCO2 monitoring needs to be supplementet by tissue-pH monitoring in about half of the patients, the only alternative being repeated scalp blood sampling.

References

(1) Nickelsen C, SG Thomsen, T Weber: Eur J Obstet Gynecol Reprod Biol 22 (1986) 215
(2) Severinghaus JW, M Stafford, AN Thonstroem: Acta Anaesth Scand (Suppl 68) (1978) 9
(3) Nickelsen C, T Weber: J Perinat Med (in press)
(4) Nickelsen C, T Weber: Br J Obstet Gynecol 93 (1986) 1268
(5) Nickelsen C, T Weber: Br J Obstet Gynecol 93 (1986) 1272