# ANIMAL STUDIES FOR INTRAPARTUM BIOCHEMICAL MONITORING - ARTIFICIAL UMBILICAL CIRCULATION

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The electrode for the measurement of the transcutaneous partial pressure of carbon dioxide ($tcPCO_2$) is an additional instrument for the supervision of the fetus during labour (5,9,12). The investigation of certain aspects of the $tcPCO_2$ monitoring in the human fetus during labour was performed during a number of animal experiments in order to study the electrode under defined conditions.

The study of the response of electrochemical sensors have been shown to be limited during clinical trials to some extent (13). The aim of this paper is to demonstrate the reliability of a combined $tcPCO_2/PCO_2$ sensor to measure the $PCO_2$ and $PO_2$ in arterial blood over a wide range of values. The variability of the gases was achieved by an artificial umbilical circulation via a membranlung (1,2,7,11).

## Method

The animal experiments were performed using twelve premature lambs, gestational age 125 to 128 days of gestation (caesarian section in epidural anesthesia). The delivered premature lambs directyl thereafter were connected to a perfusion circuit using catheters that were implanted into the umbilical artery and umbilical vein (thinwalled, largewalled catheters embedding stainless steel springs (14). The perfusion circuit included an 0,4 m Scimed - Kolobow membrane lung, 3/16 Polyurethan-tubing and a mechanical pump. The priming volume of 160 ml was maternal blood. The flow rate in the extracorporeal circuit was initially regulated aiming at a $PCO_2$ of 45 to 55 mm HG. $PCO_2$ values in the extracorporeal circuit were measured by intermitten blood samples from the arterial line and by a sensor and a flow chamber that measured the $PCO_2$ and $PO_2$ values at a measuring temperature of 37 °C. The circuit and the animal were thermostated at 37°C by means of an incubator. Transcutaneous electrodes were placed on the fetal head by the glue technique (4). The measuring site was prepared in the following way: hair was removed and the measuring site was cleansed from mucus and blood using squabs. Fixation rings thereafter were applied on this measuring site using butyl-

cyanoacrylat. The rings were then filled with contact solution and the electrode was screwed into the fixation rings. On an schematic drawing the experimental set up that is used during the investigation is demonstrated (Fig. 1).

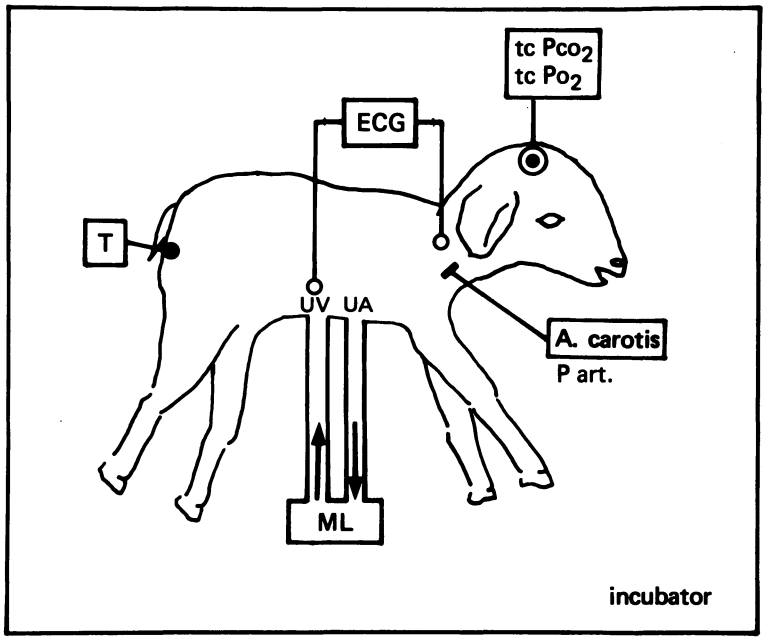


Fig. 1 Schematic drawing of the experimental set up: premature lamb connected via the umbilical vessels (UV,UA) to an extra corporeal arteriovenous circuit to a membrane lung (ML) - Blood pressure (P.art) temperature (T) and heart frequency (ECG) are monitored. $TcPCO_2$ and $tcPO_2$ is continously recorded.

The data of the continuously recorded $PCO_2$ measurement using the transcutaneous technique was compared with the results of blood gas checks of blood samples taken from the arteria carotis. The arterial blood pressure was recorded continuously (A. carotis) by means of a Statham system.

The experimental set up of an artificial umbilical circulation with a connection to membrane lung that provides a $CO_2$ removal and oxygenation enables to study the $PCO_2$ and $PO_2$ and its registration by transcutaneous electrodes over a wide range of gas values at different flow rates in the umbilical circuit and different gas concentration in the membrane lung. On the multi-channel-recorder the data of the transcutaneous tracings of $PCO_2$ and $PO_2$ as recorded by the Draeger electrodes at 44°C as well as the recorded arterial blood pressure as well as the heart-rate of the lamb (Fig. 2).

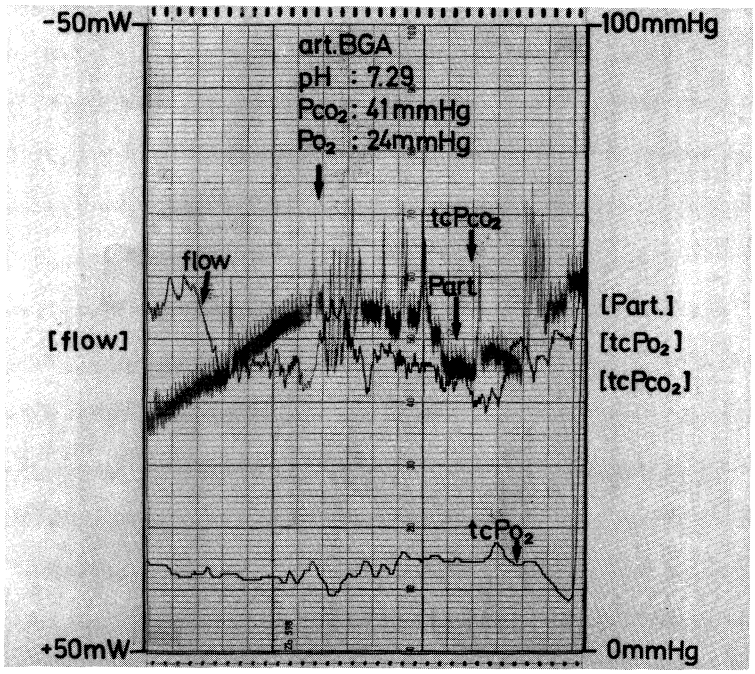


Fig. 2 Registration of Part, $tcPCO_2$ and $tcPO_2$ and the heart rate and relative heat deviation (flow) as well as the result of intermittend blood gas analysis (BGA) during artificial umbilical circulation.

Results

The comparison between the transcutaneous $PCO_2$ -values and the values in the fetal blood as collected during the experiments clearly shows a characteristic overestimation of the $PCO_2$ by the transcutaneous system. This overestimation occurs characteristicly during transcutaneous recordings of $PCO_2$ due to the raised temperature and $CO_2$ production in the tissue. There was a statistically significant correlation ($r = 0,91$ $p < 0,0001$). While the intecept was 17,80 and the slope 0,99 (Fig. 3).

For the comparison between $tcPO_2$ and $PO_2$ values we also found a good correlation ($r = 0,89$). There was a tendence to underestimate the gas value in the blood though (intercept=-10,36).

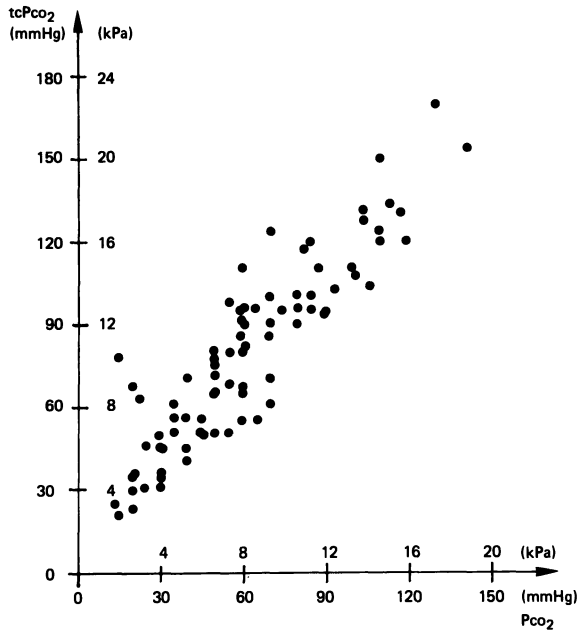


Fig. 3 Correlation between tcPCO $_2$ and PCO $_2$ in the blood of the premature lamb (r=o,91, p <0,00001, intercept =+ 17,80, slope = 0,99).

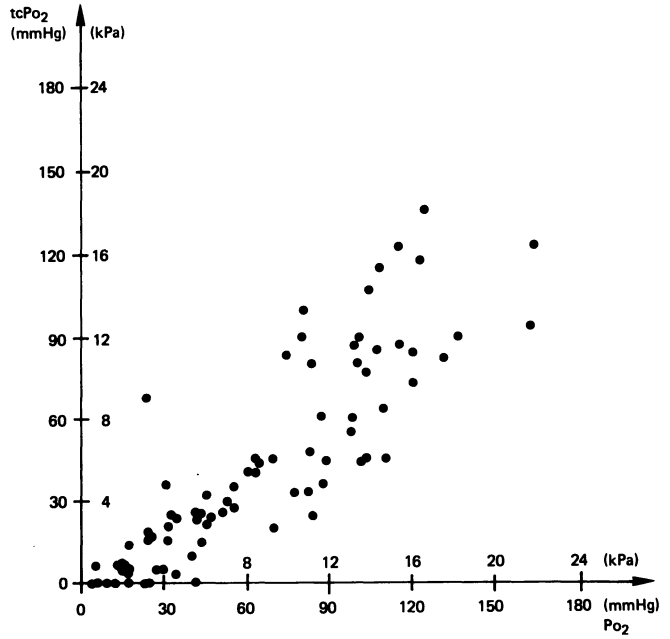


Fig. 4 Correlation between tcPO $_2$ and PO $_2$ (r=0,89, p< 0,00001, intercept = - 10,37, slope = 0,80).

## Discussion

Two different experimental set ups have been described before for the study of tc-sensors. The Rudolph-technique - chronically instrumented sheep - has the advantage that using the original technique animals can be investigated in a steady state situation (6,7,8,14). When investigating transcutaneous electrodes one has the disadvantage of the fact that the electrodes ideally should be implanted during the first session and then would have to be fixed on the fetal head by head by a technique that garanties that a dislodging does not occur (3,4,5,13). While basically an in vivo calibration of the electrode would be possible I would suspect that a dislodging of the electrode using a glue technique is very likely after a period of five days. On the other hand, if no leakage occurs one would be afraid of changes in the perfusion of the skin below the electrode leading to edema of the skin. If the animal experiments with chronically catheterized animals are performed using a second laparotomy, one has to keep in mind that during the second laparotomy it is again possible to cause a considerable disturbance of the fetal circulation (8,10). In this sense the data collected during our experiments can only to some extend be interpreted as data of a chronical experiment (8,10).

Using the technique of artificial umbilical circulation one has the advantage that using a membrane lung it is possible to change the $PCO_2$ and $PO_2$ values in the fetal blood over a large range. Additionally using a $PCO_2$ and $PO_2$ -flow-probe it is possible to compare the data with a transcutaneous data synchronously and continuously. On the other hand it is a disadvantage of this technique that the environment even if using an incubator is different from an intrauterine situation which leads to a larger oxygen up-take and additionally if the necessity of ventilation occurs it induces a disturbance of the fetal circulation (10). In this way data collected during such experiments can only to a certain degree be compared with the biological intrauterine situation. The problematic of such an experiments can only to a certain degree be compared with the biological intrauterine situation. The problematic of such an experiment is also very well demonstrated by the fact that a transcutaneous to fetal blood difference for $PO_2$ even data are corrected of occur during such experiments, that shows very clearly that a certain amount of a centralisation leading to a disturbance in the skin perfusion can be detected which is shown on the last Figure. Such disturbance occurs during the first hours of such a perfusion and is only improved after some three hours (unpublished observation). In conclusion we might say that animal experiments lead to the possibility of investigation of transcutaneous trancings of $PCO_2$ and $PO_2$ under defined conditions. A clerification of certain aspects is achieved. None of the

experimental set ups used by our group ideally simulate the fetal environment and one should additionally keep in mind that certain aspects such as compression phenomena that occur rhythmically during the fetal measurment in the human as well as the phenomenon of the diffusion disturbance during caput succedaneum may not very well be simulated during such animal experiments so that the influence of such circumstances occuring with the progress of labour should be inbestigated only during clinical trials (4,12,13).

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