Fetal brain-maternal aorta temperature differences in sheep

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METHODS

Food, but not water, was withheld from each of the 11 Dorset and Columbian ewes 2 or 3 days before surgery. Nine ewes received 100-250 mg of progesterone (Proluton, Schering) in oil each day for 1-3 days prior to the operation. To test the value of the treatment, it was withheld from two. The two untreated ewes aborted. Six living lambs were delivered either vaginally or by cesarean section from the nine ewes that were treated.

Our standard procedure included, in addition to the progesterone, the injection, intramuscularly, of 250 mg sodium pentobarbital, 1.5 mg scopolamine hydrobromide, and 200 mg lidocaine hydrochloride (Xylocaine, Astra) 1 hr before surgery. The ewe was anesthetized with a gas mixture of 80% N₂O, 20% O₂ and varying amounts of methoxyflurane (Metafane, Pitman Moore). When the ewe was relaxed and quiet under this anesthesia, 4-6 mg of tetracaine hydrochloride (Pontocaine, Winthrop Laboratories) were injected into the spinal canal through the interspace between the last lumbar and the first sacral vertebrae or the next caudal. The ewe was then placed on her back and tied to the table. With the usual precautions against sepsis, two separate thermojunctions made with 36-gauge, copper-constantan, nylon-coated wires (Revere Corporation, Wallingford, Conn.) that had been drawn into sealed polyvinyl catheters (0.038 inch id, 0.070 inch od) were threaded 25-35 cm into the abdominal aorta via a femoral artery.

The abdomen was then opened by a midline incision, the fetal head located and with a minimum of manipulation shifted into the distal part of the uterine horn where it could be held firmly by gripping it within the uterine muscle. Prior to incising the uterine wall over the dorsal surface of the head, that area was infiltrated with 1 ml of progesterone in oil (Proluton, 50 mg/ml) and encircled by fine silk sutures which passed through the uterine wall and the fetal membranes. These structures and the scalp were separated by an incision that extended from the forehead to the occiput. The edges of the wound were retracted and the periosteum on the skull elevated over an area about 2.5 cm in diameter caudal to the bregma and bisected by the midline.

The procedure for implanting the thermojunction in the fetal brain (its reference junction was one of the two...
Thermocouples were successfully implanted in the fetal brain and the maternal aorta respectively in six ewes that were within 3 weeks of term, and records of the difference in temperature between these points were obtained over periods that ranged between 2 and 10 days before the fetus was delivered alive either by cesarean section or vaginally. In each case, the temperature of the fetal brain was, on the average, 0.4-0.8 °C higher than the blood in the maternal aorta. In three cases, the difference was slightly higher in the hour just prior to delivery. Three of the fetuses were delivered vaginally; three were delivered by cesarean section after labor had started.

Typical records of the temperature in the maternal aorta and of the difference in temperature between the fetal brain and maternal blood are presented in Fig. 2. The record was made on the 7th day after the implantation of the thermocouples. Fetal brain temperatures in 5 min averages were calculated from the recorded temperatures. The small variations of 0.1-0.2 °C in the temperature difference appear to reflect fluctuations in the temperature of the aortic blood, for the same oscillations can be seen in the record from the thermocouple that monitored the absolute brain temperature. The maternal aortic blood temperature began to increase quite abruptly about 45 min after the injection and was accompanied at times by noticeable shivering. The fetal brain temperature also rose after a short delay and it was always higher than that of the aortic blood of the ewe. Similar results were obtained in one other ewe following the administration of the pyrogen.

These records differ significantly from those obtained in sheep in which the fetus was judged to be dead from the condition of the ewe, the absence of spontaneous fetal movements, or movements in response to palpation and the
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subsequent delivery of a dead fetus. In sheep 635 (Fig. 4), the temperature difference underwent many changes, including reversals, during normal oscillations in maternal blood temperature.

Rupture of the fetal membranes of one sheep was followed some hours later by a rise in her blood temperature, presumably as the result of an infection. Here again the temperature of the fetal brain rose at the same rate as that of the maternal blood and remained higher. When the fetal brain temperature had risen to 41.4°C, it continued rising but at a much slower rate. The original temperature difference became less, and after 1 hr the difference became negative. A dead fetus was delivered by cesarean section when the maternal temperature reached 43°C. At that time, the ewe was in considerable distress. We suspect, though we do not know, that the death of the fetus occurred at about the time the temperature difference reversed.

The fetus of another ewe was delivered by cesarean section with thermocouples intact. Vigorous shivering followed a brief period of brain cooling. Within 45 min this mature, active lamb, resting in a thermally neutral room, was regulating its brain temperature within 0.2°C of its prenatal level.

DISCUSSION

The results presented above demonstrate that the near-term fetal lamb in utero—as judged by the temperature of its brain—is 0.4–0.8°C warmer than the blood in the maternal aorta. We have inferred from these results that in “steady-state” conditions the fetus is continuously losing heat to the maternal blood and that the fetus in utero is not, as has been suggested (5, 6, 14, 17, 21), “warmed” by the mother.

Our results are in accord with the earlier observations of other workers. Von Barensprung (23) observed that the temperature of the pelvic cavity in rabbits and dogs that were not pregnant was lower than that of the abdomen; in pregnant animals, to the contrary, the pelvic cavity and the cavity of the uterus were a degree warmer than the cavity of the abdomen. Hart and Faber (18) thrust thermocouples into freshly killed rabbit fetuses and found, after 25 days of gestation, that the fetal temperatures were higher than those of the mother. These authors, however, cautioned against extrapolating their results to other species. Temperature differences, they said, would depend, among other things, on fetal size, insulation and metabolic rate, and umbilical blood flow.

Our results are also in agreement with those of Alexeeff (4), as well as the more recent observations of Adamsons (3), Wood and Beard (22), and Mann (19), all of whom found the temperature of the human fetus at delivery to be higher than that of the maternal reference point. Moreover, our data lend support to the view that the temperature difference in those cases was not due solely to the circumstances of labor and birth.

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