OBSTETRIC ANESTHESIA AND PERINATOLOGY

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Title: CARDIOVASCULAR, CATECHOLAMINE, AND AVP RESPONSE TO CYCLIC ICP OSCILLATION IN FETAL SHEEP

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Introduction. Selective fetal head compression against the maternal pelvis during normal labor in humans can result in intracranial pressure (ICP) elevations during uterine contractions. The fetal cardiovascular and catecholamine response to increased ICP is largely unknown. We have previously shown2 that stepwise sustained increases in fetal ICP (as high as 41 mmHg) results in markedly decreased blood flow to the kidneys, skin, and gastrointestinal tract, with preservation of blood flow to the brain and placenta. Plasma epinephrine (E) and norepinephrine (NE) levels increased, along with adrenal blood flow. In the present study, we oscillated ICP to determine whether similar blood flow and hormonal responses occurred under dynamic conditions closer to those seen during labor.

Methods. Eighteen fetal lambs (128-137 days gestation) were studied. Monitoring catheters were implanted two days prior to study, and included a lateral cerebral venous catheter, ventricular catheter, arterial catheter, umbilical arterial catheter, fetal arterial catheter, and umbilical venous catheter. Blood flow was measured using the radioactive microsphere technique. NE and E levels were measured using HPLC, and arginine vasopressin (AVP) was measured by RIA. In Group 1 (n=12), ICP was oscillated in 10 cycles, each cycle lasting 3 min, with peak ICP approximating baseline mean arterial pressure (MAP), and each nadir approximating baseline ICP. ICP was elevated during each cycle by an artificial CSF infusion into the lateral ventricle from a pressurized reservoir, and ICP was allowed to fall by decreasing reservoir pressure. The resulting ICP wave form was approximately sinusoidal. In 6 of these animals, blood flow was measured by microsphere injection at 75 min intervals during cycle 1, and in the remaining 6 animals it was measured at 75 min intervals during cycle 6. Hormone levels were determined after cycles 3 and 10. In Group 2 (n=6), ICP was also oscillated in 10 cycles, but each cycle lasted 5 min. Over the first 75 min of each cycle, ICP was gradually increased to baseline MAP. Over the next 75 min, ICP was allowed to return to baseline ICP. For the remaining 3.5 min, ICP remained at baseline. Regional blood flow changes were determined after cycle 3 and 10. NE, E, and AVP levels were determined after cycles 4 and 10. Data are mean ± SEM.

Results. In Group 1, baseline MAP was 50 ± 1 mmHg. MAP increased transiently with each ICP increase during the first few cycles, and then underwent sustained increase through cycle 10, when MAP was 65 ± 2 mmHg. Although cerebral blood flow was unchanged from baseline at the beginning of cycles 1 and 6, at 1.5 min later, at peak ICP, cerebral blood flow fell 63% in cycle 1 but only 43% in cycle 6. Small intestine and renal blood flow fell transiently only at peak ICP in cycle 1; however, during cycle 6 the reductions in blood flows were sustained throughout the cycle. Myocardial, adrenal, and placental blood flow increased during cycles 1 and 6. NE, E, and AVP increased after cycles 3 and 10 (see figure). In Group 2, MAP increased during the ICP spike. During the pause between spikes, MAP remained 8±2 mmHg elevated after 10 cycles. There were no changes in blood flow to the cerebral hemispheres, kidneys, small intestine, placenta, heart or adrenals measured during the interval between ICP spikes. NE and E were unchanged, but AVP levels increased from 6±1 to 23±5 pg/ml by cycle 10.

Discussion. In fetal sheep, the cardiovascular system responds rapidly to dynamic increases in ICP. This potent vasoconstrictor response blunts a drop in cerebral blood flow. With 3 min periodicity (Group 1), two components of this response can be identified: an early phasic increase in MAP seen during the first ICP oscillations, and a later sustained vasoconstriction seen during subsequent continuous cycling. The peripheral vasoconstrictor response is similar qualitatively and quantitatively to that seen during steady-state ICP elevation, and coincides with an increase in circulating vasoconstrictors. This form of the Cushing response may be protective of fetal cerebral well-being during parturition if the fetus is subjected to continuous cyclic ICP increases. On the other hand, when the ICP is allowed to return to baseline for a period of time between cycles (Group 2) we observed much less effect on regional blood flows, although MAP and plasma AVP levels increase by 50 mmHg of repetitive ICP spikes. One possible explanation for this finding is that the vasoconstrictive component of the Cushing response in fetal sheep is dependent not only upon peak ICP, but instead on a time-averaged increase in ICP. (Supported by NIH HL 38285).

References:

<table>
<thead>
<tr>
<th>Cycle 3</th>
<th>Cycle 10</th>
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<tbody>
<tr>
<td>NE (ng/ml)</td>
<td>.2 ± .1</td>
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<tr>
<td>E (ng/ml)</td>
<td>.3 ± .2</td>
</tr>
<tr>
<td>AVP (pg/ml)</td>
<td>5 ± 1</td>
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Figure. Group 1 (n=12) NE, E, and AVP levels. *p<.05 vs baseline