NEUROSCIENCES AND ANESTHETIC ACTION—POSTER

TITLE: ANESTHETIC INFLUENCE ON CEREBRAL OXYGENATION DURING HEMORRHAGE

AUTHORS: D. E. Longnecker, M.D., J. R. Woodside, M.D., T. W. Laudeman, B.S.

AFFILIATION: Department of Anesthesiology, University of Virginia Medical Center, Charlottesville, VA 22908

Introduction. Previous studies demonstrated that anesthetics influence survival following hemorrhage. Specifically, ketamine, as compared with halothane, fluoroxyne or pentobarbital, increased the survival of hemorrhaged rats. Tissue hypoxia is an important component of hemorrhagic shock and it may be that anesthetics alter survival through their influence on tissue oxygenation. Therefore, we measured tissue oxygen tension (PtO2) in the rat cerebral cortex during hemorrhagic shock while receiving one of four anesthetics.

Methods. Twenty-four male Sprague-Dawley rats (300-375 g) received enflurane anesthesia for surgical preparation. Ventilation was controlled via tracheostomy to maintain PaCO2 between 37 and 43 mmHg. Cannulae were placed in the femoral artery and both femoral veins. The skull was immobilized and 3 mm burr holes were placed bilaterally in symmetric locations 4 mm posterior and lateral to the bregma. The animals were anesthetized with one of four tests anesthetics in a randomized selection: enflurane (ENF 2.2 vol%); ketamine (KET) 60 mg/kg/hr IV (125 mg/kg IV loading dose); fentanyl (FEN) 200 μg/kg/hr IV (100 μg/kg IV loading dose); thiopental (TPL) 60 mg/kg/hr IV (30 mg/kg IV loading dose). A period of 30 min was allowed for transition to the new agent. The dura was punctured with a fine needle and a platinum tissue oxygen microelectrode (tip diameter 2-4 μm) was advanced in 10 μm intervals through the parietal cerebral cortex. The electrode was paused nine seconds at each location and PtO2 was recorded at a total of 150-200 locations. Forty percent of the estimated blood volume was removed from a femoral vein over a 10 min period; 20 min later the oxygen microelectrode was introduced through the contralateral burr hole and a second series of PtO2 measurements recorded during hypervolemia. The PtO2 values were expressed as histograms and a mean value was determined for each animal during normovolemia and hypovolemia. Comparisons among groups were made by analysis of variance (ANOVA) using the method of least significant difference.

Results. Results are summarized in the Table. The greatest mean PtO2 was observed in normovolemic animals receiving fentanyl anesthesia. This value was significantly larger than the mean PtO2 in normovolemic animals receiving ketamine or enflurane. The mean PtO2 during thiopental was intermediate and not significantly different from any of the other anesthetics. Mean PtO2 during hypovolemia was similar for all four anesthetic groups. Prior to hemorrhage MAP was greater in those receiving thiopental or fentanyl compared with those receiving ketamine or enflurane anesthesia. During hypovolemia, the MAP was similar in those receiving thiopental, fentanyl, or ketamine and significantly less than that with enflurane. Values for PaO2 and PaCO2 were not significantly different among anesthetic groups during normovolemia or hypovolemia.

Discussion. Oxygen delivery to tissue is a function of many variables including arterial oxygenation, blood flow to the organ, and distribution of flow within the microcirculation. Tissue PtO2 approximates a measure of oxygen availability to the cells and reflects the balance between oxygen supply and consumption.

During normovolemia, fentanyl anesthesia resulted in significantly greater PtO2 values than during ketamine or enflurane anesthesia. Others have demonstrated that, in rats, fentanyl depresses both cerebral blood flow (CBF) and cerebral metabolic rate for oxygen (CMR-O2), and our data indicate that oxygen availability to cells is preserved. Ketamine is known to increase CMR-O2 and this may account for reduced mean PtO2 with this anesthetic. The low mean PtO2 with enflurane anesthesia would not be predicted since it decreases CMR-O2 and increases CBF. It appears that the excess blood flow is not distributed effectively at least through the cerebral cortex.

During hypovolemia the reported cerebral protective effects of thiopental were not evidenced by increased PtO2. It may be that the hypovolemia model we studied is fundamentally different from ischemic or hypoxic models where the beneficial effects of barbiturates have been demonstrated. Alternatively, it may be that barbiturates protect by a mechanism which is independent of cortical oxygen availability.

Gas Tensions and Mean Arterial Pressure During
Normovolemia (N) and Hypovolemia (H)

<table>
<thead>
<tr>
<th></th>
<th>ENF (N=8)</th>
<th>FEN (N=7)</th>
<th>KET (N=6)</th>
<th>TPL (N=6)</th>
<th>AVOA*</th>
</tr>
</thead>
<tbody>
<tr>
<td>PtO2</td>
<td>H 10±2</td>
<td>9±3</td>
<td>5±1</td>
<td>6±2</td>
<td></td>
</tr>
<tr>
<td>PaCO2</td>
<td>N 41±1</td>
<td>41±1</td>
<td>39±2</td>
<td>41±2</td>
<td></td>
</tr>
<tr>
<td>PaO2</td>
<td>H 119±7</td>
<td>122±7</td>
<td>116±11</td>
<td>123±11</td>
<td></td>
</tr>
<tr>
<td>MAP</td>
<td>H 58±6</td>
<td>130±4</td>
<td>101±8</td>
<td>135±9</td>
<td></td>
</tr>
</tbody>
</table>

*p<0.05, all values in mmHg ± SEM

References.