NEONATAL RESPIRATION FOLLOWING ABDOMINAL DELIVERY

Clinical study of the effect of anaesthetic management on carbon dioxide content of umbilical venous blood

BY

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SUMMARY

The study was undertaken to ascertain whether variations in maternal ventilation, designed to produce respiratory acidosis and alkalosis in the mother, could influence umbilical venous carbon dioxide content and whether there was a correlation between carbon dioxide values and onset of effective spontaneous respiration in the infant. Neonatal acidosis was studied both with and without central depression in order to ascertain whether carbon dioxide was capable of stimulating the respiratory centre under either or both conditions. The results suggest that respiratory acidosis stimulates respiration in the newborn and the alkalosis has the opposite effect.

Little is known in regard to the stimuli which initiate spontaneous respiration in the newborn (Smith, 1959). Oxygen lack does not produce a stimulus by way of the chemoreceptors, as in the adult subject; on the contrary, hypoxia appears to depress breathing in the neonate (Miller and Behrle, 1954). Whether carbon dioxide stimulates the respiratory centre at birth is contested. Smith (1959) reviews the literature on the subject and considers that there is no conclusive evidence of such a response. Cross, Hooper and Oppé (1953) and Miller (1954), however, have demonstrated it and it may well be that the response is conditioned by the existing state of the medullary neurones; birth trauma, ischaemia, hypoxia and central drug depression will affect it adversely. Cross (1961) concludes that acidosis stimulates respiration in the newborn and he observed one case which suggests that alkalosis may have the opposite effect.

In view of these findings it was decided to study the carbon dioxide content of the umbilical venous blood at the time of abdominal delivery under anaesthetic conditions designed to produce acidosis, alkalosis and central depression. It was thought of interest to ascertain whether variations in maternal ventilation could influence arterial Pco₂ in the child and whether a correlation between carbon dioxide content and onset of breathing could be observed.

METHOD OF INVESTIGATION

Forty subjects were selected for this study from patients who had elective Caesarean sections within one week, either way, of the estimated date of term because of previous section or cephalopelvic disproportion, or both, but for no other pathological or obstetrical indication. Mothers with any other abnormal obstetrical or relevant pathological history were excluded from the study. The subjects thus selected were placed into four groups of ten each, according to management of maternal anaesthesia (table I).

Anaesthetic management was designed to produce the following conditions:

Group I: Respiratory acidosis without central depression.

II: Respiratory acidosis with central depression.

III: Respiratory alkalosis without central depression.

IV: Control—normal respiratory environment.

The operations were carried out with the operating table in the horizontal position in case a head-down tilt should restrict respiration. The time which elapsed between delivery and start of regular spontaneous breathing by the infant was noted. Table II summarizes the following relevant information concerning the four groups of subjects:
The table summarizes the anaesthetic management employed in the four groups of mothers up to the time of delivery.

<table>
<thead>
<tr>
<th>Group</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

### Maternal anaesthesia

<table>
<thead>
<tr>
<th>Group</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal anaesthesia</td>
<td>Atropine 0.6 mg</td>
<td>Thiopentone 250 mg</td>
<td>d-Tubocurarine 15 mg</td>
<td>Nitrous oxide in oxygen</td>
</tr>
<tr>
<td></td>
<td>Thiopeptone 250 mg</td>
<td>50%</td>
<td>Cyclopropane and oxygen</td>
<td>Occasional closed circuit</td>
</tr>
<tr>
<td></td>
<td>Cuffed orotracheal tube</td>
<td></td>
<td>Circle absorber</td>
<td>Oropharyngeal airway</td>
</tr>
<tr>
<td></td>
<td>SPONTANEOUS RESPIRATION</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table II

Summarizes periods of maternal anaesthesia and controlled ventilation up to time of delivery, estimated periods of gestation and infants' birth weights. Average figures for group in brackets.

<table>
<thead>
<tr>
<th>Group</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>General anaesthesia (min)</td>
<td>10-23</td>
<td>7-24</td>
<td>8-14</td>
<td>None</td>
</tr>
<tr>
<td>Controlled respiration (min)</td>
<td>None</td>
<td>5-16</td>
<td>5-11</td>
<td>None</td>
</tr>
<tr>
<td>Estimated duration of pregnancy (days) (term at 266 days)</td>
<td>260-272 (263.7)</td>
<td>259-266 (262.9)</td>
<td>259-269 (262.9)</td>
<td>259-273 (265.5)</td>
</tr>
<tr>
<td>Birth weight (g)</td>
<td>2736-3884 (3357)</td>
<td>2523-5018 (3663)</td>
<td>2820-3727 (3294)</td>
<td>2963-4195 (3376)</td>
</tr>
</tbody>
</table>

1. Periods of maternal anaesthesia and controlled respiration up to the time the umbilical cord was clamped.
2. Estimated duration of pregnancy. For purposes of calculation, term was assumed to be 266 days after conception.
3. Range of birthweight of infants. Mean values for all these figures are shown in brackets.

Specimens of umbilical venous blood were obtained by clamping off a generous section of umbilical cord as soon as possible after incision of the uterus but in any case before the baby had drawn its first breath. Whenever doubt existed about the application of the clamps having been timed properly, the case was excluded from the study. As soon as the section of cord was obtained, 10-12 ml of blood was withdrawn under anaerobic conditions from the umbilical vein into a 20-ml syringe charged with a small amount of finely ground potassium oxalate and 4-5 ml of liquid paraffin. Thereafter, the blood was at once ejected into the floor of a specimen jar, also charged with potassium oxalate and liquid paraffin, and transferred to the biochemistry laboratory for estimation of carbon dioxide content by the Van Slyke method. When this study was planned it was intended to estimate maternal arterial carbon dioxide from a blood sample obtained at the time of clamping the umbilical cord. However, when the investigation was begun, arterial puncture was thought the only reliable method of achieving this and, in consultation with the obstetrical staff, this was not deemed justifiable.
RESULTS

The values for umbilical venous carbon dioxide content, obtained in the four groups of patients, are plotted in figure 1, together with the time (in seconds) which elapsed between delivery and onset of regular spontaneous breathing by the infant. The arrows denote mean values of carbon dioxide content for the group.

The two acidotic groups (I without and II with central depression) yielded almost identical mean values for carbon dioxide content (23.5 and 23.6 m.equiv/l, respectively), although the individual values were more scattered in group II. Onset of neonatal respiration was within 10 seconds of delivery in all cases in group I but was delayed in five of the group II babies. There was no correlation between carbon dioxide content and onset of breathing in group II.

In the alkalotic group (III), mean carbon dioxide content was 17.4 m.equiv/l. There was a negative correlation between individual carbon dioxide content and onset of respiration in nine infants in this group.

In the control group (IV), the mean carbon dioxide content was found to be 20.5 m.equiv/l. Onset of breathing was immediate in seven and the longest delay was 50 seconds. There was no correlation between carbon dioxide content and delay in respiratory onset.

Statistical evaluation shows that the mean total carbon dioxide in the babies of the first three groups is each significantly different from the mean total carbon dioxide in the infants of group IV (control). Only in group III, is there a significant negative correlation between carbon dioxide content and the time required for regular spontaneous respiration to begin.

The statistical analysis is summarized in table III.

DISCUSSION

Before considering the effects of respiratory acidosis or alkalosis in the newborn, it is necessary to decide what is to be regarded as a normal umbilical venous carbon dioxide content at birth. MacKinney et al. (1958) found a mean value of 19.1 m.equiv/l for 275 newborn infants before respiration but no details as to maturity or mode of delivery are given. Beer, Bartels and Raczkowski (1955) obtained a mean total carbon dioxide of 18.4 m.equiv/l for twenty-five normal vaginal deliveries "before the first cry". The mean figure found by Haselhorst and Stromberger (1932) after twenty-two normal spontaneous births, before the babies had breathed, was 20.3 m.equiv/l.

Attempts were made by the writer to study a control group of normal vaginal deliveries but it was found impossible to clamp the umbilical cord before respiration had begun. The infants had always breathed and cried before the cord...
TABLE III  
Summarizes statistical analysis of findings of study of umbilical venous carbon dioxide content in the four groups of patients. The mean total carbon dioxide in the babies of the first three groups is each significantly different from that of group IV (control).

<table>
<thead>
<tr>
<th>Group</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>23.5</td>
<td>23.6</td>
<td>17.4</td>
<td>20.5</td>
</tr>
<tr>
<td>SD</td>
<td>1.5</td>
<td>2.4</td>
<td>3.3</td>
<td>1.69</td>
</tr>
<tr>
<td>P*</td>
<td>&lt;0.01</td>
<td>&lt;0.02</td>
<td>&lt;0.05</td>
<td></td>
</tr>
</tbody>
</table>

In group III only there is a significant negative correlation between carbon dioxide content and time (correlation coefficient = —0.93, P<0.01).

Possibility of mean not being significantly different from mean of group IV.

had emerged from the vagina. It was then decided to use as control ten babies delivered by Caesarean section under local analgesia alone (group IV). Local, in preference to spinal, analgesia was chosen for the control group in order to avoid a possible increase of toxicity of the uterine muscle in case this should have an influence on the carbon dioxide values obtained. However, the mean carbon dioxide content in the group IV infants was 20.5 m.equiv/l., whereas that found by Haselhorst and Stromberger (1930, 1932) after eight elective Caesarean sections, all for contracted pelvis, under subarachnoid spinal analgesia was 20.1 m.equiv/l.

Although the infants in groups I and II were in an approximately equal state of respiratory acidosis (mean carbon dioxide values about 3 m.equiv/l. higher than that for the control group), as expected, onset of neonatal respiration was delayed in group II, when compared with group I, because the group II mothers received considerable quantities of cyclopropane in order to permit controlled respiration, while those in group I were given only minimal amounts. Thus the babies in group II suffered from central drug depression. There was no correlation between carbon dioxide content and delay in onset of regular respiration among the group II infants, because the degree of central depression varied from case to case. Furthermore, as variations in the degree of muscular relaxation determine the efficiency of passive ventilation, a scatter in carbon dioxide values was to be expected in this group.

The mean carbon dioxide content for group III was 3.1 m.equiv/l. lower than that for the control group and there is quite clearly a negative correlation between individual carbon dioxide content and the time required for regular breathing to begin, with the exception of one baby (18.4 m.equiv/l., 360 seconds). One carbon dioxide value was as low as 10.2 m.equiv/l. and, apart from occasional ineffective gasps, starting about 5–6 minutes after delivery, this infant started to breathe effectively after 14 minutes. In group II no such correlation between onset of respiration and carbon dioxide content is observed because in these babies delay was predominantly due to cyclopropane depression.

CONCLUSIONS

The findings of this study indicate that the management of maternal ventilation during anaesthesia for abdominal delivery can influence umbilical venous carbon dioxide content and that alkalosis (group III) may be a factor in retarding the onset of regular respiration in the baby.

The carbon dioxide values obtained in group I and the prompt onset of respiration in these infants suggest that the respiratory centre of the newborn is sensitive to a moderate increase in carbon dioxide content (3 m.equiv/l.).

It is interesting to note that among the group III babies (alkalosis) there was the longest delay in the onset of efficient spontaneous breathing.

It is not claimed that umbilical venous carbon dioxide content was the only factor governing the onset of respiration in these infants.

These conclusions are not at variance with the fact that acidosis is a feature of asphyxia neonatorum. True asphyxia neonatorum is due, in the case of livida, to respiratory obstruction, and in the case of pallida, to medullary depression brought on by cerebral trauma, ischaemia, hypoxia or prolonged drug depression. The temporary apnoea encountered in group III occurred in alkalotic but otherwise normal babies. Those in
group II were depressed by cyclopropane but this effect had been of short duration and foetal arterial oxygen saturation can be assumed to have been normal. All forty babies were born well oxygenated and with a good circulation, and circulation and oxygenation deteriorated only when effective respiration was delayed for more than 5 minutes.

ACKNOWLEDGMENTS
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REFERENCES

RESPIRATION DES NOUVEAUX-NÉS APRÈS DÉLIVRANCE ABDOMINALE

SOMMAIRE
L'auteur a cherché à savoir si des variations de ventilation maternelle entraînant de l'acidose ou de l'alcalose respiratoire chez la mère étaient susceptibles d'influencer le taux veineux de dioxyde de carbone ombilical et s'il existait un rapport entre les taux de dioxyde de carbone et le commencement de la respiration spontanée effective de l'enfant. L'acidose du nouveau-né fut étudiée avec et sans dépression centrale afin de déterminer si le dioxyde de carbone était capable de stimuler le centre respiratoire dans les deux alternatives ou du moins dans une d'elles. Les résultats font penser que l'acidose respiratoire stimule la respiration du nouveau-né et que l'alcalose semble avoir l'effet opposé.

ZUSAMMENFASSUNG
Die Untersuchung wurde unternommen zur Feststellung, ob Veränderungen der mutterlichen Beatmung mit der Absicht, bei der Mutter eine respiratorische Azidose oder Alkalose hervorzurufen, den Kohlendioxydgehalt in der Vena umbilicalis verändern können und ob eine Beziehung zwischen den Kohlendioxydwerten und dem Einsetzen der Spontanatmung beim Neugeborenen besteht. Die neonatale Azidose wurde sowohl bei als auch ohne zentrale Depression untersucht, um festzustellen, ob Kohlendioxyd in der Lage ist, das Atmungszentrum entweder bei einer der beiden oder bei beiden Voraussetzungen zu stimulieren. Die Ergebnisse sprechen dafür, daß eine respiratorische Azidose die Atmung des Neugeborenen stimuliert, während die Alkalose anscheinend die entgegengesetzte Wirkung hat.