CLINICAL REPORTS

Ronald D. Miller, M.D., Editor

Anesthesiology
56:304-306, 1982

Preterm Infants are More Prone to Complications Following Minor Surgery than are Term Infants

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The immaturity of physiologic processes of the premature infant represents a potential complicating factor during the perioperative period. A higher incidence of cardiorespiratory and metabolic complications may be expected in the premature which may persist as the child grows older. The premature infant has significant impairment of respiratory functions until at least the age of one year.1 We sought to determine the incidence of anesthesia complications in the premature as compared with the full-term newborn following a relatively minor surgical procedure, inguinal herniotomy.

METHODS

Seventy-one patients were studied retrospectively (table 1). The patients in Group 1 were 33 consecutive preterm infants (i.e., born before the 38th week of gestation) who presented for inguinal herniotomy from 1974–1978 at the Hospital For Sick Children. Infants with cardiac, neurologic, endocrine, or metabolic diseases were excluded from the study. Their birth weights were 650–2,250 g with a mean birth weight of 1,399 g. The postnatal age at operation varied from 3 weeks to 28 weeks. Nine patients (28 per cent) had a history of respiratory distress syndrome (RDS). This had been treated by means of endotracheal intubation (7 patients), intermittent positive pressure ventilation (4 patients), continuous positive airway pressure (5 patients) and by oxygen therapy (8 patients). Thirteen patients (39 per cent) had a history of apneic episodes at some time during the past. One patient had retrolental fibroplasia and two had radiological evidence of bronchopulmonary dysplasia.

The 38 patients in Group 2 were all full-term infants with birth weights in excess of 2,500 g. Their weights at operation were from 2,570–7,200 g with a mean of 4,236 g. Their age at operation varied from one week to 36 weeks. These patients were chosen randomly from among those who had herniotomy during the same period as the infants in Group 1.

All the infants were inpatients. Pre-operatively, no infant had any acute illness. Two patients in each group had a history of an incarcerated hernia. This had been treated by manual reduction and surgery was performed 24–36 hours later. The hemoglobin levels were generally lower in Group 1 infants than those in Group 2. No infants were given blood transfusions pre-operatively. Atropine (0.1–0.15 mg) was administered intramuscularly 20–30 minutes pre-operatively or intravenously at or immediately after induction of anesthesia. No other drugs were administered pre-operatively. Clear fluids were offered up to 4 hours prior to the time of operation. All the patients in both groups were anesthetized using nitrous oxide (50–70 per cent) and halothane. This was preceded by an intravenous dose of 2.5 per cent thiopental (3–5 mg/kg) in 18 per cent of infants in Group 1 and in 37 per cent of infants in Group 2. Endotracheal intubation was performed in 26 patients in Group 1 (79 per cent) and 25 patients (66 per cent) in Group 2. Awake endotracheal intubation was performed in 12 patients (36 per cent) of Group 1. Spontaneous ventilation was maintained satisfactorily in the majority of patients in both groups but was replaced by assisted or controlled ventilation when indicated to correct hyperventilation. Routine measures to maintain body temperature and avoid cold stress were employed and included the use of heating blankets, overhead radiant heaters, humidified anesthetic gases, and warmed skin prep solutions.

At the end of the operation, the infants were returned to a heated bassinet or wrapped in a warm blanket and transferred to the post-anesthesia room.

The incidence of complications in the two groups of patients was compared using the chi squared test.

RESULTS

Only one patient in Group 2 experienced a complication (table 2) which consisted of a minor breath-holding episode during anesthesia.

Eleven patients in Group 1 (33 per cent) encountered...
TABLE 1. Patients Studied

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of Operations</th>
<th>History of Incarceration</th>
<th>Bilateral Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Premature)</td>
<td>33</td>
<td>2 (6 per cent)</td>
<td>15 (45 per cent)</td>
</tr>
<tr>
<td>2 (Full-term)</td>
<td>38</td>
<td>2 (5 per cent)</td>
<td>5 (13 per cent)</td>
</tr>
</tbody>
</table>

The most frequent of these was apnea which occurred either during operation or up to 12 hours postoperatively. In each instance, this was recognized early and treated by manual stimulation and/or administration of oxygen by means of a bag and mask. Two patients showed radiologic evidence of postoperative atelectasis which required treatment with chest physiotherapy. Two patients developed aspiration pneumonia which was confirmed radiologically. The time of aspiration could not be established definitely but there was no history of evident regurgitation during or immediately following anesthesia. The tracheas of both patients had been intubated during the operation.

The patients in Group 1 who experienced apnea were all under 10 weeks postnatal age and under 3,000 g body weight at the time of operation (fig. 1). Their birth weights (1,230 g to 1,950 g) were not different from the remainder of Group 2. Two of these patients had a prior history of apnea and four did not. Nine infants with a prior history of apnea episodes did not exhibit apnea during or after surgery. There was no difference between the body temperature on arrival in the postanesthetic room of those patients who experienced apnea and the other patients in Group 1 (table 4). Apnea was not confined to those patients in Group 1 with a history of RDS nor did it appear to occur more commonly in these infants. None of the patients in Group 1 who received thiopental for induction experienced apnea, these being the older and larger infants.

**DISCUSSION**

The incidence of complications in the group of infants born prematurely was significantly higher than in the group of full-term infants. All the complications seen in this study involved the respiratory system. Despite the almost universal use of halothane, significant hypotension did not occur in any patient. All the patients in the present study did receive atropine and this may account for the absence of cardiovascular problems.

The high frequency of apnea in association with and following anesthesia is particularly alarming and indicates that the patients should be observed closely for 24 hours during the postoperative period. Even minor surgery on the ex-premature should not be performed as an outpatient, certainly not until the age of several months. Further studies will be necessary to define which preterm infants at what age can be assured to respond in a normal fashion to general anesthesia.

The cause of apnea in the peri-operative period is uncertain. All the patients in this series were anesthetized using a potent inhalation agent (halothane). Perhaps the depressant effects of halothane on the chemoreceptor response to hypoxemia\(^2\) could predispose these infants to apnea. Very low levels of halothane in the blood may produce this effect,\(^2\) and thus, episodes of apnea in the post-anesthetic room could be explained. However, disturbances of ventilation after several hours are probably not due to residual halothane levels. In those patients, another mechanism must be postulated. Ventilatory muscles of the preterm newborn are easily fatigued.\(^3\) This is related to the few number of high oxidative fatigue

**TABLE 2. Incidence of Complications**

<table>
<thead>
<tr>
<th></th>
<th>Intra-operative</th>
<th>Postoperative</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>5</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>(n = 33)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 2</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>(n = 38)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(P < 0.1\) \(P < 0.01\) \(P < 0.001\)

**FIG. 1.** Incidence of perioperative apnea in Group 1 patients (prematures) in correlation with postnatal age and body weight.
TABLE 4. Body Temperature on Arrival in Post-Anesthetic Room

<table>
<thead>
<tr>
<th>Group 1 patients:</th>
<th>Mean (°C)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>With apnea</td>
<td>36.6</td>
<td>35.7–37.8</td>
</tr>
<tr>
<td>Others</td>
<td>36.8</td>
<td>35.6–38.1</td>
</tr>
</tbody>
</table>

resistant muscle fibers in the diaphragm of small infants. Although apnea traditionally has been thought to occur exclusively on a neural basis, a relationship between diaphragmatic muscle fatigue and some episodes of apnea recently has been suggested.

An increase in ventilatory muscle fatigue and hence a subsequent episode of apnea could be explained by several mechanisms which might have effect during and following surgery. Paradoxical movement of the highly compliant rib cage of newborns occurs readily during anesthesia, and is accentuated by the depressant effect of halothane on intercostal muscle activity. Such paradoxical movement increases the work required of the diaphragm and thus hastens fatigue. Tachypnea which typically accompanies halothane anesthesia may also shorten the endurance time of the ventilatory muscles, and hasten fatigue. Postoperatively, the discomfort occasioned by the operation may continue to stimulate restlessness and tachypnea. Finally, any surgical procedure inevitably results in a degree of nutritional deprivation, and thereby may affect the energy requirements of the muscles of ventilation and precipitate fatigue. Hypoglycemia is a recognized precipitating factor in neonatal apnea.

A retrospective study such as this undoubtedly has some serious limitations. The preliminary observations from this analysis do, however, indicate that further prospective studies are urgently required to define the risks for preterm infants of anesthesia in the first months of life.

I conclude that preterm infants who require minor surgery in the first months of life are more likely to develop respiratory complications during and following anesthesia when compared to full-term infants. Apnea is the most common complication and may occur several hours following the anesthetic. Ventilatory muscle fatigue may offer a possible explanation for this complication. Preterm infants should be carefully and continuously observed for 24 hours postoperatively. They should not be operated upon as outpatients in the first three months of life. Further studies are needed to clearly define the risk of complications in the preterm infant.

REFERENCES