ENDOTRACHEAL ASPIRATION AND OXYGENATION IN RESUSCITATION OF THE NEWBORN

BY

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The indications for active intervention in neonatal resuscitation vary from hospital to hospital. There is little agreement as to whether the clinical control should be the immediate responsibility of the obstetrician, the paediatrician or the anaesthetist (Schmidt, McLandress and Cruickshank, 1956), and which of a large variety of methods should be used (Abramson, 1956).

Most physicians now agree that the administration of oxygen takes precedence over the administration of drugs, but there is no general agreement concerning the route of administration. The shortcomings associated with the administration of oxygen by mask are now appreciated and recently the effectiveness of intragastric oxygen, first advocated by Akerren and Fürstenburg (1950) and Waller and Morris (1953), has been questioned by Holme and Payne (1955), James et al. (1959) and Barrie (1959). Osborn (1958) has further shown that indwelling oesophageal catheters are not without their dangers, and rupture of the stomach due to over-distension has followed this method of resuscitation (Hodges, 1956).

It has been alleged that endotracheal intubation may lead to shock and trauma, so increasing the infant mortality rate (Bloxsom, 1951). Some therefore regard this procedure as contra-indicated (Lancet, 1951); especially in small infants (Lord, Powell and Roberts, 1953). Laryngeal ulceration has been cited as a complication, and even among those who advocate it, intubation is not always regarded as a primary measure (Peddie, 1957).

In this unit during operative obstetric deliveries when an anaesthetist is present the responsibility for neonatal resuscitation is, in the first instance, delegated to him.

In anaesthesia endotracheal suction and the administration of oxygen by intermittent inflation is an accepted form of therapy for obstructed, failing, or absent respiratory effort. We follow these principles which are applied to neonatal resuscitation also by others (Roberts, 1949; Kromm, 1955; Rees, 1958).

This paper analyzes the results obtained in 137 infants in whom endotracheal resuscitative measures were undertaken. Conclusions are drawn as to the difficulties, dangers and the effectiveness of the technique.

MATERIAL AND METHOD

All the patients were in-patients in the obstetric unit and formed a series of 754 operative procedures from an overall 6,574 patients delivered.

All the anaesthetics were administered by members of the anaesthetic department, and consisted of a sleep dose of thiopentone followed by suxamethonium, nitrous oxide and oxygen with endotracheal intubation. This method has been described, found to have advantages over the more traditional methods, and further to be associated with little or no neonatal depression referable to anaesthesia (Hodges et al., 1959, 1960).

After delivery the infant was placed on a special neonatal trolley near the head of the operating table. The infant lay on a padded rest which could be tilted as desired. Resuscitative equipment was available on this trolley.

Immediately after delivery, if the clinical observations suggested that aspiration of liquor or regurgitated gastric contents had occurred, endotracheal suction was undertaken.

After the establishment of a clear airway, with or without endotracheal suction, the indications for endotracheal oxygen and intermittent positive pressure inflation were signs of anoxia associated

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with apnoea, subsequently cyanosis, or failure to establish regular spontaneous respirations within 2 to 3 minutes. Each case was judged individually according to these criteria. Bradycardia and cardiac irregularities were regarded as indicative of anoxia. Intubation was carried out using size 00 Magill tube, or a Foregger shouldered tube. Oxygen was administered by manual compression of an open-ended bag on a T-piece circuit with manometric control. Pressures of between 30 and 40 cm H\textsubscript{2}O were obtained, but were maintained for the shortest possible period. The movement of the chest was carefully observed. Suction was carried out as rapidly as possible, and was continued intermittently for short periods only. Between these periods of suction the infant was allowed to inhale oxygen, or in the absence of spontaneous respirations intermittent positive pressure inflation was continued. The infants were extubated as soon as the airway was cleared and regular spontaneous respirations were established.

All premature infants and those in whom the response to resuscitative measures was considered unsatisfactory, were transferred to the paediatric department.

The state of the infant at birth and the resuscitative measures applied were recorded on the anaesthetic-obstetric punch card previously described (Hodges, 1959). These observations together with the subsequent obstetric, paediatric and, when necessary, pathological records form the basis of this paper.

All stillbirths and neonatal deaths were classified at special monthly obstetric meetings held for this purpose by the obstetric department, and attended by representatives from the departments of paediatrics, anaesthesia, and pathology.

**RESULTS**

The group of 137 infants considered here represented 18 per cent of the operative deliveries, the incidence of intubation following Caesarean section being the highest. In 74 infants (54 per cent) pre-operative foetal distress in utero had been diagnosed. Six infants were delivered pulseless and apnoic, being apparently stillborn. Resuscitative measures restored regular pulse and respirations in one patient but with short-lived success. Subsequently 11 other neonatal deaths took place.

Thirty-three per cent of the infants were premature according to their dates, and 15 per cent weighed less than 2,500 g. The majority of the group of premature infants was delivered by Caesarean section.

Most of the infants were intubated because of primary apnoea (or because they had only gasping respiratory efforts), subsequent clinical hypoxia, or failure to establish regular respiratory effort within 2 minutes of birth. Seventeen per cent of the infants breathed regularly at birth, but either relapsed later and had only a weak respiratory effort associated with hypoxia, or aspirated mucus and liquor and became obstructed or depressed. This was regarded as secondary respiratory depression. Twenty per cent of the infants suffered primarily from obstruction and were intubated for the purpose of aspiration (table II).

**TABLE I**

*Details of 137 infants intubated for endotracheal toilet and/or oxygenation after delivery.*

From 754 operative obstetric deliveries all conducted under a standard anaesthetic technique.† (From a total of 6,574 deliveries in a 32 month period).

<table>
<thead>
<tr>
<th>Infants intubated</th>
<th>Total</th>
<th>Number of intubations</th>
<th>Pre-operative foetal distress</th>
<th>Failures (stillbirth)</th>
<th>Neonatal deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caesarean section</td>
<td>...</td>
<td>333</td>
<td>80 (24%)</td>
<td>43 (54%)</td>
<td>4</td>
</tr>
<tr>
<td>Midcavity forceps</td>
<td>...</td>
<td>245</td>
<td>41 (17%)</td>
<td>20 (49%)</td>
<td>—</td>
</tr>
<tr>
<td>Outlet forceps</td>
<td>...</td>
<td>153</td>
<td>12 (8%)</td>
<td>8 (75%)</td>
<td>—</td>
</tr>
<tr>
<td>Breech delivery</td>
<td>...</td>
<td>23</td>
<td>4 (17%)</td>
<td>3 (75%)</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>...</td>
<td>754</td>
<td>137 (18%)</td>
<td>74 (54%)</td>
<td>5 (3.6%)</td>
</tr>
</tbody>
</table>

* According to the criteria outlined in text. † Thiopentone-suxamethonium-nitrous oxide-oxygen.
Only in relatively few instances did the duration of intubation exceed 20 minutes, ranging in most cases from 5 to 15 minutes (Table III). Frequently only brief intermittent positive pressure inflation with oxygen was necessary before regular spontaneous respirations were initiated even in puny and depressed infants.

Table IV shows the progress of the infants after delivery. Of the group of 120 live infants, 102 remained well and were healthy on discharge from hospital. Twelve infants showed transient effects of birth trauma but were also well on discharge. Six infants showed persistent residual atelectasis which cleared within 2 to 3 days. These infants were treated in an incubator and were thriving on discharge. Four of this last group had been premature by weight and five were delivered by Caesarean section. All premature infants when subsequently seen in the paediatric out-patients department were progressing well. In none of the group of 120 infants was there any sequelae observed which might have been associated with endotracheal instrumentation.

Table V details the 12 neonatal deaths which took place among the group of 137 infants intubated at birth. Table VI gives details of the 10 neonatal deaths among the remainder of the 754 operative obstetric deliveries. In table V we may exclude from our considerations all but the single instance of hyaline membrane disease (pulmonary syndrome) and the 4 instances of intrapartum asphyxia. These latter infants died at 4, 6, 11 and 12 hours (the last being the resuscitated still-birth), and death was considered to be due to atelectasis associated with intrapartum distress and aspiration of amniotic fluid and debris. Clinically treatment had improved but failed to reverse the condition. There was no evidence at autopsy (at

| Table II |
| The reason for intubation in 137 infants. |
| From 754 operative deliveries.† |
| seizure depression at birth ... 54% |
| Secondary respiratory depression at birth ... 17% |
| Obstruction due to intrapartum, or postpartum inhalation ... 20% |
| Mixed causes ... 8% |

* See table I.

| Table III |
| The duration of intubation in 137 infants intubated for endotracheal toilet and/or oxygenation. |
| From 754 operative deliveries.† |
| Percentage of total ... 27 38 20 11 4 |
| Time in minutes ... <5 <10 <15 <20 <20 |

* According to the criteria outlined in text.
† See table I.

Table V gives details of the 10 neonatal deaths among the remainder of the 754 operative obstetric deliveries. In table V we may exclude from our considerations all but the single instance of hyaline membrane disease (pulmonary syndrome) and the 4 instances of intrapartum asphyxia. These latter infants died at 4, 6, 11 and 12 hours (the last being the resuscitated still-birth), and death was considered to be due to atelectasis associated with intrapartum distress and aspiration of amniotic fluid and debris. Clinically treatment had improved but failed to reverse the condition. There was no evidence at autopsy (at

| Table V |
| Neonatal deaths occuring in 137 infants intubated at birth for the purpose of endotracheal toilet and/or oxygenation. |
| From 754 operative deliveries.† |
| Congenital abnormality Birth trauma Pulmonary syndrome Prematurity Intrapartum asphyxia Incidental disease Total |
| Caesarean section ... 1 1 1 1 2 1 6 |
| Forceps delivery ... 2 1 — — 2 — 5 |
| Breech delivery ... 1 — — — — — 1 |
| Total ... 4 1 1 1 4 1 12 |

* According to the criteria outlined in text.
† See table I.
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TABLE VI

Neonatal deaths occurring in 617 infants in whom resuscitation was not considered necessary at birth.
From 754 deliveries.*

<table>
<thead>
<tr>
<th></th>
<th>Congenital abnormality</th>
<th>Birth trauma</th>
<th>Pulmonary syndrome</th>
<th>Prematurity</th>
<th>Intra-partum asphyxia</th>
<th>Incidental disease</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caesarean section</td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Forceps delivery</td>
<td>2</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Breech delivery</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>10</td>
</tr>
</tbody>
</table>

* See table I.

dangers and difficulties of endotracheal inflation have been allegedly so great that much alternative and complicated apparatus (such as cabinet respirators and phrenic nerve stimulators, etc.) have been designed for the performance of artificial respiration. We agree with Abramson (1956) that much of this apparatus is too complicated for general use.

Of late, large series of endotracheal intubations in the course of neonatal and paediatric anaesthesia have been reported, showing a very low incidence of complications (Eckenhoff, 1951; Smith, 1953; Pender, 1954; Rees, 1958). These have modified the view held previously that "special hazards are associated with instrumentation of the infant larynx". Rees (1958) regards these hazards as further examples of medical mythology. Furthermore, it is now known that positive pressure should not be held for longer than 0.5 sec and that the lungs can withstand a high pressure for a fractional period better than a more prolonged lower pressure (Day et al., 1952). Ideally, skilful endotracheal intubation is less likely to cause trauma or infection than the traditional blind pharyngeal proddings of the sucker to which many infants born in this country are subjected. Since an anaesthetist is often the specialist best acquainted with the respiratory airway the dynamics of respiration and of circulation and the necessary technical procedures, it seems good sense that he should, on occasions, assume the responsibility for neonatal resuscitative procedures (Abramson, 1956); indeed such procedures are being placed more and more under the care of the anaesthetic staff (Secher, 1956).

Naturally no direct comparison between the neonatal death rates in the intubated (table V) and nonintubated infants (table VI) can be made.

which the pharynx, trachea, and lungs were carefully examined) to suggest that tracheal instrumentation had led to any untoward sequelae.

DISCUSSION

In 1752 William Smellie wrote, "the child has been sometimes recovered by blowing into the mouth with a silver canula, so as to expand the lungs".* The tracheal catheter was recommended by Scheel in 1780 (quoted by De Lee) and De Lee (1924) stated that he intubated routinely all cases of asphyxia pallida, using his finger as a guide. He then performed artificial respiration by squeezing the chest or by blowing with his mouth. Flagg (1928) described a speculum for direct intubation and oxygenation in neonatal asphyxia.

Blaikley and Gibberd (1935) pioneered endotracheal intubation of the newborn in Great Britain. They insufflated the trachea with oxygen using a fine gum elastic catheter introduced under direct vision, which allowed a leak-back of oxygen outside the catheter. The pressure was controlled by the use of a reservoir bag and a manometer. The apparatus is not intended for, nor should it be used for, expanding the lungs. Misuse of this apparatus has probably been a factor in strengthening the still existing opposition to intubation of infants in general. The gum elastic catheter is potentially more traumatic than a soft endotracheal tube and, should the leak-back be obstructed, there is a greater danger of damage to lung tissue from excessive or prolonged positive pressure. However, until recently it has still been said that any method of attempting neonatal resuscitation by blowing gases into the lungs should be condemned (Lancet, 1951). The

*The italics are ours.
as the former group was especially selected on the grounds of respiratory difficulties. A study of these deaths is, however, not uninformative.

In our series of nonintubated infants (from 754 deliveries) there was only one neonatal death due to intrapartum asphyxia associated with the aspiration of amniotic debris (table VI). This infant relapsed after regular spontaneous respirations had been initiated at birth. Laryngoscopy produced considerable reaction. We agree with Roberts (1949) that most infants who actively object to the insertion of a laryngoscope blade probably do not need intubating, and so in this case oxygen was administered first by face mask only and later in an incubator. The infant rapidly deteriorated until death 14 hours later. Postmortem disclosed atelectasis with bronchi filled with amniotic debris. Retrospectively we feel that more active intervention was indicated and might well have proved lifesaving.

One case of hyaline membrane disease in the intubated series was fewer than we had anticipated, for it is widely held that this condition is prone to occur in premature infants delivered by Caesarean section (Claireaux, 1954). Only one other case occurred in the whole series, of whom 333 were Caesarean deliveries, 33 per cent of these being premature by dates. Brown (1959) suggests that failure to establish regular respirations early is a major aetiological factor in this condition and Barrie and Bonham Carter (1959) suggest that the enormous pressure swings, in respiratory distress with negative phases of 20–30 cm water, are even more important. It is an interesting conjecture that rapid establishment of normal respiratory effort, initiated by early endotracheal inflation with oxygen, may be associated, in part, with the low incidence of hyaline membrane disease which we have encountered.

Adequate respiratory effort is often initiated in depressed and feeble infants by literally a few seconds of positive pressure inflation with oxygen. This only suggests, we feel, that intubation does not need to be maintained. We realize that the more conservative minded may deduce that interference was unnecessary and we do not question that many of the infants treated would have been "alright" if left alone, with maybe the traditional oxygen funnel as the sole treatment. Feeble infants have survived since Cain and Abel without active intervention and they will continue to do so, but, it is impossible to say whether some degree of permanent cerebral damage may not take place during periods of hypoxia. As Donald (1958) says, "(one) imagines their mentality being slowly reduced from that of the upper fifths to that of the lower fourths, as the seconds tick away". It is doubtful if it can ever be proved that transient anoxia can make the difference between a first-class honours degree and a simple pass. But Penfield (1954) states that considerably more than half of the patients on whom he operates for focal epilepsy would never have had a seizure but for brief anoxia or trauma at birth.

Politi (1957) wonders how many doctors would treat the apnoeic adult with the traditional stimulatory measures sometimes applied to the depressed neonate. We further wonder who would treat apnoeic adults by inactive conservative observation augmented perhaps with an oxygen funnel and who member of a modern surgical team would treat incipient respiratory arrest and cardiac failure with drugs, without assisting the respirations? We recognize that the physiological factors associated with the change-over from foetal to neonatal circulation and the reversion to primitive respiratory function brought about by central depression are absent in adult respiratory or cardiovascular failure. This does not alter the fact, that central anoxia is the primary aetiological factor and that this can be, and must be, corrected.

CONCLUSIONS

Our conclusions are merely additive to many of those already outlined (Russ, 1946; Roberts, 1949; O'Brien and Roberts, 1952; Lord, Powell and Roberts, 1953; Kromm, 1955; Flowers, 1956; Abramson, 1956; Secher, 1956; Schmidt, McLandress and Cruickshank, 1956; Shroeder, 1957; Burmeister, 1957; Donald, 1957; Politi, 1957; Rees, 1958). We hope that the publication of a further successful series, in which endotracheal resuscitative measures have been applied in the newborn may speed the general adoption of a technique which we believe has been already too long delayed.

A controlled clinical trial designed to demonstrate the worth of intubation would be extremely difficult, especially for those who believe in its value. Russ (1946), Fletcher and Rogers (1951),
Lord, Powell and Roberts (1953) and O'Brien and Roberts (1952) report series of intubations in the newborn. From their figures, and our own, it is not possible to analyze the role of intubation by the statistical method. We are, however, confident that no harm results, and like many others we regard endotracheal intubation as the safest and most effective means of resuscitation, initiating regular respiratory effort, correcting hypoxia, and of indirectly accelerating the change-over from foetal to neonatal circulation.

Endotracheal intubation is not the only method of neonatal resuscitation, but it is the most effective. Early treatment is essential and the sooner adequate oxygenation is achieved the shorter is the duration of assistance necessary.

We consider that intubation of the apnoeic neonate is best performed with endotracheal catheter of a size similar to a 00 Magill tube. The lungs should be expanded and inflated intermittently using a pressure not greater than 40 cm H₂O and usually much less, using a very brief inspiratory phase. Some modification of the T-piece principle (Ayre, 1937) should be used to prevent rebreathing and to allow free expiration. When the lungs are expanded lower pressures suffice for artificial respiration.

We have found it relatively easy to maintain oxygenation in the majority of instances. Our greatest difficulty has occurred when there has been intrapartum aspiration, which has not responded to repeated suction so that some degree of respiratory difficulty or cyanosis persists. However, in most instances oxygenation was improved, and the general condition could be maintained by such therapy. Sometimes, however, residual atelectasis persisted for a few days.

The objections raised to endotracheal intubation can no longer be justified. The essential requirements include experienced personnel, a minimum of equipment, and of great importance, mutual agreement and liaison between the departments concerned. It is our experience that the procedure is simple to perform when the proper facilities are at hand and when the responsibility is well defined in a department accustomed to such procedures. When the personnel is inexperienced in the technical procedure involved, and when the departments concerned are unaccustomed to the method, suspicious of its dangers, and with no clearly defined delegation of responsibility, we agree that the indications for intubation might be modified especially in the presence of other resuscitative measures. When intubation is the policy, however, the individuals responsible must be capable of rapid nontraumatic instrumentation.

Brown (1959) underlines the fact that respiratory and circulatory functions cannot be separated, but whereas improvements in oxygenation will lead to improvements in circulation, the treatment of circulatory collapse is of little avail in the presence of apnoea and the absence of oxygenation.

There are, of course, dangers to endotracheal intubation, as there are dangers associated with surgery, anaesthesia and the administration of drugs. The dangers do not, however, prevent the correct application of the technique.

SUMMARY

The factors associated with the resuscitation of a group of 137 newborn infants by means of endotracheal intubation, aspiration, and inflation with oxygen are analyzed. There was no evidence of any morbidity associated with this regime, which provides a simple, valuable, and efficient means of achieving early oxygenation, the importance of which is discussed.

We stress that the large-scale success of this procedure depends on the use of the correct equipment, favourable departmental organization and the right attitude of mind.

REFERENCES