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Endotracheal resuscitation of preterm infants at birth

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SUMMARY The adequacy of initial ventilation in 21 preterm babies (25-36 weeks' gestation), who required endotracheal intubation and positive pressure ventilation, were studied. Pressure and flow were measured at the proximal end of the endotracheal intubation tube and expiratory volume calculated from the flow trace. The results were compared with those from a group of 26 term infants who also required resuscitation. Five of 21 preterm babies (24%) had adequate tidal ventilation with the first inflation. This rose to seven of 21 (33%) by the third inflation. This was significantly less than the results in the term infants ($\chi^2=4{\cdot}38$ $p<0{\cdot}05$). Respiratory reflex responses to resuscitation were seen in 41% of inflations in preterm and 56% of inflations in term infants. There was a significant correlation between reflex activity and adequate ventilation in the preterm group ($\chi^2=11{\cdot}83$, $p<0{\cdot}001$) but not in the term group ($\chi^2=0{\cdot}212$, p=NS). No correlation was seen between initial ventilation and outcome.

Endotracheal intubation with positive pressure ventilation is the definitive method of resuscitation of the newborn. Although endotracheal intubation resuscitation is empirically successful, relatively little work has been published on the mechanics of ventilation, and nearly all these studies have been concerned with term infants. This paper aimed to assess the adequacy of initial ventilation in preterm babies and to compare this with the group of term babies requiring resuscitation. Previous studies by Ditchburn *et al*,[1] Hey and Kelly,[2] and Hull[3] used a volume limited system rather than a pressure limited one and they were not able to measure tidal volumes directly.

Subjects and methods

Over 1000 deliveries were attended. Babies were transferred after birth to our modified Vickers resuscitaire, details of which have been described previously.[4 5] Endotracheal intubation followed standard criteria—that is, apnoea with a heart rate less than 100 at two minutes, or apnoea and a heart rate less than 60 at any time. At some deliveries an oesophageal pressure transducer was passed at intubation as the laryngoscope was withdrawn. Inflation pressure was about 30 cm water and was maintained for one second at a rate of 30/minute—that is, one second in, one second out. In a few cases the initial inflation was longer—three to five seconds. Resuscitation was continued until adequate respiration was established and the babies were subsequently managed on usual clinical criteria. The study was approved by the north Nottingham ethical committee.

Equipment. Babies were intubated with Coles's shouldered endotracheal tubes (size 12–14). A pneumotachograph (Fleish type 0) was attached to the endotracheal tube proximal to the T piece to measure flow with a linear response to above 15 l/minute. Inflation pressure was measured via a port close to the endotracheal intubation tube (SE Labs 4–86). Oxygen was supplied to the T piece through a spring loaded pressure limiting valve and the pressure delivered by occluding the T piece with a finger. In 33 cases (eight preterm, 24 full term) an oesophageal pressure transducer (Gaeltec) mounted on a 7FG catheter was used to validate the babies own respiratory efforts. All signals were recorded on tape for later playback and the first three inflations subsequently displayed against time on an oscillograph for analysis.

Analysis. Time of inflation and plateau inflation pressure were measured from the pressure trace and tidal volume from the area under the flow curve using a 'Hipad' Digitiser (Houston Instruments) and commercial computer program.

Results

Table 1 gives birth details of the babies studied. In the term group of 26 babies all were born by

Table 1 *Details of infants studied*

	Preterm (n=21)	*Full term (n=26)*
Gestation:		
Mean (SD)	31·5 (2·7)	39·5 (1·1)
Range	25–36	37–42
Birthweight:		
Mean (SD)	1·5 (0·5)	3·1 (0·7)
Range	0·77–3·02	2·0–4·45
Inspiratory pressure:		
(cm H_2O) Mean (SD)	27·3 (4·8)	26·9 (5·6)

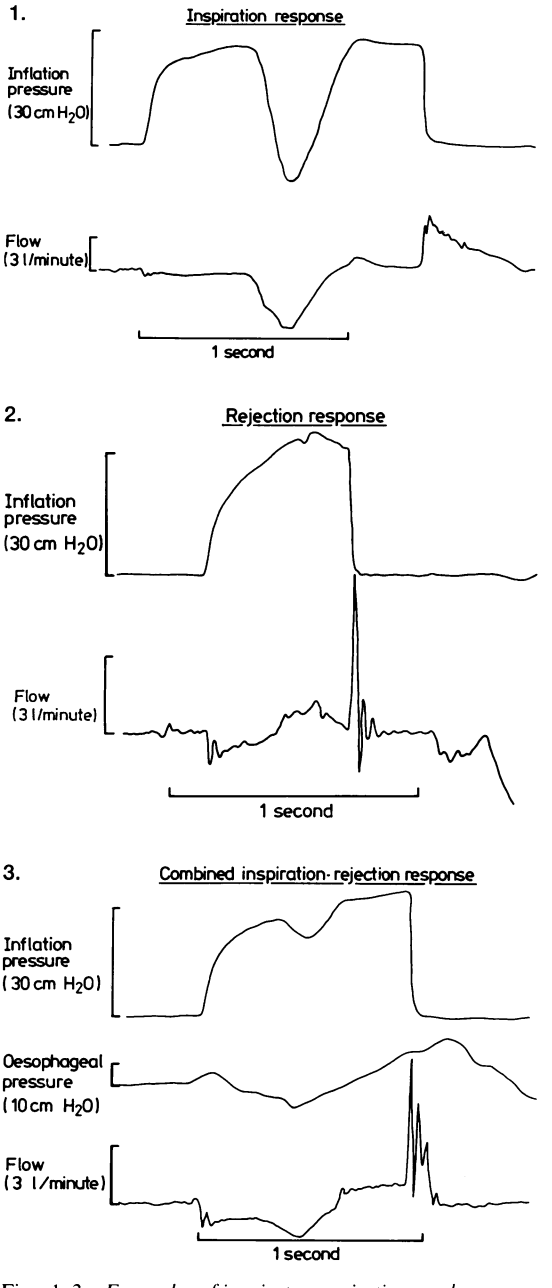
Table 2 *No of infants with tidal exchange of less than 4·4 ml/kg*

	Preterm	*Full term*	χ^2	*Significance*
First inflation	5 of 21	11 of 26	1·04	NS
Second inflation	6 of 21	16 of 26	3·85	p<0·05
Third inflation	7 of 21	20 of 26	7·33	p<0·01
All three	18 of 63	47 of 78	4·38	p<0·05

caesarean section, 11 performed after labour had started. Reasons for operative delivery were: fetal distress (n=5); failure to progress in labour (n=5); abruptio placentae (n=1); breech presentation (n=8); transverse lie (n=2); and one each with postmaturity, twins, maternal diabetes, small for dates, and cephalopelvic disproportion. In the preterm group of 21 babies 15 were delivered by caesarean section, 11 after labour had started. The four elective deliveries were due to maternal hypertension or pre-eclampsia in three cases, and previous caesarean section plus hypertension in the fourth. Of the six vaginal deliveries, there were three breech deliveries, two low forceps, and one normal delivery.

The first three inflations were analysed. Inflation pressures were comparable in the two groups and a prolonged first inflation was given in three preterm infants. Adequate tidal exchange, defined as >4·4 ml/kg, was obtained in less than a third of the preterm infants in the first three breaths (Table 2). Table 2 shows that inflations in term infants were more successful. The χ^2 tests on the first three inflations show that from the second inflation there was a significant difference between the two groups, with more term infants achieving adequate ventilation.

Three patterns of neonatal respiratory reflexes were seen. Head's paradoxical reflex was identified by the fall in the inflation pressure from the plateau accompanied by inspiratory flow; a rejection response was identified by an increase in the plateau pressure with or without expiratory flow; both responses were seen during a single inflation (Figs 1–3). In 19 cases an oesophageal pressure trace was



Figs. 1–3 *Examples of inspiratory, rejection, and combined response from preterm group of babies. Inspiratory flow is in downward direction. Oesophageal trace in fig 3 confirms initial active inspiration (downward movement) with inspiratory flow and dip in inflation pressure trace followed by active expiration (upward movement) associated with expiratory flow against inflation pressure.*

obtained and confirmed our designations in all cases. A reflex was seen in 26 inflations in the preterm group (41%). Fifteen were a Head's paradoxical reflex, five a rejection response, and six both reflexes in a single inflation. There was a correlation between tidal exchange and presence of a reflex response (Table 3). There was no obvious difference between the different reflexes and the associated tidal exchange, but the numbers are too small for valid statistical analysis. Of particular importance—of 37 inflations with no reflex activity, only four achieved adequate tidal exchange, and three of these had been preceded by reflex activity in a previous breath.

Any type of reflex was seen in 44 inflations in the term infants (56%), and this comprised 16 Head's reflexes, 25 rejection responses, and three combined responses. In contrast to the premature infants, there was no significant correlation between presence of reflex and adequate tidal exchange (Table 4), although if a reflex was present the tidal exchange was more likely to be in the upper part of the inadequate range—that is, one to two dead space volumes.

Within the group of preterm infants there was no relation between gestational age and either tidal exchange or presence of reflex response. The numbers, however, were small after subdividing into gestational age groups, and only three babies were less than 30 weeks' gestation.

Outcome. There were four deaths in the group of premature infants. All deaths were related to severe respiratory distress syndrome and occurred in the first 48 hours. Gestational ages of these four were; 25 weeks (two babies both second twins) and 31 weeks (two babies). Three of these had inadequate tidal ventilation in the first three breaths. The fourth, 25 weeks' gestation, initially had a 10–16 ml/kg tidal exchange but required positive pressure ventilation from birth to maintain adequate blood gases. Overall, five of the babies required ventilation for respiratory distress syndrome and three required oxygen for more than 24 hours; there was no association between development of respiratory distress syndrome and initial tidal exchange in the first three breaths.

Table 3 *Premature resuscitation*

Tidal exchange (ml/kg)	*Reflex present*	*No reflex*	*Total No*
<4·4	12	33	45
>4·4	14	4	18
	26	37	63
χ^2=11.83	p<0·001		

Table 4 *Full term resuscitation*

Tidal exchange (ml/kg)	*Reflex present*	*No reflex*	*Total No*
<4·4	16	15	31
>4·4	28	19	47
	44	34	78
χ^2=0·212	Not significant		

Although three of the four babies who subsequently died had reflex activity, the response to inflation was a poor indicator of outcome. Two of the 11 with reflex responses developed respiratory distress syndrome that required ventilation compared with three of the 10 who showed no response.

Exposing the preterm baby to labour might be expected to influence the response to resuscitation, but no such effect was seen in this relatively small study. Three of the seven babies delivered electively had no response compared with seven of 14 delivered vaginally or by emergency caesarian section.

Discussion

One of the difficulties in this study was the lack of data on inspiratory volumes. In a large number of the preterm babies there was a leak of gas around the endotracheal tube when the positive pressure was applied. This leak made analysis of inspiratory volumes impossible. A clinically important volume of gas might have entered the babies' lungs but was retained there to form a functional residual capacity. We feel that this is unlikely to have been a large source of error as there were 11 babies in the preterm group, in whom there was no leak around the endotracheal intubation tube. Eight had no functional residual capacity formed in the first three breaths, and in the other three increments in functional residual capacity that were not considered to be due to leak were all associated with adequate expiratory volumes. In the term group where leak around the tube was less of a problem, a functional residual capacity was formed in 10 of 23 babies by the third breath. It is also, of course, possible that a functional residual capacity was formed in the time from delivery to insertion of the endotracheal tube.

The use of 4·4 ml/kg to define adequate tidal exchange is based on estimations of anatomical dead space of 2·2 ml/kg.[6] This figure is independent of age. Two dead spaces is 4·4 ml/kg, and by definition half of the gas will be taking part in gaseous exchange. Our decision to use two dead spaces as a

cut off seems appropriate but is essentially arbitrary.

It seems that endotracheal intubation resuscitation of preterm infants depends, to a great extent, on reflex responses, particularly the Head's reflex, although whether strictly speaking it corresponds to the original reflex described by Head is unclear.[7] These inspiratory gasps were related to the inflation but there was no temporal relation to the start of the inflation, as seen in the description of the augmented inspiratory reflex by Greenough *et al.*[8] Likewise, there was no evidence that a higher inflation pressure was more likely to stimulate a gasp. Cord pH and fetal scalp pH samples were not recorded in this study and so we are unable to correlate reflex response with degree of asphyxia. If work on animals[9] is applicable to human preterm resuscitation one might expect the degree of asphyxia to be a major determinant of these reflexes. It is important to know whether babies who exhibited reflex responses are those who are only mildly asphyxiated. If so, the strategies to maximise reflex responses are of less clinical importance than those that effect adequate passive ventilation.

Delivery after labour has started might influence effectiveness of resuscitation. It may be associated with asphyxia, particularly in the preterm group, but there may also be benefits to the fetus, such as stimulating absorption of lung fluid and surfactant release. The benefits are more likely to be apparent at a later stage, however, and mechanical factors are probably more important than biochemical factors in response to initial resuscitation. In our data there was no evidence of an effect of labour on reflexes or tidal exchange for either the term or preterm groups, but it is difficult to draw any conclusions from this as emergency and elective section babies are obviously selected groups.

The underlying assumption of this study is that early establishment of adequate ventilation is important in preterm infants and that if this can be achieved in the first few inflations then outcome will be improved. We have been unable to show any correlation between initial resuscitation and outcome but the numbers are small, and many other factors including gestational age and degree of asphyxia at birth also affect subsequent progress.

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