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Mechanical ventilation in newborn infants

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Summary

A 20-month experience of mechanical ventilation (MV) in the newborn infants (birth weight ⩾ 1500 g) from a developing country is described. A total of 41 neonates (4.1% of total admissions to the Neonatal Intensive Care Unit) were treated with MV. The mode of MV was intermittent positive pressure ventilation and continuous positive airway pressure via nasotracheal intubation. The mean birth weight and gestational age were 2544 g and 36.2 weeks, respectively. The mean age at the start of MV was 141 h and the mean duration was 54 h. The indications for MV were respiratory distress syndrome (18), aspiration pneumonia (8), non-aspiration pneumonia (6), apnoea (8) and tetanus neonatorum (1). The complications encountered during MV were sepsis (26.8%), pulmonary haemorrhage (21.9%), congestive heart failure (17.1%), pneumothorax (14.6%) and intraventricular haemorrhage (7.3%). Post-extubation atelectasis was observed in 29.6% of cases. The overall survival rate was 43.9%. The risk factors for a poor outcome were birth weight less than 2000 g, prematurity and late referrals to the Neonatal Intensive Care Unit.

Résumé

L'expérience pendant vingt mois de ventilation mécanique du nouveau-né (poids à la naissance ⩾ 1500 g) dans un pays en voie de développement est décrit. 41 nouveau-né (4.1%) d'admission dans les soins intensives du nouveau-né, ont reçu la ventilation mécanique (VM). Le type de la ventilation mécanique était ventilation avec pression positive intermittente ou ventilation continu par une intubation rhinetracheál. Naissance-poids, âge de gestation sont 36.2 semaines et 2544 g, respectivement. L'âge moyenne au début de la ventilation mécanique était 141 h et la durée moyenne était 45 h. L'indication de la VM étaient, la maladie des membranes hyalines (18), phenumonies d'aspiration (8), pneumonies non aspiratoires (6) apnée (8), le tatanos du nouveau-né (1). Les complications encontrés pendant la VM étaient septicemies (26.8%), hémorragie pulmonaire (21.9%), insuffisance cardiaque (17.1%), pneumothorax (14.6%), hémorragie intraventriculaire (7.3%), atélectasie post-extubation était observé en 29.6% de cas. Survivance était 43.9%. Les facteurs de hazard pour un mauvais résultat étaient poids de naissance moins que 2000 g, Prématurité et transfer retardé en soins intensives du nouveau-né.

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Introduction

Artificial ventilation is being frequently used as an adjunct to therapy in newborn infants with respiratory failure [1]. Most of the reports on mechanical ventilation in the newborn have been from developed countries [1–6]. The present study describes our experience with mechanical ventilation of neonates with birth weight ⩾ 1500 g at a newly established referral intensive care unit in a developing country.

Patients and methods

During the period 1 June 1982 to 31 January 1984, a total of 995 neonates with birth weight ⩾ 1500 g were admitted to the referral Neonatal Intensive Care Unit (NICU), El-Fatah Children's Hospital, Benghazi. Of these, 41 were treated with mechanical ventilation (MV). Infants with birth weight ⩽ 1500 g, major congenital malformations and severe birth asphyxia (Apgar score less than 2 at 1 and 5 min

after birth) were not put on ventilator therapy.

Assisted ventilation was initiated if hypoxaemia (PaO_2 less than 50 torr; fractional inspiratory oxygen [FiO_2] 0.6) could not be corrected by simple continuous positive airway pressure (CPAP), when the carbon dioxide tension exceeded 50 torr in the presence of a pH $\leq$ 7.25, or if there was persistent apnoea [6].

Mechanical ventilation was administered via nasotracheal intubation using a Bournes BP 200 — a time-cycled, pressure-limited ventilator. The initial settings included peak airway pressure varying from 18 to 25 cm H_2O, respiratory frequency of 40/min, and inspiratory : expiratory ratio (I:E ratio) of 2 : 1. The settings of the ventilator were adjusted later on, with the aim of keeping the $PaCO_2$ between 40 mmHg and 45 mmHg, and a PaO_2 between 50 mmHg and 80 mmHg. All cases initially had intermittent positive pressure ventilation (IPPV) with individualized positive end expiratory pressure (PEEP). Continuous positive airway pressure ventilation (CPAP) was employed while weaning the infants from the ventilator.

AVL Automatic Gas Check 940 was used to analyse blood gas and acid-base status in arterialized capillary blood samples from heel pricks. All cases had continuous monitoring of transcutaneous oxygen ($TcPaO_2$) and carbon dioxide ($TcPaCO_2$); fractional inspiratory oxygen measurements (FiO_2); cardiac rate and rhythm.

Blood pressure was monitored using Doppler Ultrasound. Portable chest radiographs were taken after intubation and subsequently as indicated. Systemic antibiotics were given in cases of suspected sepsis after taking appropriate cultures. All the infants were fed intravenously throughout the period of MV. Chest physiotherapy was applied during and after ventilation.

Statistical analysis was done using the Chi-square test and Student's *t*-test. A probability value of less than 0.05 was considered significant.

Results

The characteristics of the study population and the indications for MV are contained in Tables 1 and 2, respectively. Infants with respiratory distress syndrome constituted the largest group (44%) among infants treated with MV. Sepsis accounted for seven of eight infants with apnoea.

The significant complications observed during MV were Gram-negative septicaemia (26.8%), pneumothorax (14.6%), pulmonary haemorrhage (21.9%), congestive heart failure (17.1%) and intraventricular haemorrhage (7.3%). Post-extubation atelectasis (29.6%) was the major complication requiring re-ventilation. Bronchopulmonary dysplasia was documented in two preterm infants who received MV for more than 7 days.

Twenty-three of 41 infants died, fourteen during ventilation and nine within 60 h of extubation (Table 3). Survivors had higher gestational ages than those who died ($P < 0.01$). However, the mean birth weight was comparable in the two groups ($P > 0.05$). Infants who died were put on MV at an earlier age and for a longer duration (Table 3).

Eleven of the 18 infants with respiratory distress syndrome died, and their course was complicated by pneumothorax (3), pulmonary haemorrhage (3), *Klebsiella pneumoniae* septicaemia (3) and intraventricular haemorrhage (2). Eight of the 14 infants with pneumonia survived. Two infants with pneumonia who were successfully weaned off MV died 2 weeks later

Table 1. Characteristics of the study population

Male : female ratio	2.4 : 1
Birth weight (g)	2544 ± 699 (1500–4000)*
Gestational age (weeks)	36.2 ± 2.6 (32–40)*
Age at start of mechanical ventilation (h)	141 ± 182 (4–672)*
Duration of mechanical ventilation (h)	54 ± 35 (5–192)*

*Values are means ± s.d., with range in parentheses.

Table 2. Indications for mechanical ventilation

Indications	Number	(%)
Respiratory distress syndrome	18	(44)
Pneumonia	14	(34.1)
Aspiration	8	
Non-aspiration	6	
Apnoeas	8	(19.5)
Sepsis	7	
Prematurity	1	
Tetanus neonatorum	1	(2.4)

from necrotizing enterocolitis and meningitis, respectively.

There was no significant difference in the blood gas and acid–base status before the start of MV between those who survived or died. However, the infants who died had significantly lower mean PaO_2 (46.7 ± 5.6 mmHg) and higher $PaCO_2$ (51.2 ± 8.9 mmHg) values during ventilation ($P < 0.05$).

Table 4 depicts the comparison of mortality rate in relation to various prognostic factors. There was significantly higher mortality in babies with birth weight less than 2000 g ($P < 0.05$).

Discussion

Mechanical ventilation has been used for the treatment of respiratory failure in infants with the respiratory distress syndrome since the pioneering work of Donald and Lord in 1953 [7]. Since then, controlled trials have demonstrated statistically significant results favouring artificial ventilation [8].

Mechanical ventilation requires a well-trained and constantly available team of physicians, nurses (with a 1:1 nurse : patient ratio), and instrument and laboratory technicians. There are few reports of MV in the newborn infants from less-developed countries [9], and this is mainly because of the absence of the above-mentioned requirements.

Artificial ventilation has been used in the newborn infants in several conditions including asphyxia neonatorum, tetanus neonatorum, pre- and post-operative ventilatory support, meconium aspiration pneumonia, central nervous system (CNS) drug depression, apnoea of extreme prematurity, and particularly the respiratory distress syndrome (RDS) [10]. Except for CNS drug depression and pre- and post-operative conditions, the indications for MV were similar in the present study, with RDS and pneumonia constituting three-quarters of the cases. Respiratory distress syndrome still remains the most common clinical diagnosis in neonates requiring MV in both developed [1, 5, 11, 12] and developing countries [9].

Complications occur frequently in mechanically ventilated newborn infants and these include the immediate dangers of prolonged intubation, infection, interstitial emphysema and pneumothorax [13]. Septicaemia was observed in 26.8% of infants, and the most frequently encountered organism was *Klebsiella pneumoniae*. Fitzhardinge *et al.* [14] reported 15% incidence of major infection among mechanically ventilated low birth-weight babies (birth weight ≤ 1500 g). Pleural air leaks are the most frequent complication in mechanically ventilated infants and have been reported in as many as 17–40% of patients [5, 15]. Tension pneumothorax occurred in 14.6% of neonates in the present study.

On necropsy, intraventricular haemorrhage has been shown in 41.9% of infants mechanically ventilated for hyaline membrane disease [5]. In the present series, the exclusion of very low birth-weight infants and the lack of post-mortem examination may partly explain a low incidence (13.04%) of intraventricular haemorrhage. The occurrence of intraventricular haemorrhage has been related to hypoxic episodes [16]. Post-extubation atelectasis occurred in 19.5% of our cases, and 37.5% of them required re-ventilation. A significantly higher frequency of post-extubation segmental or lobar atelectasis has been observed in nasotracheal infants intubated via the nasotracheal route (34.9%) than in those who had orotracheal intubation (11.9%)[17]. Among the survivors of our cases, only one infant developed radiological changes consistent with bronchopulmonary dysplasia (BPD). However, in other series a high incidence (36%) of BPD has been observed [12]. The use of pressure-limited ventilation [4], lower peak airway pressures and inspiratory oxygen concentration, and short duration of ventilation, may

Table 3. Outcome in relation to prognostic factors and indications for mechanical ventilation (MV)

Outcome	Birth weight (g)	Gestational age (weeks)	Age at start of MV (h)	Duration of MV (h)	Indications		
					Respiratory distress syndrome	Pneumonias	Apneas
Deaths (n = 23)	2490 ± 849 (1500–4000)	35.9 ± 3 (32–40)	123 ± 152 (4–576)	62 ± 43 (5–192)	11 (47.8%)	6 (26.5%)	5 (21.7%)
Survivors (n = 18)	2612 ± 465 (1970–3400)	36.7 ± 2 (34–40)	163 ± 207 (36–672)	44 ± 25 (16–131)	7 (38.9%)	8 (44.4%)	3 (16.7%)
Probability	$P > 0.05$	$P < 0.01$	$P < 0.05$	$P < 0.01$			

Values are means ± s.d., with range in parentheses.

Table 4. Comparison of mortality rates in relation to various prognostic factors

Factors	Infants died/ total cases	(%)
Birth weight		
≤ 2000 g	11/24	(78.5)*
> 2000 g	12/17	(44.4)
Gestational age		
≤ 37 weeks	13/19	(68.4)**
> 37 weeks	10/22	(45.4)
Age at start of MV		
≤ 72 h	14/22	(63.6)**
> 72 h	9/19	(47.3)
Duration of MV		
≤ 72 h	16/32	(50)**
> 72 h	7/9	(77.7)

*$P < 0.05$, **$P > 0.05$.

be responsible for a lower frequency of BPD in the present series.

The survival rate with mechanical ventilation increases strikingly with increasing birth weight and more mature infants [10]. In the present study, survival rates of infants with birth weight > 2000 g was about 2.5 times more than those weighing < 2000 g. A controlled trial has shown that mechanical ventilation has significantly improved the survival of infants with RDS weighing > 2000 g, from 15 to 43% [18]. The survival rate in infants with RDS was in 52.2% in the present study.

The follow-up reports of infants (especially low birth weight ≤ 1500 g) surviving ventilator therapy have revealed increased frequency of lower respiratory tract infection [14], with the incidence of major neurological and intellectual defects being in the range of 10–20% [12].

We are presently following up the survivors of mechanical ventilation to assess their long-term pulmonary, intellectual and neurological status.

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