A SIMPLE WAY TO VENTILATE BABIES UTILIZING A MARK VII BIRD VENTILATOR AND A MODIFIED MAPLESON "D" BREATHING CIRCUIT*

J.A. BAIN† AND D. REID‡

MOST PAEDIATRIC VENTILATORS have complicated circuitry and are very expensive. For the past several years ventilation of neonatal and infant patients has been carried out in our centre using the Bird Mark VIII ventilator with Paediatric "Q" Circle. This breathing circuit is difficult to understand because of its many connections and therefore presents problems in sterilization, setting up and changing. The stiff plastic tubing tends to drag on the tracheal tube and is awkward to attach to a neonate in an isolette. Also the FI_{O_2} can only be regulated with expensive equipment. To resolve these problems we have used the Modified Mapleson "D" Breathing Circuit described by Bain and Spoerel to ventilate neonates and infants.¹ The fresh gas inflow line being contained within the large bore exhalation tube makes a single tube breathing circuit.

METHOD

A Mark VII Bird Ventilator with the Modified Mapleson "D" Circuit combined with a Cascade humidifier and air-oxygen flowmeters were used to ventilate these patients. This method of ventilation overcame all of our previous problems. Only readily available hospital equipment was utilized.

A schematic representation of the ventilator circuit is seen in Figure 1. Figure 2 shows the actual ventilator arrangement as set up by our Respiratory Technology Department. The components are all compactly mounted on one pole. The single, long, light-weight tube connects without drag on the tracheal tube or through the porthole of an isolette at the baby's head (Figure 3).

The flexible tube allows the baby to be turned easily without disconnection from the ventilator. An adapter for the patient end of the breathing circuit permits easy and frequent monitoring of FI_{O_2} .

The following simple steps are required to set up the ventilator. The flowmeters are set to deliver at least 4 l/min of fresh gas before attaching the circuit to the endotracheal tube. The air/ O_2 ratio is adjusted to give the desired FI_{O_2} and the Bird Mark VII is then adjusted to meet the ventilatory requirements of the baby.

We try to maintain peak airway pressure below 30 cm H_2O if possible. Further adjustments in ventilation, total fresh gas inflow and FI_{O_2} are made on clinical impression, by measurement of blood gases and by direct monitoring of the FI_{O_2} . The Cascade humidifier is set to deliver adequate humidity.

*Presented at the annual meeting of the Canadian Anaesthetists' Society, St. John's, Newfoundland, June 17-20, 1974.

†Department of Anaesthesia and Department of Paediatrics,‡ University of Western Ontario and Victoria Hospital, London, Canada.

MODIFIED VENTILATOR

FIGURE 1. Schematic Drawing of the Modified Ventilator Circuit.

Strict criteria for ventilation were followed allowing us realistically to assess the ventilation and to relate it to survival.

Any one of the following was an indication for use of the ventilator.

- (1) Apnoea not responding to bag and mask ventilation.
- (2) PaO_2 30 mmHg when breathing 100 per cent O_2 . This measurement was made in blood taken from the umbilical artery in the neonates and in capillary blood samples in the older infants.
- (3) Failure to maintain the pH with bicarbonate. Any metabolic component of acidosis was treated by the administration of bicarbonate. Inability to maintain the pH was usually due to a respiratory acidosis with a PaCO_2 greater than 70 mmHg.

RESULTS

Figure 4 shows the babies divided into groups according to diagnosis. The length of time they required ventilation ranged from one-half to 10 days with a mean of 4.5 days. In this small initial series of 14 we had 7 survivors. Two deaths while on the ventilator were not related to the ventilation. Five babies with severe neurological abnormalities went on to neurological death and ventilation was discontinued.

DISCUSSION

Fourteen babies ranging in weight from 600 gm to 9000 gm were ventilated with this modified ventilator. Strict criteria for ventilation were followed. Ventilation was effective and efficient in all these cases which represented a wide variety of pulmonary and other problems leading to respiratory failure. FI_{O_2} could be

FIGURE 2. Photo of the Actual Ventilator Set-up.

regulated easily by varying the inflow of oxygen. A total inflow of four to five litres of fresh gas per minute was adequate for all babies. Humidity was excellent at setting number 5 or less (usually 3) on the Bennett Cascade Humidifier as judged by the thin secretions, and patency of the lumen of the endotracheal tubes (usually 3.5 mm oral endotracheal tubes in the neonates). Humidity presented a problem in one patient in which the heating coil of the Bennett Cascade burned out and the respirator had to be changed.

Where fresh gas inflow exceeds the ventilating volume the patient's PaCO_2 depends upon the ventilating volume.² In this series 4 to 5 l/min of fresh gas far exceeded the ventilating volume and the PaCO_2 could be manipulated to achieve respiratory alkalosis or, more desirably, to maintain the PaCO_2 between 40 and 49 mmHg.

There was a decrease in infections associated with the use of this ventilator,

FIGURE 3. Modified Ventilator Attached to a Neonate in an Isolette.

which we attribute to the large volume of the humidifier, which required infrequent filling; and to the ease with which the breathing circuit can be changed. Frequent changes (at least every 24 hours) caused no mechanical problems. The circuit can be changed in about 30 seconds as compared to the 4 to 5 minutes required for the Paediatric "Q" Circle. Disconnection time is less and the risk of hypoxia is therefore reduced.

Various supportive treatments used in caring for infants requiring assisted ventilation have been previously described by others. These include intermittent positive pressure ventilation,³ negative pressure assisted ventilation,⁴ positive pressure ventilation with the use of a face mask⁵ and intermittent mask and bag therapy.⁶ All teams emphasize the critical and overriding importance of management by an organized group of experienced physicians, nurses and technicians, who must provide around-the-clock care.⁷ Heese and associates state that "Prolonged artificial ventilation is a very demanding form of treatment: success can be anticipated only where intensive care facilities exist with constant supervision by experienced medical and nursing staff."³ Scott concluded that volume ventilators in the neonate and infant produced no improvement in results over pressure regulated ventilators but that volume ventilators require less frequent adjustments.⁸ Successful ventilation of babies depends much more on the team than on the equipment. Expensive equipment does not assure success.

A ventilator for neonates and infants must deliver up to 40 cm water pressure and have a cycling frequency of 50 to 65 per minute. Triggered breathing is pre-

GROUP	NO. CASES	SURVIVED	DIED	NEUROLOGICAL DEATH	REMARKS
I Congenital Heart	3	2	1		All had Pulmonary edema with $PaO_2 < 30$ mm. Hg. In 100% O_2
II Congenital Infection	1			1	
III Central Depression	3	2		1	
IV Immature	4	1		3	800 gms. or less
V R.D.S.	2	2			
VI Systemic Infection	1		1		
TOTAL	14	7	2	5	

Average Number of Days Ventilated = 4.5

FIGURE 4. Shows the Babies Divided Into Groups According to Diagnosis and the Survival in Each Group.

ferable and negative phase is not necessary. Heese *et al.* found the Bird Mark VIII Ventilator with the "Q" Circle to have these characteristics.³ Our modified ventilator has retained these desirable features and added perhaps more important features of simplicity, an easy regulation of FI_{O_2} without expensive equipment and an easily understood circuit that can be changed quickly.

SUMMARY

Fourteen babies with a wide variety of pulmonary problems have been ventilated effectively and successfully with a Bird Mark VII ventilator combined with a Modified Mapleson "D" Circuit and Bennett Cascade Humidifier. No mortality can be attributed to the ventilator. Its simple circuitry is readily understood by all personnel. FI_{O_2} can be varied easily and predictably. In larger infants exhaled volume can be measured with a Wright Respirometer at the endotracheal tube.

ACKNOWLEDGEMENTS

Thanks are due to Mr. Ron Tracy, Chief of Respiratory Technology, Victoria Hospital and Mr. Don Bowen for their assistance with this project.

RÉSUMÉ

Grâce à un montage articulant entre eux un ventilateur Bird Mark VII, un humidificateur Bennett Cascade et un circuit de Mapleson type D. modifié (Circuit Bain), nous avons ventilé avec succès 14 bébés présentant divers problèmes respiratoires.

D'une grande simplicité, ce montage est facilement compris de tous, il permet

de régler précisément la $F_{I_{O_2}}$ et de mesurer les volumes expiratoires chez les nourissons plus développés avec un ventimètre de Wright.

Aucun des sept décès de cette courte série n'est attribuable à ce mode de ventilation.

REFERENCES

1. BAIN, J.A. & SPOEREL, W.E. A streamlined anaesthetic system. *Canad. Anaesth. Soc. J.*, 19: 426 (1972).
2. BAIN, J.A. & SPOEREL, W.E. Flow requirements for a modified Mapleson "D" system during controlled ventilation. *Canad. Anaesth. Soc. J.*, 20: 629 (1973).
3. HEESE, H. DE V., HARRISON, V.C., KLEIN, M., & MALAN, A.F. Intermittent positive pressure ventilation in hyaline membrane disease. *J. Pediat.* 76: 183 (1970).
4. STALLMAN, M.T., MALAN, A.F., SHEPHARD, F.M., BLANKENSHIP, W.J., YOUNG, W.C., & GRAY, J. Negative pressure-assisted ventilation in infants with hyaline membrane disease. *J. Pediat.* 76: 174 (1970).
5. HELMRATH, T.A., HODSON, W.A., & OLIVER, T.K. Positive pressure ventilation in the newborn infant: the use of a face mask. *J. Pediat.* 76: 202 (1970).
6. GRUBER, H.S. & KLAUS, M.H. Intermittent mask and bag therapy: an alternative approach to respiratory therapy for infants with severe respiratory distress. *J. Pediat.* 76: 194 (1970).
7. BEHRMAN, R.E. Commentary: the use of assisted ventilation in the therapy of hyaline membrane disease. *J. Pediat.* 76: 169 (1970).
8. SCOTT, K. Personal Communication June 1974.