MANAGEMENT OF INFANTS WITH POSTOPERATIVE RESPIRATORY DISTRESS

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POSTOPERATIVE RESPIRATORY INSUFFICIENCY is not uncommon following major procedures in infants. The early recognition and accurate assessment of the insufficiency with rapid institution of appropriate treatment is obviously essential. This paper deals with our experiences in the management of severe persistent respiratory insufficiency in infants under the age of 2 years. The cases discussed had all undergone major surgical procedures, and Intermittent Positive Pressure Breathing (I P P B, I P P R), using the Bud Mark 8 respirator with infant "Q" circle, was given for the maintenance of adequate ventilation. No acute obstructive episodes have been included and we have had no cases of respiratory insufficiency due to the persistent effects of relaxant drugs.

INCIDENCE

In the last year, 18 infants have required I P P B for postoperative respiratory failure. This represents 8 per cent of all cases under 2 years of age undergoing major surgery. Only 5 of these patients survived. The operative procedures concerned were for the relief of

1	Congenital heart disease	12
	A Transposition of great vessels	7
	B Pulmonary atresia	3
	C Ventricular septal defect	2
2	Tracheo-oesophageal fistula	3
3	Posterior fossa tumour	2
4	Diaphragmatic hernia	1

DIAGNOSIS AND ASSESSMENT

The clinical features indicating gross respiratory insufficiency are usually obvious.

Our patients fell into two clinical groups. The smaller group were the two infants who had undergone craniotomy and who suffered from central respiratory failure with slow, shallow, failing respiration and increasing cyanosis. I P P B does not increase brain damage and in these cases allowed time for resumption of central respiratory control.

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The larger group were dyspnoeic and showed restlessness and intense respiratory effort, with use of the accessory respiratory muscles and alae nasi, often with imbalanced diaphragmatic effort and lower rib-cage retraction. Cyanosis was present in varying degrees (most had congenital cyanotic heart disease)

Auscultation may demonstrate bronchospasm, accumulation of secretions, pneumothorax, atelectasis, or pneumonia. Radiography is an anatomical index which can be improved by the use of the biplane. Useful respiratory function tests are the measurement of tidal and minute volume (we collect expired air in a small plastic Douglas bag with face mask and valve) and the estimation of alveolar CO_2 by the rebreathing method. But our main diagnostic aid for the indication and management of respiratory failure is the frequent estimation of arterial pH and $p\text{CO}_2$ (Astrup or Beckman)

We found in some cases of partial correction of transposition of the great vessels, as did Osborn and others,¹ that clinically gross dyspnoea was present, characterized by tachypnoea, but with normal minute volumes and blood gases, which did not become abnormal until some hours postoperatively when the infant tired

In some cases of minor insufficiency, reduction of the dead space, temporarily by insertion of an endotracheal tube, or for more than 24 hours by tracheostomy, is considered first and may be adequate. Continuous effective humidification is imperative for these cases and intermittent nebulization of bronchodilators may help. Usually, however, it is necessary to institute I P P B

CHOICE OF VENTILATOR

The "Bird Mark 8" with infant "Q" circle was selected for use in this series. Although not one of the models considered by Mushin and others² in their assessment of suitable respirators for infants, it has many of the requirements they list. In particular, it is capable of generating variable flows, down to very slow rates, allowing laminar flow, more equal distribution of gases, and a lower cycling pressure. The dead space in the infant "Q" circle is extremely low. Negative pressure is used primarily to reduce the resistance of tubing to expiratory flow. A variable resistance to expiration is available should it be thought necessary to increase intrathoracic pressure for the purpose of reducing pulmonary oedema or venous return. The apparatus and connections are light-weight and sterilizable and there is an excellent nebulizer for the maintenance of adequate humidity and the introduction of therapeutic agents. The major defect is the lack of accurate methods of measuring the pressures, volumes, and flows delivered, and the timing of the cycles. The calibrations on the respirator give some indication, but are liable to drift. As in all pressure-cycled systems, the ventilation is reduced if obstructions develop or if compliance is reduced.

MANAGEMENT

The main points in the management of I P P B have been described frequently (e.g. Gilston³). Postoperatively in infants, there are several points that require

special emphasis and care. By far the most important is the collection and training of a large and dedicated staff. These patients are very ill and precariously balanced. They demand a constant watch and frequent attention. Alteration in any parameter must be noted immediately, assessed properly, and any action necessary performed promptly. A team of anaesthesiologist, cardiologists, surgeon, bronchologist, inhalation therapists, and intensive care nurse must be available 24 hours a day and seven days a week. In approximately a quarter of our cases, the maintenance of life has been shown to be impossible because of the impossibility of adequate surgical correction of the defects involved.

Along with an intensively trained team, an intensive monitoring programme is necessary. The patient is nursed on an automatic, temperature-controlled water blanket kept at any preset desired temperature, this being recorded and controlled by a rectal or oesophageal thermistor. The electrocardiograph is continuously demonstrated by an oscilloscope with an alarm system. The respirator settings initially required are noted and alterations made as compliance varies. Variation of compliance is seen by a change in inspiratory time. The arterial pH and $p\text{CO}_2$ are monitored initially every 4 hours, then daily as stability ensues. Standard bicarbonate and plasma electrolytes are measured daily.

Initially respiration is controlled, but patient cycling is allowed when a suitable rate is established. Tachypnoea is almost constant initially and tends to recur whenever ventilation is reduced for any reason, so that control frequently has to be re-established on several occasions. The initial ventilator settings produce hyperventilation, as patients have respiratory acidosis. Control is usually achieved at arterial $p\text{CO}_2$ levels of 20–30 mm Hg, the pH being 7.4–7.5. Subsequent adjustments to respiratory rates and volumes are made in an attempt to maintain these levels and are based on clinical judgment, published nomograms giving only a very rough indication of requirements in this size of patient. Values in many cases with partially corrected cyanotic heart disease may be most variable, however, and can only be used to judge the progress of the particular case.

The main part of the management of these cases is concerned with the management of the airways. The production of a tracheostomy in an infant carries with it a considerable death rate and when normal cough mechanisms are decreased by IPPR, this is probably increased. We use silver tracheostomy tubes (Holinger). Because of the small size of the airways, these initially are chosen to produce a fairly close fit in the trachea. Air leaks are small and can be compensated for, so that cuffs are not used. The inner lining of the tracheostomy tube is not used whilst on IPPR, as it causes further reduction of an already small airway and increase in air leak. This increases the difficulty in cleaning, but allows a wider-bore connection to be fitted directly into the tracheostomy tube, reducing turbulent flow, while also giving better suction facilities.

Good suction technique is vital. Death normally occurs following manipulation and suctioning. An absolutely sterile technique is essential—sterile gloves, catheters, and washing water for each suction, therefore at least two nurses are required. Speed is also important, so that one nurse disconnects the ventilator while the other puts the suction catheter into the trachea, allowing suction only

on withdrawal, giving only one suction at a time and allowing a few minutes IPPR in between. Endobronchial suction is done as one or the other lung shows signs of obstruction. An angulated suction catheter is required (Bush⁴). In patients who are fit enough, suction is preceded by exhibition of a bronchodilator, percussion, and postural drainage. Frequency of suction is reduced as soon as possible to hourly or two-hourly to minimize the possibility of tracheal trauma and the introduction of infection. Emergency bronchoscopic suction may be required for the removal of large or viscous plugs—often repeatedly in the same patient.

Adequate removal of secretions is only possible if effective humidification is carried out. The Bird nebulizer provides this by introducing droplets of 1–5 μ which evaporate to saturate the air–oxygen mixture as the temperature rises in the trachea. Bronchodilators may be introduced by this method (we use isoproterenol 0.5% or epinephrine 1:500, and also 20% alcohol to reduce the foaming of pulmonary oedema). Antibiotic coverage is essential, but despite this, gross respiratory infection is not infrequently the major cause of death, especially where there was a previous tracheo-oesophageal fistula.

Every effort is made to end IPPR as early as possible, allowing intermittent periods of spontaneous respiration of increasing length according to the infant's capacity. Similarly the tracheostomy is closed as soon as possible, again using increasing intermittent periods of withdrawal, to minimize tracheal wall weakness and collapse, and formation of granulation tissue.

SUMMARY

In some infants with postoperative respiratory failure, life can be sustained by IPPR to give time for compensatory mechanisms to come into play.

In the infant, pathological and physiological changes may be very rapid and clinical evaluation difficult. For these reasons a large, well-trained staff must be available to monitor the infants constantly clinically and biochemically, and immediate specialist help is required for the treatment of complications.

RÉSUMÉ

In the last year, 18 infants required IPPR for postoperative respiratory failure. Only 5 survived. IPPR was given by Bird Mark 8 respirator with infant "Q" circle, monitored by arterial pH and $p\text{CO}_2$ obtained by the Astrup method. The importance of sterile management, good suction technique, and humidification is stressed, and the absolute necessity for the establishment of a well-trained, experienced nursing and medical team if high survival rates are to be achieved.

Il n'est pas rare d'observer de l'insuffisance respiratoire postopératoire après des opérations majeures chez les enfants; il est essentiel de s'en rendre compte précocement, d'en reconnaître l'importance et de pratiquer rapidement le traitement approprié. Ce travail fait part des résultats obtenus dans le traitement de

l'insuffisance respiratoire sérieuse et prolongée chez les enfants au-dessous de deux ans, à l'hôpital Children's Memorial, Chicago, Ill

Au cours d'une année, on a dû traiter 18 enfants par la respiration sous pression positive intermittente, à cause d'insuffisance respiratoire postopératoire. Ceci représentait 8 pour cent de tous les cas de chirurgie majeure chez les enfants au-dessous de deux ans. De ces enfants, cinq seulement survécurent. Douze avaient été opérés pour maladies congénitales du cœur, trois pour fistule trachéo-œsophagienne, deux pour tumeur de la fosse postérieure, et un pour hernie diaphragmatique. Ces malades étaient répartis en deux groupes cliniques.

Ceux du premier groupe, peu nombreux, souffraient d'insuffisance respiratoire d'origine centrale, alors que les autres, beaucoup plus nombreux, étaient dyspnéiques et devaient faire un effort respiratoire considérable en s'aidant des muscles respiratoires accessoires.

On a utilisé le ventilateur Bird, Mark VIII, équipé du circuit "Q" pour enfants. Cet appareil peut produire des débits variables même à un rythme très lent, ce qui permet un débit laminaire, une distribution des gaz plus régulière et une plus basse pression d'opération. L'appareil et les raccords sont légers et faciles à stériliser, il est équipé d'un excellent vaporisateur pour maintenir l'humidité et pour administrer des médicaments. Son principal défaut est qu'il manque de méthodes précises pour mesurer les pressions, les volumes et les débits, ainsi que la durée du cycle complexe respiratoire.

Le point le plus important dans les soins à ces tout petits est la formation d'un personnel nombreux et efficace. Le malade est soigné sur un matelas dans lequel on fait circuler de l'eau (*water blanket*). La température de cette eau est contrôlée automatiquement et maintenue à un degré déterminé à l'avance. L'électrocardiogramme est continuellement en action, et ses données sont indiquées sur un oscilloscope muni d'un système d'alarme. Le réglage initial du respirateur est noté, et l'on fait les changements à mesure que varie la compliance. On constate la variation de la compliance par le changement du rythme respiratoire. Le pH et le CO₂ sont enregistrés par la méthode Astrup.

On insiste sur l'importance d'une bonne aspiration stérile et d'une bonne humidification.

REFERENCES

- 1 OSBORN, J. J., POPPER, R. W., KERTH, W. J., & GERBODE, F. Respiratory Insufficiency Following Open Heart Surgery. *Ann Surg* 156 (4) 638 (1962)
- 2 MUSHIN, W. W. M., MAPLESON, W. W., & LUNN, J. N. Problems of Automatic Ventilation in Infants and Children. *Brit J Anaesth* 34 514 (1962)
- 3 GILSTON, A. The Management of Respiratory Distress after Cardiothoracic Surgery. *Thorax* 17 139 (1962)
- 4 BUSH, G. H. Tracheobronchial Suction in Infants and Children. *Brit J Anaesth* 35 322 (1963)