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References

O. N. BHAKOO* and J. W. SCOPES†
Neonatal Research Unit, Institute of Child Health, Hammersmith Hospital, London W.12.

*Present address: Post-Graduate Institute, Chandigarh, India.
†Correspondence to Dr. J. W. Scopes, Department of Paediatrics, St. Thomas's Hospital, London SE1 7EH.

Prolonged continuous positive airways pressure for pulmonary oedema due to persistent ductus arteriosus in the newborn

Distending pressure is now recognized therapy for neonatal respiratory distress syndrome (RDS) (Gregory et al., 1971; Chernick, 1973). In most cases the duration of therapy is less than 3 days. This paper describes the prolonged use of continued positive airways pressure (CPAP) to control drug-resistant pulmonary oedema in 2 babies who initially suffered from RDS, but aged 1 week developed the signs of a persistent ductus arteriosus (PDA).

Methods
RDS was managed in the standard manner (Davies et al., 1972). The Bennett PR 2 ventilator was used when intermittent positive pressure ventilation (IPPV) was indicated and also for administering CPAP through the endotracheal tube (Etches, Houghton, and Moore, 1973).

Case reports
Case 1. A female, birthweight 1190 g at 28 weeks' gestation, was apnoeic at birth. Intubation and positive pressure ventilation were applied but severe RDS developed and the IPPV was continued. Aged 30 minutes on IPPV (pressure 24 cmH$_2$O, rate 32/min, oxygen 80%) the blood gases were pH 7.16, Pao$_2$ 56 torr, Paco$_2$ 52 torr. Her RDS improved and by 7 days the blood gases were satisfactory in 40 to 50% oxygen at ventilator pressures of 16 to 18 cmH$_2$O and rates of 20 to 30/minute. Periods of spontaneous respiration occurred.

The pattern of her illness now changed, with widespread crepitations in both lungs. Chest x-ray was compatible with pulmonary oedema. The blood pressure was 60/20 with bounding pulses, and a loud systolic murmur heard in the pulmonary area suggested a PDA. She was not infected. Attempts to discontinue IPPV from the 14th to the 17th day failed due to progressive hypercapnia and pulmonary oedema not consistently controlled by digitalis and frusemide (Fig. 1). The frusemide did control an exacerbation of the pulmonary oedema after a plasma and blood infusion at age 14 days, but hypernatraemia developed. Pao$_2$ remained satisfactory in 35 to 50% oxygen throughout this period. Her weight fell to 950 g and she was never fit enough for cardiac catheterization to confirm the clinical diagnosis. CPAP with 32% oxygen, applied for the first time at age 17 days, controlled the pulmonary oedema for 22 hours. Paco$_2$ then increased, crepitations

![Fig. 1.—Clinical course of Case 1 from 14 to 20 days of age.](http://adc.bmj.com/Archives/1974/10.1136/adc.49.7.585/page-588)
recurred, and further IPPV was necessary. A second period of CPAP with 28 to 32% oxygen controlled the pulmonary oedema from 18 till 22 days (Fig. 1). When pulmonary oedema recurred at age 27 days it was controlled by CPAP for a further 23 days at pressures of 4 to 7 cm H₂O, initially using 26 to 32% oxygen, and using air from 34 days. Digitalization was maintained and occasional doses of frusemide were needed. CPAP was discontinued at age 50 days, the endotracheal tube was removed, and pulmonary oedema did not recur. At age 10 months she is well and neurologically normal. The murmur disappeared at 8 months.

Case 2. A male, weighted 1650 g at 29 weeks' gestation. He developed signs of RDS by 30 minutes of age. Umbilical catheters were inserted, and breathing 98% oxygen pH was 7.28, PaO₂ 143 torr, PaCO₂ 34 torr. His RDS responded well to CPAP applied by head box from 4 to 35 hours of age. Aged 5 days he became jaundiced requiring 3 exchange transfusions. Infection was suspected but never proved. Broad spectrum antibiotics were given. CSF was uniformly blood-stained. At age 6 days recurrent apnoea developed requiring IPPV (30% oxygen, pressure 10 to 14 cmH₂O, rate 24/min). At age 12 days he was breathing spontaneously and his illness changed again. He had signs of persistent ductus arteriosus similar to Case 1, with CO₂ retention and pulmonary oedema confirmed radiologically. He was digitalized but diuretics were used sparingly due to hyponatraemia. His weight had fallen to 1140 g and cardiac catheterization was not feasible.

Between the 12th and 15th day crepitations increased and PaCO₂ rose when breathing spontaneously (Fig. 2). IPPV was required for satisfactory control. At age 15 days CPAP was started using 24 to 30% oxygen at pressures of 4 to 6 cm H₂O. The crepitations disappeared and PaCO₂ gradually fell. An attempt to discontinue CPAP failed at 17 days (Fig. 2), but was successful at 26 days. The murmur was quieter and disappeared 1 week later. The pulmonary oedema did not recur. However, he developed hydrocephalus and aged 40 days a Pudenz valve was inserted, but he died 5 days later.

Necropsy revealed an old intraventricular haemorrhage obstructing the foramina of the 4th ventricle. The lungs were normal and the ductus arteriosus was closed.

Discussion

Persistent ductus arteriosus complicating the recovery of hyaline membrane disease has been increasingly recognized in recent years. Infants develop pulmonary oedema refractory to medical therapy, with marked hypercapnia but milder hypoxaemia. Early surgical intervention and ligation of the PDA has been recommended (Kitterman et al., 1972; Gupta et al., 1972). However, a high mortality rate occurred in severely ill infants. Conservative management has been advocated (Krovetz and Rowe, 1972), since spontaneous improvement occurs after the initial severe illness, as exemplified by the spontaneous closure of the PDA in our cases. Though the diagnosis of PDA was not proved by catheterization, the clinical picture was typical. Some authorities feel that the picture is so classical that cardiac catheterization need not precede operation.

IPPV is a successful therapy for severe pulmonary oedema (Robin, Cross, and Zelis, 1973). The cases presented here show that CPAP can be equally successful except when the oedema is very severe, as in Case 1 during the earlier severe stage of her illness. Because of the hazards of endotracheal intubation, we prefer to apply CPAP using a head box. Nevertheless, for long-term use, the head box is not practicable and we apply CPAP through an endotracheal tube using a Bennett ventilator. In a unit experienced with severely ill low birthweight infants, we believe this form of therapy to be less hazardous than cardiac surgery. The oxygen concentration given to these cases does not cause pulmonary damage. Only 14 endotracheal tube changes were required over 40 days of CPAP in
these 2 infants. Secretions were controlled by frequent aspiration of the tube, and pulmonary infection with *Esch. coli* responded to kanamycin or gentamicin. There were no pneumothoraces.

**Summary**

Two cases of pulmonary oedema due to persistent ductus arteriosus are described. Both were satisfactorily treated with the use of CPAP, in Case 1 for 29 days in three spells, and in Case 2 for 12½ days. This approach to therapy is particularly useful in babies unfit for cardiac catheterization or in centres where access to sophisticated cardiothoracic facilities is limited.

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N. R. C. Robertson
Department of Paediatrics, John Radcliffe Hospital, Headington, Oxford OX3 9DU.