

nique. All five cases showed a statistically significant increase in the blood levels of mepivacaine with each refill dose. Mepivacaine crossed the placental barrier but did not depress the neonate.

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## Resistance of Nasotracheal Tubes Used in Infants

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Currently, nasotracheal intubation is preferred to tracheostomy for prolonged maintenance of the airway in the newborn infant.<sup>1,2</sup> Management of the airway is simpler and there appear to be fewer post-extubation complications.<sup>3</sup>

An endotracheal tube has a smaller internal diameter than an infant's glottis, and may produce a significantly greater airway resistance than that of the infant's upper airway. Mechanical ventilation can be used to overcome such an increase in resistance, but during spontaneous ventilation the increase in total airway resistance would increase the work of breathing. This situation arises during the period of weaning from a ventilator, when it is desirable to leave the tube in place and avoid frequent reintubation.

The purpose of this investigation was to study the airway resistance of nasotracheal tubes of sizes commonly used for prolonged intubation of infants<sup>4,5</sup> and to make a comparison with the reported upper airway resistance of the newborn.<sup>6</sup>

## METHOD AND MATERIALS

Three sizes of plastic tubes were chosen for study (table 1). They were cut to lengths usually required to maintain the tip of the tube in the trachea, midway between the carina and the glottis. Connectors (Bennett †)

† Puritan Bennett, subsidiary of Puritan Compressed Gas Corporation, Kansas City, Missouri.

TABLE 1. Dimensions of Tubes Studied

French Scale	Magill No.	Int. Diam. in. mm.	Daval No.	Length in cm.	Connector Size
12	<00	2.5	0	10	2 L
14	00-0	3.0	<1	11	3 S
16	0	3.5	>1	12	4 S

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TABLE 2. Measured Drop in Pressure (cm. H<sub>2</sub>O) Across Nasotracheal Tubes

Flow	Tube Size (mm. I.D.)		
	2.5	3.0	3.5
5.0 l./min. 83 ml./sec.	2.7	1.5	1.0
10.0 l./min. 166 ml./sec.	14.0	4.5	2.5

for attaching the tubes to an infant ventilator circle were inserted into the tubes. Slight variations in length of the tubes for different infants would not make a significant difference in total resistance, for at a constant driving pressure flow in a tube is proportional to the fourth power of the diameter, assuming laminar flow.<sup>7</sup>

Pressure differences were measured with a water manometer (table 2) and air flow rates with a precision flowmeter (Fisher-Porter). The resistance of the tube was calculated from the pressure differences across the connector and tube at different rates of flow. The range of 5 to 15 l./min. was used (83 to 250 ml./sec.). These flows include the maximum flow rates seen in infants.<sup>8</sup> The range for premature and newborn infants is 48 ml./sec. to 161 ml./sec.<sup>8, 9, 10</sup>

RESULTS

Figure 1 shows pressure difference in cm. H<sub>2</sub>O plotted against air flow rates in l./min. and ml./sec. At the lowest flows the differences between the tubes were small. Resistance increased disproportionately to flow rate with the smallest tubes 2.5 mm. in internal diameter (I.D.), above 50 ml./sec., indicating the development of turbulent flow. The 3.5 mm. I.D. tube appeared to have essentially laminar flow throughout the range studied.

DISCUSSION

The total airway resistance of newborn infants has been found to average between 18 and 29 cm. H<sub>2</sub>O/l./sec.<sup>10, 11, 12</sup> The mean nasal airway resistance is reported to be 12.1 cm. H<sub>2</sub>O/l./sec. (range 5.6-19.9) or 40 per

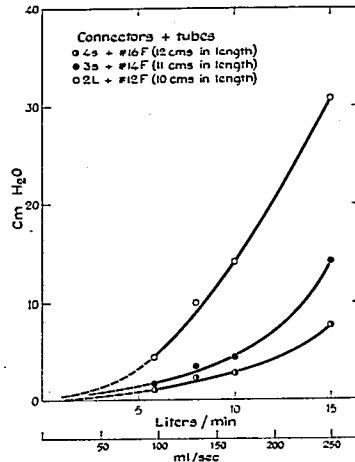


FIG. 1. Relationship between pressure difference (cm. H<sub>2</sub>O) and air flow rate (l./min. and ml./sec. in three sizes of nasotracheal tube.

cent of the total airway resistance.<sup>6</sup> Nasal airway resistance constitutes approximately two-thirds of the upper airway resistance, whereas the glottis and larynx appear to constitute only a small amount (less than 10 per cent).<sup>13</sup> It seemed reasonable to compare the resistance of the endotracheal tubes studied with the upper airway resistance of the newborn to estimate whether they would increase the work of breathing if left in place in spontaneously-breathing infants.

At 100 ml./sec. the resistances of the 3.0 mm. I.D. and 3.5 mm. I.D. nasotracheal tubes studied (with connectors) were equal to or less than the upper airway resistance. On the other hand the 2.5 mm. I.D. tube had a resistance equal to or greater than either the upper or the total airway resistance of infants. During spontaneous breathing it is unlikely that there will be an increase in work of breathing if the 3.0 mm. I.D. or the 3.5 mm. I.D. tubes are used. The increase in work would be significant if the 2.5 mm. I.D. tube is used (table 3).

TABLE 3. Resistances of Tubes as Percentages of Reported Total Airway Resistance<sup>10,11,12</sup>

2.5 mm. I.D.	100%
3.0 mm. I.D.	60%
3.5 mm. I.D.	41%

## CONCLUSION

The resistances to air flow in three sizes of endotracheal tubes and connectors were measured and compared with the reported upper airway resistance of the infant. 3.0 and 3.5 mm. I.D. tubes of the usual length appeared to impose little chance of increasing the work of breathing in the spontaneously-breathing newborn infant. 2.5 mm. I.D. tubes had a high resistance, compared with the infant's airway resistance, and should be used only in association with artificial ventilation.

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## Surgery

**DELIRIUM IN THE CCU** Eleven patients experienced varying degrees of delirium during the treatment of myocardial infarction in a coronary care unit. Sensory monotony and sleep deprivation seem to be of importance in the etiology of this state. Early signs of impaired thinking, confusion, or inappropriate behavior should alert the physician to impending delirium. The patient should be moved promptly to an environment of more nearly normal surroundings where family members may stay with him for long periods. Use of oxygen tents and monitoring equipment usually must be discontinued temporarily. Restraints should be avoided whenever possible. Sedation is almost always necessary, and one of the phenothiazines should be used in preference to barbiturates, which frequently accentuate the delirium. (Parker, D. L., and Hodge, J. R.: *Delirium in a Coronary Care Unit*, *J.A.M.A.* 201: 702 (Aug.) 1967.)