Effects of Feeding on Respiratory Mechanics of Healthy Newborn Infants

GEORGE RUSSELL and ELIZABETH A. FEATHER

From the Department of Child Health, University of Aberdeen, and Aberdeen Maternity Hospital

Russell, G., and Feather, E. A. (1970). *Archives of Disease in Childhood*, 45, 325. **Effects of feeding on respiratory mechanics of healthy newborn infants.** Methods for the study of respiratory mechanics of the newborn infant are described. In 20 healthy neonates, small feeds had no adverse effect on respiratory mechanics.

In previous studies of the respiratory mechanics of newborn infants no attempt has been made to relate the results to feeding, though Barrie (1968) has described increased intra-oesophageal pressure swings following tube-feeding. In the present paper a technique for the study of neonatal respiratory mechanics is described, and the effects of feeding on the respiratory work and pulmonary compliance of 20 healthy newborn infants are reported.

Materials and Methods

Infants studied. 20 apparently healthy infants born in Aberdeen Maternity Hospital were studied. All weighed over 2500 g. at birth. Further data are presented in Table I.

TABLE I
The 20 Babies and Their Feeds

	Mean	SE
Birthweight (g.)	3107	71
Age when studied (hr.)	43.6	3.8
Volume of feed (ml.)	38.5	4.1
Volume of feed (ml./kg.)	12.4	1.3
Time between studies (min.)	14.4	2.0

Tidal volume measurements. A pneumotachygraph* was connected to the infant by means of an acrylic coupler with vinyl† nose pieces, fixed in position by non-irritant adhesive tape‡ (Fig.). The pneumotachygraph had a screen area of 0.28 sq. cm., an internal volume of 1.5 ml., and gave linear recordings up to

12 l./min., well in excess of the peak flows recorded in neonates by Swyer, Reiman, and Wright (1960). The internal volumes of the couplers varied between 0.7 ml. and 1 ml. The pneumotachygraph was attached to a defocusing differential pressure transducer,* the output from which was integrated electronically,† and the resulting signal, proportional to volume, was displayed on a polygraph.‡

Oesophageal pressure measurement. A 3 cm. long air-filled balloon§ with a circumference of 1.5 cm. was attached to a 5 f.g. vinyl feeding-tube at the end of which additional side openings had been cut. This was passed by mouth into the oesophagus and connected to a defocusing pressure transducer¶ whose output was displayed on the polygraph.

Calibration procedure. Before and after each study, the response characteristics and linearity of the two pressure recording systems were compared. Usually the response times were identical, 95% of the response to a square wave pressure change occurring in 0.09 sec., and the inclusion of the integrator in the circuit had no measurable effect on the response time. Occasionally the balloon delayed the response of the oesophageal pressure channel, and when this delay amounted to more than 0.01 sec., the record was discounted. Allowance was made for shorter delays in the analysis of the tracings. Both systems invariably gave linear responses to volume and pressure changes.

Compliance and work of breathing. Pulmonary compliance was calculated from 10 consecutive breaths by the method of von Neergaard and Wirz (1927). Respiratory rate, mean tidal volume, and minute volume were calculated from the same 10 breaths. A represen-

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*F2, 6 mm flow-head, Mercury Electronics Ltd.

†Portex ivory vinyl, Portland Plastics Ltd.

‡Dermicel surgical tape, Band-aids; Cleartape, Johnson and Johnson.

*Greer micromanometer, capsule A10, Mercury Electronics Ltd.

†Integrator supplied by Devices Sales Ltd.

‡M8 recorder, Devices Sales Ltd.

§Oesophageal balloon, Dunlop Rubber Co. Ltd.

¶Greer micromanometer, capsule A 1000, Mercury Electronics.

FIG.—The nasal adaptor has openings opposite the nares through which the nostrils may be aspirated, and it can be opened at either end to allow the coupling of apparatus such as the pneumotachograph shown here. With the spigots removed from all these openings, air has free entry to the adaptor and dead space effect is negligible.

tative breath was selected, a volume-pressure loop constructed, and total and viscous work were measured by planimetry as described by Otis, Fenn, and Rahn (1950). The length of the breath so analysed was measured, and rates of work were based on the respiratory frequency derived from this figure which was not used for any other purpose. Total work per minute measured in this way was compared with values calculated using McIlroy's formula (Cook *et al.*, 1957).

The design of the Greer micromanometer (Greer, 1958) is such that it is impossible to subtract the pressure drop across the pneumotachograph from the measured oesophageal pressure: this has no effect on compliance measurements but introduces a small amount of additional viscous work; this has not been allowed for in the calculations as the error is slight and is in any case present both before and after feeding.

Study procedure. The coupling device and the oesophageal balloon were secured in position and the infant was bottle-fed. He was then returned to his cot, the pneumotachograph was attached, and tracings of tidal volume and oesophageal pressure obtained and scrutinized for technical errors or artefacts. The pneumotachograph was then removed and the infant left undisturbed until signs of hunger appeared. With the infant on his right side, the pneumotachograph was again attached and further recordings were made (pre-feed study). With the coupler but not the pneumotachograph *in situ*, the infant was picked up and given the feed prescribed by the paediatrician on the ward. The infant was then returned to the cot, placed on his right

side, and further pressure-volume recordings made (post-feed study). The interval between the pre- and post-feed studies ranged from 5 to 35 minutes (see Table I).

Statistical analysis. The Student *t* test for pairs was used to evaluate the differences between the results of the pre-feed and post-feed studies, the differences being expressed both as absolute numbers and as percentage changes.

Results

A comparison of the results of the pre-feed and post-feed studies is presented in Table II. Feeding had no significant effect on any of the factors measured. Work measured by planimetry correlated well with work measured by McIlroy's formula ($r = 0.98$; $p < 0.00001$).

Discussion

The work of breathing measured in the present study is similar to that reported elsewhere (McIlroy and Tomlinson, 1955; Cook *et al.*, 1957; Swyer *et al.*, 1960). The compliance figures are similar to those reported for other healthy infants (Cook *et al.*, 1957; Geubelle *et al.*, 1959; Swyer *et al.*, 1960; Karlberg and Koch, 1962; Drorbaugh *et al.*, 1963; Chu *et al.*, 1964; Polgar and String, 1966), though higher than compliances derived from the data of McIlroy and Tomlinson (1955) and higher

TABLE II
Effects of Feeding on Respiratory Mechanics in 20 Babies

	Mean Pre-feed (A)	Mean Post-feed (P)	Mean Change (A-P)	SE of A-P	p	Mean % Change $\frac{A-P}{A}$ %	SE of $\frac{A-P}{A}$ %	p
Total work per breath (g. cm.)	53.95	41.25	12.70	7.67	>0.1	3.31	12.31	>0.7
Total work per minute (g. cm.)	2766	3308	458	404	>0.2	1.86	13.27	>0.8
Viscous work per breath (g. cm.)	47.10	34.05	13.05	7.80	>0.1	1.71	13.88	>0.9
Viscous work per minute (g. cm.)	2396	1953	443	406	>0.2	4.42	15.44	>0.7
Respiratory rate (per minute)	56.65	55.65	1.00	3.09	>0.7	3.28	5.43	>0.5
Minute volume (ml.)	741	740	1.00	43.8	>0.9	-1.74	7.00	>0.8
Pulmonary compliance (ml./cm.H ₂ O)	4.825	6.020	-1.195	0.691	>0.05	-43.54	24.44	>0.05

than those recorded in anaesthetized infants by Reynolds and Etsten (1966) and by Lunn (1968).

Though the feeds given in the present study were small (mean 12.4 ml./kg. given orally over 14.4 minutes), particularly when compared to those given by Barrie (1968) (60 ml. per kg. given by naso-gastric tube over 20 minutes), it is notable that feeding had no adverse effect on any of the factors measured and, though the changes were not statistically significant, there was a slight rise in compliance and a tendency for both viscous and total work to fall after feeding. Respiratory rate and minute volume were virtually unchanged. Barrie's (1968) results may be attributable to the unusually large volumes of feed given; it certainly cannot be assumed that feeding causes some degree of respiratory embarrassment in all newborn infants. It is obviously necessary for studies to be undertaken to demonstrate the point at which adverse effects appear; this may depend not only on the volume of feed relative to the size of the infant, but also on the maturity of the infant, the time taken for the feed, and the route by which it is given. The methods described above are suitable for such investigations, and no adverse effect attributable to the apparatus has been noted during or after the studies.

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Correspondence to Dr. George Russell, Department of Child Health, University Medical Buildings, Foresterhill, Aberdeen, AB9 2ZD, Scotland.