EVALUATION OF A RESPIROMETER FOR NEONATES

BY

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SUMMARY

The adult (Wright) respirometer has been redesigned for neonates. A calibrated Krogh spirometer has been used to check the accuracy and a regression relationship derived over a range of minute volumes 0.4–2.8 l./min. The added resistance of 29 cm H₂O/1/.sec lowered minute volume according to a second regression line which was also experimentally derived. Combining the two regressions allows true minute volume to be predicted from the respirometer reading. This respirometer is potentially useful in ventilator and anaesthetic circuits.

There is a need for a clinically applicable instrument for the measurement of minute volume in the newborn.

A commonly used adult respirometer (Wright, 1955, 1958) has errors of measurement at rates of breathing above 40 per minute and at peak flows below 3.8 l./min (Byles, 1960; Hall and Reeser, 1962; Nunn and Ezi-Ashi, 1962) and is therefore unsuitable for neonatal measurements. Plethysmography (Cross, 1949; Du Bois et al., 1956; Karlberg et al., 1960) and pneumotachography (Owen-Thomas, 1967; Swyer, Reiman and Wright, 1960) require relatively complex equipment, accurate calibration procedures and personnel trained in their use.

One of us (F.C.D.W.) has redesigned the Wright respirometer in such a way as to make it suitable for the measurement of the lower respiratory volumes of neonates. We report an evaluation of its performance in a closed circuit system using a Krogh spirometer as modified by Adamsons (1959) and Levison, Delivoria-Papadopoulos and Swyer (1965) (fig. 1).

The purpose of this study was (1) to check the dynamic calibration of the respirometer against

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FIG. 1

Closed circuit system modified for the evaluation of the infant respirometer. When the gas line is clamped at A the Krogh spirometer only is functional. When clamp is applied at B the respirometer and spirometer are in series and simultaneous readings can be made.

Gas was recirculated at 9 l./min.

a previously calibrated Krogh spirometer and (2) to evaluate any change in minute volume resulting from the series interposition of the respirometer in the Krogh circuit, due to the added resistance to breathing.

From the information gained in (1) and (2) above, a prediction of Krogh spirometric minute
volume could then be obtained from the respirometer readings, hence yielding an estimate of minute volume uninfluenced by the respirometer resistance.

**METHODS**

Sixteen infants with normal respiratory function were studied, ranging in age from 5 to 28 days and ranging in weight from 1.5 to 3.2 kg. All were tested 30 minutes following feeding. No special effort was made to study the infants under resting conditions as the object was only to evaluate the performance of the instrument. The infant was swaddled, and a ring of warm, water-soluble jelly, applied to the face and pneumatic rim of the face mask. The face mask contained a baffle which deflected circulating gas across the face in order to avoid rebreathing. A gas mixture containing 60 to 80 per cent oxygen was recirculated at a rate of 9 l./min with a carbon dioxide absorber in the circuit (fig. 1). The face mask was then connected to the closed circuit as shown (fig. 1). Calibration of the spirometer was by a calibrated glass syringe. The dynamic response of the system was linear up to 100 cycles/min to a ± 5 per cent error.

An electrical analogue of tidal volume was recorded after amplifying the signal produced by displacement of an angular transducer (Metrisite Brush Instruments, Cleveland, Ohio, USA) attached to the spirometer. Expired tidal volumes were measured and totalled over 1 minute. The respirometer was sited in such a way that it could be included or excluded from the circuit by cross-clamping the tubes at A or B (fig. 1).

Ten readings of spirometer and respirometer minute volumes were simultaneously recorded (clamp at B) and ten spirometer readings with the respirometer excluded from the circuit (clamp at A) for each infant. Observations were randomized, measuring minute volumes with the respirometer alternatively in and out of the circuit for each patient. In order to ensure comparable conditions only uninterrupted records over 20 minutes were used.

The drop in pressure across the respirometer in response to steady flow of up to 300 ml/sec was measured and the resistance of the instrument was calculated.

**RESULTS**

The calibration of the respirometer, as indicated by simultaneously recorded Krogh spirometer volumes, is given by the regression equation Krogh = 0.054 + 0.935 × respirometer (fig. 2), over the range of 0.4–2.6 l./min.

![Fig. 2](image)

Regression of the respirometer minute volume on Krogh spirometer minute volumes, simultaneously recorded with the two instruments in series (clamp in position B—see fig. 1). Each point represents the mean of ten observations. The 95 per cent confidence limits of the line of regression are shown.

There was a lowering in minute volume consequent on the flow resistance of the respirometer. This accords with the work of Milic-Emili and Tyler (1963) in adults who showed that minute volume decreases as non-elastic resistance to breathing increases.

The flow resistance of the respirometer was 29 cm H,O/l./sec, a value which is comparable to the non-elastic flow resistance of the spontaneously breathing newborn infant (Cook et al., 1957; Swyer, Reiman and Wright, 1960), and the regression equation describing this relationship is Krogh = -0.137 + 1.245 × Krogh (loaded with respirometer) (fig. 3).

The regression equations allow prediction of (Krogh spirometer) minute volume from the respirometer reading obtained from any given
patient in the following way:

In figure 2 assume

1. Respirometer minute volume reading
2. Read Krogh minute volume = 1.46 l.

On figure 3

1. Read true Krogh minute volume (series loaded) on abscissa = 1.46 l.
2. Find true Krogh (unloaded) minute volume on the ordinate = 1.66 l.

Hence when the respirometer minute volume reading is 1.50 l, then true minute volume would be 1.66 l.

Recalibration of the respirometer dial according to the predictions in the two regression equations, will therefore enable true minute volume to be measured.

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REFERENCES


EVALUATION D’UN RESPIROMETRE POUR NOUVEAU-NES

SOMMAIRE
Le respiromètre (Wright) pour adultes a été transformé pour les nouveau-nés. Un respiromètre calibré de Krogh a été employé pour vérifier l’exactitude et une relation de régression a été dérivée sur une série de volumes-minute de 0,4 à 2,8 l./min. La résistance supplémentaire de 29 cm H2O/l./sec. réduit le volume-minute suivant une seconde ligne de régression, qui a également été dérivée expérimentalement. Combiner les deux régressions permet de prédire au départ de la lecture du respiromètre, le vrai volume-minute. Celui-ci semble pouvoir être utile dans des circuits de ventilation et d’anesthésie.

BOOK REVIEW


The proceedings of the International Conference on Traumatology, held in Budapest in October 1961, have now become available in German.

Negowski, of Moscow, considers resuscitation to be a new branch of medicine, naming it reanimatology, whose task begins when life has ceased. In cases of slow death or irreversible shock he recommends, on the basis of 25 years' clinical and experimental research, intra-arterial transfusion under pressure, together with artificial respiration with 100 per cent oxygen, defibrillation and open cardiac massage. During the early post-mortem period intravenous infusion of sodium bicarbonate and exchange transfusion have been of decisive aid towards recovery. Negowski's publications seem to exert considerable influence, and intra-arterial transfusion is used by a number of authors, often combined with intravenous transfusion and with hibernation.

Several authors advise hydroxydione anaesthesia for orthopaedic operations on patients over 60 but in younger people excitement, is managed by careful administration of extraction of whole adrenal is recommended prior to anaesthesia. Experience with phencyclidine is similar to British results; it is satisfactory in orthopaedic operations on patients over 60 but in younger people excitement and hallucinations are caused. One author describes successful reduction of many dislocations and fractures of the upper extremity by slow traction followed by pressure, without any anaesthetic and without mentioning the use of analgesics.

Although literature is quoted, a bibliography has not been provided, perhaps on the assumption that users of this translation cannot read the original papers as they are mainly written in Eastern European languages. Since the addresses of the speakers have also been omitted readers are regrettably left without any means of contacting the authors.