NOTES ON RESPIRATORY PERFORMANCE DURING LABOUR

BY

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SUMMARY

Independent studies were undertaken on patients in labour in Aberdeen and London. Measurements of peak inspiratory flow rate, respiratory rate, tidal volume and the volume of air inspired during contractions and at delivery were made. The peak inspiratory flow rate was found frequently to exceed 250 l./min, and in the first stage of labour was occasionally well over 300 l./min. It was computed that 1500 litres of gas mixture should be available for the conduct of analgesia in primigravid labour, and that 1000 litres of gas mixture should be available for the multigravid patient.

There are few published accounts of measurements of respiratory mechanics during labour, although the effect of pregnancy upon respiratory performance has been intensively investigated (Hytten and Leitch, 1964; Gee et al., 1967; Bonica, 1967).

In countries such as Britain, where considerable use is made of inhalational analgesia during labour, knowledge of the range of values of inspiratory flow rate, the tolerable resistance to inspiration and expiration, and the volume of gas mixture demanded by the patient during labour, should be mandatory to the design of appropriate apparatus.

We have, quite independently, assessed some aspects of respiratory performance during labour. Each investigation was rather small, but the results coincided reasonably well, so it was considered worth while to present our pooled data in the hope that they will provide not only interesting information about the labouring woman, but also some guidance in the design of equipment.

(A) STUDIES CARRIED OUT AT THE WHITTINGTON HOSPITAL (J.S.C.)

Methods.

Twenty randomly-selected patients (twelve primigravidae) were investigated. Measurements were made during the second half of the first stage of labour (fourteen patients studied), the second stage (fourteen patients) and at delivery (twelve patients). Each patient was breathing room air at the time of study.

Inspiratory airflow rate measured by using a Fleisch No. 3 pneumotachograph whose performance had been calibrated against a reference Rotameter. The pneumotachograph was coupled, via a Ruben unidirectional valve, to an anaesthetic facepiece which was held firmly in place by the investigator throughout the period of contraction or as the mother was being delivered. The pressure drop developed across the pneumotachograph during inspiration was measured by a micromanometer with a sensitivity of 2 mm H2O full scale, and the electrical signal was written out on a multichannel pen-recorder on which was also recorded the time in 5-second intervals. A length of corrugated rubber tubing was attached to the distal end of the pneumotachograph, and to the other end of the tubing was fitted a Wright respirometer. The volume of air inspired during each contraction could thus be recorded along with the peak inspiratory flow rate and the number of inspirations per contraction.

Results.

Fourteen patients in first-stage labour were studied, observations being made during the course of from 3 to 20 contractions (mean 10.5), lasting 20-170 seconds (mean of patient’s means 33 seconds). The number of respirations during each contraction was from 2 to 124 (mean of individual patient’s means 34.2). The maximum peak inspiratory flow rate in respective cases ranged from 22 to 340 l./min (mean of individual

* By courtesy of the British Oxygen Company, Brentford.
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The volume of air inspired during each contraction ranged from 1.6 l. to 94.6 l. (mean of individual patient’s means 23.1 l.). The calculated tidal volume was 227–2258 ml (mean of individual means, 750 ml).

Measurements were recorded from fifteen patients in second-stage labour. The results were as follows:

- Number of contractions observed: 1–24 (mean 10.6).
- Duration of contractions: 20–120 seconds (mean of means 46 seconds).
- Number of respirations during each contraction: 3–47 (mean of means 15).
- Maximum peak inspiratory flow rates: 30–300 l./min (mean of means 140.6 l./min).
- Volume of air inspired during a contraction: 1.4–48.0 l. (mean of means 11.9 l.).
- Calculated tidal volume: 104–3024 ml (mean of means 866 ml).

Observations were made on eleven patients whilst they were panting during the process of delivery. The volume of air inspired at this time ranged from 4.2 l. to 19.8 l. (mean 10.9 l.). The peak inspiratory flow rate ranged from 45 l./min to 300 l./min (mean of individual means 120 l./min).

Discussion.

In this part of the study there was little to be gained from trying to discriminate between the respective performances of primigravid and multigravid patients, nor could the possible influences of antenatal tuition, socio-economic and ethnic background, and drugs used during labour be assessed. However, the data can be used to provide a rough guide as to the volume of gas which a normal patient might require during a well-conducted labour, if it is assumed that under those conditions an inhalational analgesic is administered during at least the final hour of the first stage of labour, and throughout the second stage and during delivery. There will be approximately 17 first-stage contractions (lasting 33 seconds each, at 3-minute intervals), and 11 second-stage contractions (lasting 46 seconds, interval 2 minutes, duration second stage 30 minutes). Applying the mean results derived from this study, it may be suggested that the mean volumes of gas mixture inhaled will be:

<table>
<thead>
<tr>
<th>Stage</th>
<th>Volume (l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>during first stage</td>
<td>392.7</td>
</tr>
<tr>
<td>during second stage</td>
<td>130.9</td>
</tr>
<tr>
<td>during delivery</td>
<td>10.9</td>
</tr>
<tr>
<td>total</td>
<td>534.5</td>
</tr>
</tbody>
</table>

(b) STUDIES CARRIED OUT AT THE ABERDEEN MATERNITY HOSPITAL (M.E.T.)

The purpose was to give an idea of the amounts of premixed gas consumed by women in labour. The subjects were 144 patients being delivered in the three Maternity Homes of the City of Aberdeen who were expected to undergo spontaneous delivery with only midwives in attendance. The midwives in charge were told that it would be possible to commence the administration of nitrous oxide and oxygen at any time in labour without fear of cumulative effects.

Method.

Premixed nitrous oxide and oxygen, 50 per cent v/v, was provided in 2000-litre cylinders [mean contents 6 lb. 7 oz. (2920 g) of gas=1720 litres at NTP; contents range 5 lb. 151/2 oz. to 6 lb. 113/4 oz. (2797 to 3051 g)].

During use, the cylinders stood upright. The apparatus connected in sequence consisted of cylinder, demand valve, 3 ft. 6 in. of standard antistatic corrugated tubing, an expiratory valve and a facepiece.

The contents (pressure) gauges of the cylinders were calibrated in divisions of 100 Lb./sq.in. and the midwives recorded the readings to the nearest 25 Lb./sq.in. (each Lb./sq.in. was equivalent to 1 litre).

The decision as to when premixed gas should be administered to any given patient was in the hands of the midwives. A detailed form was completed by the midwives in each case.

In those cases where peak inspiratory flow (p.i.f.) was measured, the p.i.f. meter was connected to the demand valve by 1 foot of corrugated tubing before the 3 ft. 6 in. (106 cm) corrugated tubing connected to the expiratory valve and facepiece assembly. The demand valve used for the p.i.f. meter was the venturi-jet type which had a maximum inspiratory resistance of 2 cm H₂O pressure (measured at the inspiratory port) up to flows over 500 l./min (excluding flow
resistance of corrugated tubing). The p.i.f. meter was zeroed at the commencement of inhalational analgesia and not touched until the administration of gas was completed at the end of labour. The maximum inspiratory flow rate achieved during labour was therefore recorded.

**Results.**

(a) The number of cylinders used by patients in trial

Number of patients in trial 144

Average actual consumption was 516 l. of premixed gas per patient.

(b) Number of patients in trial, primiparae 63

Number of patients in trial, multiparae 81

Median consumption, primiparae patients (maximum 2580 l.) 516 l.

Mean consumption, primiparae patients

764 l.

Median consumption, multiparae patients (maximum 1740 l.) 215 l.

Mean consumption, multiparae patients

292 l.

(c) Maximum peak inspiratory flow rates (l./min) (35 cases):


**CONCLUSIONS TO BE DRAWN FROM THE TWO STUDIES**

There is reasonably good agreement in two areas of some importance. The peak inspiratory flow rate evolved by patients in labour quite commonly exceeds 250 l./min and it would be reasonable to require that apparatus designed for providing inhalational analgesia should be able to meet a demand rate of 350 l./min without the imposition of an embarrassing degree of resistance to inspiration. In domiciliary midwifery, two full 500-l. cylinders of premixed gas should be taken to conduct the delivery of a multigravid patient; for the primigravid patient three cylinders should be available.

**REFERENCES**


**NOTES AU SUJET DU RENDEMENT RESPIRATOIRE AU COURS DE L’ACCOUCHEMENT**

Des études indépendantes ont été faites à Aberdeen et Londres chez des patientes en couches? On a mesuré le flux respiratoire maximal, la fréquence respiratoire, le volume courant et le volume d’air inspiré durant les contractions et la délivrance. On a observé que le flux respiratoire maximal dépassait fréquemment 250 l/min, et occasionnellement dans la première partie du travail largement 300 l/min. On en déduit que 1500 litres de mélange gazeux doivent être disponibles pour l’analgésie chez une primipare et 1000 litres chez une multipare.

**BEMERKUNGEN ZUR ATMUNG WÄHREND DER WEHENTATIGKEIT**

In Aberdeen und London wurden bei in Wehen liegenden Patientinnen unabhängig von einander Untersuchungen durchgeführt. Gemessen wurden die höchste inspiratorische Gaszufuhr, die Atemfrequenz, das Atemvolumen und das Luftvolumen, das während der Kontraktionen und der Entbindung aufgenommen wurde. Es zeigte sich, daß die höchste inspiratorische Gaszufuhr häufig 250 l/min überschritt und im ersten Stadium der Wehen gelegentlich deutlich über 300 l/min betrug. Es wurde berechnet, daß zur Einleitung der Analgesie bei einer Erstgebärenden 1500 Liter Gasgemisch und bei einer Mehrgebärenden 1000 Liter Gasgemisch zur Verfügung stehen sollten.