THE CONCENTRATION OF OXYGEN REACHED IN OXYGEN TENTS

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Oxygen tents are now almost universally used in hospital nurseries, yet there seem to be few published figures giving the concentration of oxygen reached. The experiments described below have been done to determine these concentrations under controlled and reproducible conditions, such as are likely to be found in such nurseries. A standard Queen Charlotte type oxygen tent has been used throughout. The results obviously apply only to this type of tent, but as many nurseries use it the results may be widely applicable. The concentration of oxygen reached with different rates of flow, with the lid closed or open and with or without preliminary flushing of the tent with oxygen, has been estimated. In order to collect data for a number of different rates of flow it was decided to use a rabbit as experimental animal rather than try to collect samples from tents in the maternity department. Results obtained from tents in the hospital closely parallel those arrived at with the experimental tent.

Methods

The tent rested directly on a cot mattress covered with mackintosh, no special precautions being taken to avoid gas leakage. During the experiment an adult rabbit weighing 5 lb. 9 oz. (2.5 kg.) was kept in the tent to mix the contents by its movement and to reproduce the gaseous exchanges occurring in a tent containing a child. It was felt that the oxygen consumption and carbon dioxide production of such a rabbit would be greater than that of the average small baby.

The oxygen was introduced into the tent from an oxygen cylinder which had a flow-meter attached, and the cylinder was connected to the metal inflow pipe on the tent by means of a stout rubber tube. From a point as nearly as possible at the middle of the tent, samples were taken at intervals through a sampling port provided in the side wall, using a piece of glass capillary tube connected to rubber bellows. The samples were collected in rubber balloons and analysed in a standard Haldane gas-analysis apparatus, the accuracy of which was checked by the analysis of known gas mixtures.

The longest period for which a tent is likely to remain closed in clinical use is three hours, and in most instances sampling was stopped at that time, although with the higher rates of flow the oxygen concentration was still rising. Some experiments were continued longer in order to follow the progress of the changes.

Results

The results are expressed as graphs which show the oxygen concentrations reached within the tent under various conditions. Fig. 1 shows that, with the tent shut and without any preliminary flushing with oxygen, a flow of 1 litre of oxygen a minute through the tent gives a concentration of 70% oxygen after three hours. A flow of 3 litres a minute reaches 75% oxygen in one

hour and 84% after three hours. A flow of 4 litres a minute gives the very high concentration of 87% oxygen at one hour.

Fig. 2 shows the effect of a preliminary flushing with 6 litres of oxygen a minute for five minutes (a common practice in hospitals) on the concentrations reached with a flow of 1 litre a minute. Comparing Fig. 2 with curve A of Fig. 1, we see that flushing causes a rapid rise to about 75–80% oxygen in the tent, which is maintained so long as the tent is shut. A permanent increase from 70% to 80% is therefore produced by this preliminary flushing.

FIG. 1.—Tent shut. Steady flow of oxygen. Curve A=1 litre a minute. Curve B=2 litres a minute. Curve C=3 litres a minute. Curve D=4 litres a minute.

FIG. 2.—Tent shut. Oxygen flow at 6 litres a minute for 5 minutes, then maintained at 1 litre a minute (composite curve from three separate experiments).

FIG. 3.—Tent lid open 1 in. (2.5 cm.) at foot. Curve A= oxygen flow at 2 litres a minute. Curve B= oxygen flow at 6 litres a minute for 5 minutes, then maintained at 2 litres a minute.

Fig. 3 shows the effect of keeping the tent lid open 1 in. (2.5 cm.). This was done because it is not uncommon for tents to be used clinically in this way. In this case a flow rate of 2 litres of oxygen a minute gives a permanent concentration of 40–45% oxygen in the tent. Comparison with curve B of Fig. 1 shows that if the tent is shut a flow of 2 litres a minute gives a concentration of 70–75% oxygen in the tent. Therefore opening the lid 1 in. (2.5 cm.) almost halves the oxygen concentration at this rate of flow.

The concentrations of carbon dioxide are not shown on the graphs but were often estimated. Only once did the concentration of CO₂ in the tent rise above 0.1%—when the animal was particularly active and the CO₂ concentration rose to 0.2%.

These results can be compared with those of Mackenzie (1950), who, though mainly concerned with CO₂ levels in tents in clinical use, also estimated oxygen in a small number of cases. Though he made no estimations beyond the end of the first hour, the figures given for oxygen are similar to those reported here. There are considerable discrepancies between concentrations of CO₂ found in the tents in the two series of experiments, but this may be due to differences in the weight and general condition of the occupant. A large series of estimations of the gas concentrations in tents in clinical use is needed, as Mackenzie's figures for CO₂ are much higher than those I found in the relatively small number of tents examined in hospital.

Summary

The oxygen concentrations reached in a standard oxygen tent under controlled conditions and with varying rates of flow have been estimated.

An adult rabbit was used as experimental animal.

It would appear that high concentrations can readily be achieved with low rates of flow.

The CO₂ concentration rose above 0.1% on only one occasion.

I am grateful to Oxyginaire Ltd. for the loan of the oxygen tent used in these experiments.

REFERENCE

Mackenzie, A. (1950). *Lancet*, 1, 669.

Medical Memoranda

Rupture of Rectus Abdominis Muscle

Spontaneous rupture of the rectus abdominis muscle is a comparatively rare occurrence; therefore it is worth while to record four cases that have occurred in the practice of this hospital during the past five years. These are all the more unusual as each was quite independent of pregnancy.

The rarity of this catastrophe is such that Wahlgemuth could find only 127 cases in the literature up to 1923, and, later, Torpin (1943) collected 27 cases since 1900, but all these had occurred during pregnancy.

The aetiology of the condition is somewhat obscure, but it is well known that febrile diseases may be followed by muscle degeneration, and that with slight trauma superimposed this may lead to rupture of the muscle. Typhoid fever, influenza, and pneumonia are alleged to be prone to the complication of hyaline muscle degeneration, a condition which has become known as Zenker's degeneration.

Rupture of the rectus abdominis muscle usually occurs in the weakest portion of the muscle—that below the semicircular line of Douglas, where the aponeurotic sheath on the posterior surface of the muscle is absent, and where the only posterior support is the transversalis fascia. Rupture of the muscle itself and of the inferior epigastric vessels would appear to be two indistinguish-

able conditions, as it is not easy to see how one could occur to any extent without the other.

The most interesting feature is the difficulty in diagnosis. Three of the four cases described below were admitted and explored as "acute abdomens." Diagnosis is particularly difficult in the fat patient, who, incidentally, is much more liable to the condition. The haematoma in the abdominal wall is so tender to palpation and movement that the only sign likely to be of value—tensing the abdominal muscles to fix the mass—is outside the patient's power of co-operation because of intense pain.

Most cases are sent into hospital labelled as twisted ovarian cysts or degenerating uterine fibroids. A number of cases have been reported in young people as a result of indirect violence, such as jumping over a gate or scaling a wall. The following four cases all occurred during coughing.

Case 1

A married woman aged 51 was admitted to hospital on January 23, 1946, with a history of sudden severe pain in the left iliac fossa, present since a coughing bout 36 hours previously. There were no other abnormal symptoms referable to any system, but just before admission she had noticed a lump in the left abdomen. There was also a previous history of three caesarean sections.

On examination her general condition was quite good, with a temperature of 97° F. (36.1° C.) and a pulse of 72. Abdominal palpation revealed a hard, fixed, fairly well circumscribed tender swelling in the left iliac fossa. A provisional diagnosis of twisted ovarian cyst was made and laparotomy carried out. A huge haematoma in the left rectus muscle was found, with disruption of the muscle. A fluted drainage tube was left in the cavity after shelling out the clot, and the abdomen was closed and the rectus sheath sutured. Short-wave diathermy was applied to the abdomen each day, and the patient was discharged 16 days after operation. When she was seen several months later the scar was sound and no clinical abnormality could be detected in the lower abdomen. It is possible that the scars in the lower abdomen predisposed to the rupture.

Case 2

A married woman aged 60 was admitted to hospital on October 21, 1946, complaining of sudden pain in the right iliac fossa several hours previously. This came on in a coughing attack; the cough itself had been present for a month.

On examination she looked rather ill and shocked. Her temperature was 97.8° F. (36.6° C.) and pulse 104. The abdomen was rather obese, but a large tender hard mass could be readily felt in the right iliac fossa. There appeared to be no generalized peritoneal irritation. A diagnosis of twisted ovarian cyst was made and laparotomy performed. On opening the right side of the rectus sheath a large haematoma was found, with disruption of the lower abdominal musculature. The clot was evacuated, no active bleeding-point was seen, and the muscle sheath was closed round a fluted drainage tube. Post-operatively, a course of sulphadimidine and short-wave diathermy was given, and the patient was discharged on the 20th post-operative day. The wound was rather slow to heal, but several months later the whole condition had completely resolved.

Case 3

A married woman aged 65 was admitted to hospital on October 18, 1947, with a history of severe pain in the left lower abdomen for four days, beginning when she had a severe coughing attack. She had vomited several times, and had not had her bowels moved since the pain began. There was nothing else relevant in the history.