THE ABILITY OF MAN TO DETECT ADDED RESISTIVE LOADS TO BREATHING

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(Received 16 November 1970)

SUMMARY

1. Resistive loads were added to the airways of patients with tracheostomies; the patients were blindfolded and the loads introduced without their knowledge.
2. The ability to detect the loads was the same in a patient with C3 transection (chest wall and diaphragm disconnected from the brain) as in a control group of patients with no neurological lesion.
3. It is concluded that receptors in the chest wall and diaphragm are not involved in the genesis of the sensation by which added resistive loads are detected.

The addition of a resistive load to a subject’s airway produces a sensation, variously described as difficulty in breathing or a sense of resistance to breathing. The ability to detect the load when it is added without the subject's knowledge can be quantified (Bennett, Jayson, Rubinstein & Campbell, 1962).

In the present study we tested a patient with chest wall and diaphragm disconnected from the brain (C3 transection) to ascertain whether afferent information from these structures was involved in the genesis of the sensation.

All the studies were done in patients with tracheostomies in view of the fact that impaired thoracic detection may be completely masked by the upper airways (Noble, Eisele, Trenchard & Guz, 1970).

METHODS

Control patients
The control group consisted of five patients with permanent tracheostomies but only minimal airway disease.

Patient with cervical-cord transection
R.A., male aged 24, suffered a fracture dislocation of C2/3 resulting in a complete lesion.
below C3 segment. The chest wall and diaphragm were completely paralysed. He was studied 3 years after the injury and 2 years after cessation of intermittent positive pressure ventilation. At the time of study he could achieve a vital capacity of 820 ml by using his greatly hypertrophied sternomastoid muscles. The endtidal $P_{\text{CO}_2}$ during quiet breathing was 35 mmHg.

**Procedure**

Resistances consisting of wire gauze mesh were arranged in series. The mesh was 0.08 mm

![Diagram](image)

**FIG. 1.** (a) The ability to detect added resistive loads in a control group of patients breathing through cuffed tracheostomy tubes. (b) The ability to detect added resistive loads in a patient with high cervical-cord transection (chest wall and diaphragm disconnected from the brain) breathing through a cuffed tracheostomy tube. Cross-hatched area represents the range of results in the control patients (from a).
Sensation of resistance to breathing

thick with strands arranged in two directions at 90° to one another; the separation of the strands was 10 μm. The resistances were separated by sections of 4 cm diameter Perspex tube, each with a circular aperture of diameter 2.5 cm in which a rubber bung could be placed. There was a similar aperture between the most proximal resistance and the tracheostomy. When this aperture was open, there was no added resistance and the dead space was 80 ml; this was the arrangement during the control period. The remaining bungs were arranged in such a way that closing the proximal aperture caused the patient to breathe through from one to seven linear resistances in series.

Each resistance was presented six times in random order and % detection calculated in the manner described by Bennett et al. (1962).

Breaths were allowed to elapse between presentations. All studies where the subject gave more than two false positive signals were rejected.

RESULTS

The detection ability in the patient with C3 transection was within the normal range obtained from the control patients (Fig. 1).

DISCUSSION

We have previously shown that impaired ability to detect added resistive loads via a tracheostomy is completely masked by allowing the pressure changes to be transmitted to the upper airways (Noble et al., 1970). It is therefore imperative that the loads be applied directly to the trachea via a tracheostomy when an analysis of thoracic mechanisms of resistance detection is attempted. Further evidence is required from patients with tracheostomy and vagus nerve block or section.

The patient with C3 transection of the cervical cord had complete paralysis of the chest wall and diaphragm. His ability to detect added resistive loads via a tracheostomy was normal. Therefore receptors in the diaphragm and chest wall are not involved in the genesis of the sensation by which this patient detected the loads. A possible mechanism for detection in this patient might be afferent information arising from the sternomastoid muscles. However, the description of the sensation given by this patient was similar to that given by the controls, namely a sense of resistance felt in the chest. The only nerves connecting the chest to the brain in this patient are the vagi.

ACKNOWLEDGMENTS

We are grateful to Professor D. F. N. Harrison, Mr P. McKelvie and Mr H. B. Holden for permission to study patients under their care. The study was supported by a grant from the Chest and Heart association. M.I.M.N. was in receipt of a personal grant from the Wellcome Foundation.

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