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TEMPERATURE DIFFERENCES IN THE OESOPHAGUS

The Effects of Intubation and Ventilation

BY

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SUMMARY

Oesophageal temperature variations during anaesthesia were measured in a number of groups of adult patients. It was found that in the upper half of the oesophagus intubation and controlled ventilation produced a greater degree of cooling than spontaneous breathing through a face-mask. Partial withdrawal of the endotracheal tube resulted in an upward shift of the cooled segment. Reducing the controlled tidal volume increased the mean temperature at the tip of the endotracheal tube and in the related part of the oesophagus. Temperatures in the lower fourth remained stable and it is concluded that the sensing probe should be inserted at least 24 cm below the corniculate cartilages when measuring the oesophageal temperature during anaesthesia.

It has been shown that marked temperature differences can occur along the length and breadth of the oesophagus in the anaesthetized and intubated adult (Whitby and Dunkin, 1968). The lowest temperatures were always found in the upper half of the oesophagus, but the site of minimum temperature varied considerably in its distance from the glottis and bore no relationship to either the height of the patient or to the anatomical distance between the cricoid cartilage and the xiphisternum. In the ten cases in which the minimum temperature was checked radiologically, it varied considerably in its vertebral level, but was always either opposite or a few centimetres below the lower end of the endotracheal tube.

Small temperature swings occurring in time with the respiration were occasionally seen in the neighbourhood of the minimum temperature point, particularly when a slow rate of controlled ventilation was being combined with a high tidal volume. The variations were of the order of 0.1°–0.2°C. Sometimes the temperature fell with inspiration, at others it rose and both types of variation have been seen at different levels in the same case.

The temperature patterns obtained in these cases were quite different from those found by Cranston, Gerbrandy and Snell (1954) in conscious adults breathing through the nose; they demonstrated a small but steady rise in temperature from the upper to the lower end of the oesophagus. They also found that spontaneous hyperventilation produced an appreciable drop in temperature in the upper half of the oesophagus.

For these reasons it seemed probable that the low temperatures recorded in the upper half of the oesophagus, in cases not being subjected to deliberate hypothermia, were respiratory in origin. It also seemed possible that the site of minimum temperature might depend largely on the distance of insertion of the endotracheal tube and on the direction in which the terminal bevel was pointing.

METHODS AND RESULTS

Effect of intubation.

To test the effect of intubation, oesophageal temperatures were taken at 1 cm intervals from 6 to 19 cm below the corniculate cartilages in sixty adults undergoing neurological operations, using an Ellab multi-lead thermocouple. Twenty cases were unintubated and breathing spontaneously, twenty intubated and breathing spontaneously, and twenty were intubated and artificially ventilated. Spontaneous ventilation was through a Magill circuit (system A; Mapleson, 1954) with a fresh

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gas flow of 10 l./min. For controlled ventilation a Blease ventilator was used at a minute volume of 9–12 l./min; carbon dioxide absorption was not used.

When possible, readings were taken after forty-five minutes anaesthesia. In ten of the unintubated cases the duration of the operation did not permit this and readings had to be taken after between twenty and forty minutes anaesthesia. These ten cases were matched against corresponding cases in each of the other two groups in which readings were taken at identical times.

The unintubated cases showed much smaller variations in temperature than the intubated, and the site of minimum temperature tended to occur at a higher oesophageal level (table I).

TABLE I

Longitudinal temperature differences in the oesophagus between 6 and 19 cm below the corniculate cartilages in intubated and unintubated patients.

	Cases intubated		Cases not intubated
	Controlled ventilation	Spontaneous respiration	Spontaneous respiration
Number of patients	20	20	20
Maximum temperature difference (°C)	4.6	4.1	1.8
Mean temperature difference (°C)	2.4	2.0	0.8
Range of site of minimum temperature point (cm)	7–15	7–15	6–10
Mean level of minimum temperature point (cm)	10	10	7

Effect of position of the endotracheal tube.

The effect of changing the position of the endotracheal tube was investigated in ten cases subjected to controlled ventilation. The tube was inserted 10 cm below the corniculate cartilages and withdrawn to 6 cm after forty-five minutes anaesthesia. Oesophageal temperatures were taken at 1 cm intervals between 6 and 19 cm below the cartilages with the multi-lead thermocouple. Readings were taken immediately before and five minutes after the withdrawal.

Withdrawal of the tube always produced an upward movement of the minimum oesophageal temperature point (e.g. fig. 1). This shift varied between 1 cm and 5 cm (mean 3 cm). At 19 cm the temperature remained unchanged in eight cases, fell 0.1° C. in one case and rose 0.5°C. in the remaining case in which the minimum temperature point before withdrawal had been at 17 cm.

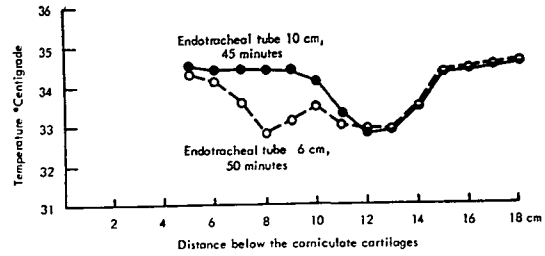

FIG. 1

Effect on oesophageal temperatures of withdrawing endotracheal tube from 10 cm to 6 cm below the corniculate cartilages. Lumbar laminectomy, controlled ventilation, readings after 45 and 50 minutes anaesthesia.

Effect of tidal and minute volumes on intratracheal gas temperatures.

Gas temperatures were taken from the lower end of the endotracheal tube in twenty cases in whom ventilation was controlled. An Ellab type F6 thermocouple lead was bound to the outside of the tube and threaded through a hole in the wall of the terminal unarmoured part of the tube so that the recording tip lay inside the lumen of the bevel.

Readings were taken after forty-five minutes anaesthesia with the tidal volume set at 1000 ml and at a cycle rate of 10/min. The tidal volume was then reduced to 500 ml by decreasing the inspiratory pressure and further readings taken after three minutes of reduced ventilation. Reducing the tidal and minute volumes produced a rise in both inspiratory and expiratory temperatures in all cases, the mean increases being 1.4° and 0.7°C. respectively (table II).

TABLE II

Readings taken from the lower end of the endotracheal tube during controlled ventilation; 20 patients.

		Tidal volume	
		1000 ml	500 ml
Inspiratory temperature (°C)	Range	26.0–32.0	27.4–33.3
	Mean	29.7	31.1
	SD	1.9	1.7
Expiratory temperature (°C)	Range	30.8–33.8	31.6–34.5
	Mean	32.2	32.9
	SD	0.9	0.8

Effect of tidal and minute volumes on oesophageal temperatures.

The effect produced on the oesophageal temperature by changing the tidal and minute volumes was investigated in 21 intubated adult cases on controlled ventilation. The endotracheal tube, fitted with a thermocouple lead projecting into the lumen of the bevel as before, was inserted 6 cm below the corniculate cartilages. Single lead oesophageal thermocouples were inserted 10 and 24 cm below the cartilages. The tidal volume on the ventilator was set at 1000 ml. Temperature readings were taken after thirty, forty-five and sixty minutes anaesthesia. After each set of readings, the tidal volume was reduced to 500 ml for three minutes and a further set of readings taken at the end of each period of reduced ventilation. The reduction of tidal and minute volumes produced a small rise of temperature of from 0.1 to 0.7°C. (mean 0.3°C.) in fifty-nine of sixty readings taken at the 10 cm level, but did not produce any directional change at the 24 cm level. The variations in temperature produced at the 10 cm level followed those recorded at the tip of the endotracheal tube (e.g. fig. 2). The result from one case was discarded because, although the expected increases did occur at the 10 cm level when the tidal volume was decreased, the temperature was rising slowly throughout at both upper and lower oesophageal levels, even when the higher tidal volume was being used.

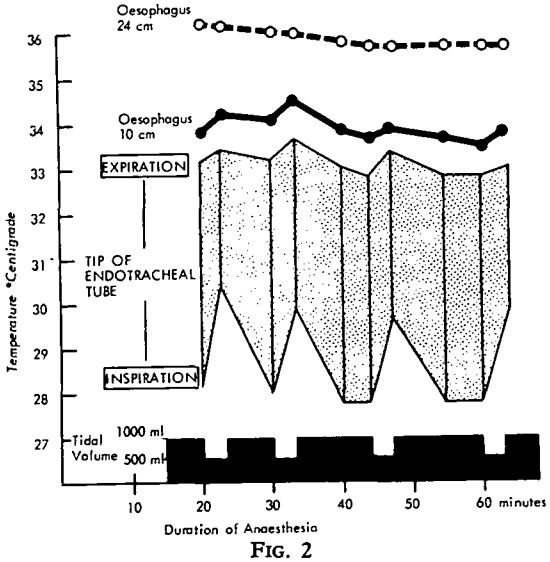

FIG. 2

Effect on oesophageal and tracheal temperatures of reducing tidal and minute volumes. Lumbar laminectomy, controlled ventilation, endotracheal tube inserted 6 cm and oesophageal thermocouple leads 10 and 24 cm below the corniculate cartilages.

DISCUSSION

There is no doubt that intubation affects temperatures in the upper half of the oesophagus by bypassing the normal warming and humidifying mechanisms of nose and pharynx and delivering cold, dry gases directly into the trachea. The level at which this effect is maximal depends on the distance the endotracheal tube is inserted and possibly also on the direction in which the terminal bevel is pointing. The fact that withdrawing the tube 4 cm did not always produce an equal degree of movement of the minimum oesophageal temperature point may have been due to some unavoidable rotation of the tube during withdrawal.

The degree of oesophageal cooling produced must depend on the quantity of gas being delivered, its temperature as it issues from the lower end of the tube and on the degree of insulation afforded by the tissues between the trachea and the oesophagus. The values that we obtained for intratracheal temperatures are in general consistent with those obtained by Dery and his co-workers (1967) but are not strictly comparable as they were using carbon dioxide absorption and were taking their readings from a point 4 cm below the end of the tube. This may explain why we differed from Dery and associates in finding that alterations in the tidal and minute volumes produced appreciable changes of intratracheal temperature during the expiratory phase.

We conclude that temperatures in the upper half of the oesophagus in the anaesthetized patient are affected by intubation and ventilation: those taken in the lower fourth are not. To ensure complete immunity from respiratory effects, it is recommended that oesophageal temperature leads should be inserted 24 cm below the corniculate cartilages.

ACKNOWLEDGEMENTS

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RÉFERENCES

Cranston, W. I., Gerbrandy, J., and Snell, E. S. (1954). Oral, rectal and oesophageal temperatures and some factors affecting them in man. *J. Physiol.*, **126**, 347.

Dery, R., Pelletier, J., Jacques, A., Clavet, M., and Houde, J. J. (1967). Heat and moisture patterns in the respiratory tract during anaesthesia with the semi-closed system. *Canad. Anaesth. Soc. J.*, **14**, 287.

Mapleson, W. W. (1954). The elimination of rebreathing in various semi-closed anaesthetic systems. *Brit. J. Anaesth.*, **26**, 323.

Whitby, J. D., and Dunkin, L. J. (1968). Temperature differences in the oesophagus. *Brit. J. Anaesth.*, **40**, 991.

DIFFERENCES DE LA TEMPERATURE DANS L'OESOPHAGE

SOMMAIRE

Les variations de la température dans l'oesophage au cours de l'anesthésie ont été mesurées dans un nombre de groupes de patients adultes. On a constaté que l'intubation et la ventilation contrôlée produisent dans la partie supérieure de l'oesophage un refroidissement plus marqué que la respiration spontanée à travers un masque facial. Le retrait partiel du tube endotrachéal cause un déplacement vers le haut du segment refroidi. La réduction du volume inspiratoire contrôlé augmente la température moyenne au bout du tube endotrachéal et dans la partie correspondante de l'oesophage. Les températures dans le tiers inférieur demeurent constants et on en conclue que la sonde de mesure doit être placée au moins 24 cm endessous du cartilage corniculé lorsqu'on veut mesurer la température de l'oesophage durant l'anesthésie.

TEMPERATURUNTERSCHIEDE IM ÖSOPHAGUS

ZUSAMMENFASSUNG

Während der Narkose wurden die Temperaturschwankungen im Bereich des Ösophagus bei einer Anzahl von erwachsenen Patientengruppen gemessen. Es wurde festgestellt, daß in der oberen Hälfte des Ösophagus durch Intubation und kontrollierte Ventilation ein stärkerer Grad von Abkühlung verursacht wird als unter Spontanatmung durch eine Gesichtsmaske. Partielles Zurückziehen des endotrachealen Tubus resultierte in einer Aufwärtsverlegung der abgekühlten Segmente. Herabsetzung des kontrollierten Atemvolumens erhöhte die mittlere Temperatur an der Spitze des endotrachealen Tubus und in dem entsprechenden Teil des Ösophagus. Im unteren Teil des Ösophagus blieben die Temperaturen stabil; daraus ergibt sich, daß bei Messungen der Ösophagustemperatur unter der Narkose die temperaturempfindliche Meßsonde mindestens bis 24 cm unterhalb des Cartilago corniculata eingeführt werden sollte.