OESOPHAGEAL TEMPERATURE DIFFERENCES IN CHILDREN

BY

J. D. WHITBY AND L. J. DUNKIN

SUMMARY

Longitudinal oesophageal temperature differences were measured in 160 anaesthetized and intubated children. All showed an area of ventilatory cooling similar to that already reported in adults. It is suggested that oesophageal temperature probes should be inserted a distance of \(10 + \frac{2 \times \text{age in years}}{3}\) cm below the corniculate cartilages, but that readings should be taken up to 2 cm above and below this point before fixing to confirm that the lead is below the area affected by ventilation. For infants, a lead packed off at the back of the pharynx 2 cm above the corniculate cartilages proved sufficiently accurate for routine monitoring.

It has been shown that the temperature of the oesophagus in the anaesthetized and intubated adult is not uniform along its length. There is an area below the distal end of the endotracheal tube that is affected by ventilation and the temperature of the inspired gases. This area does not extend into the lowest quarter of the oesophagus (Stupfel and Severinghaus, 1956; Whitby and Dunkin, 1963, 1969).

The purpose of this paper is to demonstrate that similar oesophageal temperature differences are found in children and to suggest a rough guide as to how far an oesophageal temperature probe should be inserted if these misleading ventilatory effects are to be avoided. An opportunity has also been taken of comparing pharyngeal and lower oesophageal temperatures in infants.

LENGTH OF THE OESOPHAGUS IN CHILDREN

The only figures available for the length of the oesophagus in children at various ages are those given by Jackson (1950) and by Bossy, de Collongny and Katz (1964). A linear scale of 10 cm at birth plus \(\frac{4}{3}\) cm for each year of life approximates closely to their measurements (e.g. fig. 1). If this formula is used and the distance of insertion is measured from the corniculate cartilages instead of from the cricoid origin of the cricopharyngeus muscle or the lower border of the cricoid cartilage, one would expect the recording point to lie a distance above the cardia approximately equal to the length of the posterior wall of the cricoid cartilage.

![Fig. 1](image-url)

A comparison between the figures given by Jackson (1950) and by Bossy et al. (1964) for the length of the oesophagus in children and the suggested distance for insertion of thermocouple leads below the corniculate cartilages, namely \(10 + \frac{2 \times \text{age in years}}{3}\) cm.
METHODS AND RESULTS

Oesophageal temperature patterns.

Using this formula to determine the depth of the probe insertion, temperatures were measured along the length of the oesophagus in 160 children anaesthetized and intubated for neurosurgical procedures. An Ellab fifteen-lead thermocouple (Whitby and Dunkin, 1968) was used in all except six neonates, in whom a single lead was inserted and then withdrawn 1 cm at a time. In these six cases, difficulty had been encountered in trying to insert the multi-lead probe the required distance, either because of its slightly greater bulk or because of the blind end that projects 2 cm below the lowest recording ring. Readings were taken after 45 minutes anaesthesia.

The children were divided into four age groups: (A) neonates; (B) 1 to 11 months; (C) 1 to 5 years; (D) 6 to 12 years.

All children in the first two groups were allowed to breathe spontaneously through the Rees modification of the Ayre T-piece system (Ayre, 1937, 1956; Rees, 1950). In the last two groups, some were allowed to breathe spontaneously through the above T-piece system or through a Magill circuit (System A; Mapleson, 1954) and some were subjected to controlled ventilation using a Blease ventilator without carbon dioxide absorption.

The results are shown in table I. All cases showed similar oesophageal temperature patterns to those found in adults. Longitudinal temperature differences were usually smaller in infants under 1 year of age than in older children. Controlled ventilation without carbon dioxide absorption tended to produce bigger temperature variations than spontaneous ventilation.

<table>
<thead>
<tr>
<th>Group</th>
<th>Ventilation</th>
<th>Number of cases</th>
<th>Maximum temperature variation (°C)</th>
<th>Mean temperature variation (°C)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Spontaneous</td>
<td>37</td>
<td>1.3</td>
<td>0.8</td>
<td>0.05</td>
</tr>
<tr>
<td>B</td>
<td>Spontaneous</td>
<td>52</td>
<td>1.9</td>
<td>1.1</td>
<td>0.06</td>
</tr>
<tr>
<td>C</td>
<td>Spontaneous</td>
<td>34</td>
<td>3.0</td>
<td>1.8</td>
<td>0.09</td>
</tr>
<tr>
<td>D</td>
<td>Controlled</td>
<td>6</td>
<td>3.0</td>
<td>2.2</td>
<td>0.32</td>
</tr>
<tr>
<td>E</td>
<td>Spontaneous</td>
<td>16</td>
<td>2.7</td>
<td>1.7</td>
<td>0.11</td>
</tr>
<tr>
<td>F</td>
<td>Controlled</td>
<td>15</td>
<td>4.8</td>
<td>2.5</td>
<td>0.25</td>
</tr>
</tbody>
</table>

For explanation of groups see text.

Three cases not included in this table gave a straight line of temperature readings similar to those found in the unintubated adult and in each of them radiological examination showed that the tip of the endotracheal tube had entered the right bronchus and was pointing away from the oesophagus. All three had deformities of the thoracic cage and none of them showed any sign that intubation had impaired the air entry on the left side.

In five children, none of them neonates, the formula used placed the lowest recording ring up to 2 cm inside the area of ventilatory cooling, which depends partly on the distance of insertion of the endotracheal tube (Whitby and Dunkin, 1969) and can extend below the carina. The readings obtained were 0.4–0.8°C below the true lower oesophageal readings.

Vertebral levels.

In forty-four children the position of the recording ring at the chosen distance was checked radiologically (table II). The preferred level of between the upper border of the eighth dorsal vertebra and the lower border of the ninth was achieved in twenty-three cases. In thirty-six cases the ventilatory cooling area ended at or above the sixth dorsal vertebra; in two cases it extended as far as the upper border of the eighth.

Pharyngeal temperatures.

When the multi-lead probe was used in infants in groups A and B, several of the recording rings lay in the pharynx. In sixty-one of these cases, temperatures were taken from the ring packed off at the back of the pharynx 2 cm above the corniculate cartilages. The temperature here closely reflected that in the lower oesophagus at the
OESOPHAGEAL TEMPERATURE DIFFERENCES IN CHILDREN

TABLE II

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of cases</th>
<th>Dorsal vertebral level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Highest</td>
<td>Lowest</td>
</tr>
<tr>
<td>A</td>
<td>8</td>
<td>8-9</td>
</tr>
<tr>
<td>B</td>
<td>15</td>
<td>6</td>
</tr>
<tr>
<td>C</td>
<td>14</td>
<td>6</td>
</tr>
<tr>
<td>D</td>
<td>7</td>
<td>7</td>
</tr>
</tbody>
</table>

recommended distance of insertion. In twenty-one cases the readings were identical. In thirty-five
the pharyngeal temperature was a little lower than the lower oesophageal, the maximum difference
being 0.4°C and the mean difference 0.2°C. In five cases the pharyngeal temperature was higher
than the oesophageal, the maximum difference being 0.5°C and the mean 0.2°C.

DISCUSSION

No formula for calculating the distance of insertion of oesophageal probes in children can
be expected to give a constant vertebral level in every case. Although the formula suggested will
usually place the recording lead below the area affected by ventilation, it is advisable to confirm
this by recording temperatures up to 2 cm above and below the estimated level, as suggested by
Hercus, Cohen and Bowring (1959), before fixing.

The fact that the temperature differences were less marked in the infants under 1 year of age
can probably be attributed to their smaller tidal and minute volumes. A completely straight line
of temperature recordings that indicates no area of cooling may mean that the tip of the endo-
tracheal tube has entered the right bronchus.

The lower pharynx seems to be a sufficiently accurate site for routine temperature monitoring
in anaesthetized and intubated infants, provided that the lead is adequately packed off and com-
pletely excluded from both inspired and expired gases and the ambient air. It is certainly prefer-
able to a lead in that part of the oesophagus being subjected to ventilatory effects.

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DIFFERENCES DE TEMPERATURE
OESOPHAGIENNE CHEZ LES ENFANTS

Les différences longitudinales de la température
oesophagienne ont été mesurées chez 160 enfants
anesthésiés et intubés. Tous ont présenté une région de
refroidissement respiratoire, similaire à celle rapportée
déjà chez les adultes. Les auteurs proposent de placer
la sonde de température oesophagienne à une distance
de 0.5 cm en-dessous du cartilage
cornici, mais de faire une lecture de la température
avant le fixation de la sonde 2 cm au-dessus et en-
dessous de ce point, afin de certifier que le repère se
trouve en-dessous de la région affectée par la ventila-
tion. Chez les petits enfants, un repère placé 2 cm
au-dessus du cartilage corniculé à la face postérieure
cur pharynx s’est avéré suffisamment exact pour un
monitoring de routine.

TEMPERATURUNTERSCHIEDE IM
ÖSOPHAGUS BEI KINDERN

ZUSAMMENFASSUNG

Bei 160 anästhesierten und intubierten Kindern wurden
die longitudinal im Oesophagus auftretenden Tempera-
unterschiede gemessen. Bei allen ergab sich ein
durch die Atmung bedingter kühler Bereich, wie er
bereits bei Erwachsenen beschrieben wurde. Es wird
empfohlen, daß die Temperatursonden im Oesophagus
bis zu einer Länge von \(10 \times \frac{2}{3} \times \text{Alter in Jahren} \)
unterhalb der Cartilagines corniculates eingeführt
werden sollten. Um die genauen Temperaturunter-
schiede festzustellen, sollte jedoch 2 cm über und unter
diesem Punkt die Temperatur abgelesen werden, damit
man Sicherheit erlangt, daß die Spitze der Sonde sich
unterhalb des durch die Atmung betroffenen Bereiches
befindet. Bei Säuglingen erwies sich eine Sondentippe,
die an der Hinterwand des Pharynx 2 cm über den
Cartilagines corniculatas lag, ab ausreichend, um die
durch die routinemäßige Überwachung erforderliche
Genauigkeit in der Temperaturentmessung zu erreichen.