diffuse across the amnion and chorion from maternal blood and through the substance of the umbilical cord. Since the amniotic fluid pH (7.14) was found to be lower than that observed in blood, there may be a tendency for mepivacaine to be trapped in this compartment. The low pH of the amniotic fluid may reflect the influence of the acidic urine of the baby.

In view of the evidence that the fetus swallows amniotic fluid, mepivacaine may have been ingested by the fetus. The significant correlation between the levels of local anesthetic in the gastric content and amniotic fluid could possibly imply this. The finding of marked concentration of mepivacaine and low pH in the gastric content also suggests that the drug may have been trapped here after diffusing across the stomach from the fetal circulation.

Finally, it is interesting to postulate that the significant correlations observed between drug levels from the different sites might indicate a circle of distribution for weak bases such as mepivacaine in the fetal–maternal unit. The drug may be excreted or diffuse into the amniotic fluid, be swallowed, pass into the small intestine where the pH is alkaline, be reabsorbed into the splanchnic circulation, pass to the liver and systemic circulation, and then be excreted by the fetal kidneys, etc.

In summary, mepivacaine can be found in amniotic fluid following maternal epidural anesthesia for labor and delivery. Fetal micturition appears to be a major source of this drug in amniotic fluid.

REFERENCES

End-tidal Halothane Concentration for Endotracheal Intubation

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The technique of inducing general anesthesia solely with an inhalation agent is frequently employed in pediatric patients. With sufficient anesthetic depth, tracheal intubation may also be accomplished. Presently, the adequacy of anesthesia for intubation is a subjective evaluation. The minimum alveolar concentration (MAC) value of an anesthetic affords an estimate of the relationship between depth of anesthesia and the response to surgical incision. Utilizing methods similar to those for obtaining MAC, we attempted to determine the end-tidal halothane concentration necessary for a safe tracheal intubation. We have defined this value as that end-tidal concentration of a gas or vapor needed by 50 per cent of the population to prevent all movement both during and immediately after endotracheal intubation (MACED).

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METHODS

Thirty-seven studies were performed in 27 ASA I surgical patients, aged 2 to 6 years. Informed consent regarding the nature and risks of the study was obtained from the parent or guardian of each participant. Premedication consisted of atropine, 0.015 mg/kg. A precordial stethoscope was used to monitor heart and breath sounds. Blood pressure was measured indirectly, and lead II of the electrocardiogram was continuously displayed. Body temperature was monitored with a rectal thermistor. Induction of anesthesia was accomplished with halothane, 2–2.5 per cent, and oxygen, (5 l/min) delivered from a Fluomatic vaporizer through a Jackson-Rees modification of an Ayres T-piece. The accuracy of gas concentrations produced by the vaporizer had been previously verified by calibration with a Varian 1400 gas chromatograph. Inspired and expired halothane concentrations were continuously monitored with a Beckman LB II infrared gas analyzer, sampling at a rate of 500 ml/min. The infrared analyzer was calibrated with the Fluomatic vaporizer before each trial. The effect of this sampling rate on the accuracy of
gas measurements was tested by withdrawing arterial blood samples from three subjects immediately after successful intubation with end-tidal halothane concentrations of 1.2, 1.4, and 1.6 per cent. Gas chromatographic analyses (n-heptane extraction method) of these arterial blood samples were performed. Conversion of the results to equivalent per cent vapor values yielded end-tidal-to-arterial blood content differences of 8 per cent or less.

Halothane concentrations were recorded at three sites. First, measurement of the inspired halothane concentration was made at the fresh-gas outflow port of the vaporizer. Next, an estimate of the end-tidal concentration was obtained by sampling at a point in the corrugated tube 5 cm distal to the inflow of fresh gas. Last, in the patient whose trachea was successfully intubated, the end-tidal halothane concentration was corroborated by gas analysis through a catheter inserted to 2 cm from the distal end of the endotracheal tube. There was no significant difference between samples obtained from the latter two sites. Therefore, when conditions were such that an endotracheal tube could not be inserted, the externally measured value for end-tidal halothane concentration was used to determine MAC_{50}.

Six end-tidal halothane concentrations were studied: 0.8, 1.0, 1.2, 1.4, 1.6 and 1.8 per cent. Some patients were tested with more than one concentration. However, no patient was exposed to more than two test concentrations during the same procedure, and none of the test concentrations was administered more than once to the same patient. After induction, the randomly-selected end-tidal concentration was approached by slowly decreasing the inspired concentration. Respirations were controlled manually with large tidal volumes. The estimated end-tidal concentration was established at the desired value (±0.05 per cent), and maintained for 10 minutes to allow equilibration of cerebral and arterial blood-gas tensions. Endotracheal intubation was then attempted. The process of intubation was evaluated in two phases. First, the adequacy of conditions for laryngoscopy was observed. Such conditions were defined as 1) easy visualization of the glottis, 2) relaxation of the vocal cords, and 3) absence of extremity movement. Second, the incidence of coughing, or "bucking," immediately after an otherwise successful intubation was recorded. Logit analyses of responses to the two phases of intubation were performed. End-tidal halothane concentrations producing adequate conditions for the first and second phases of intubation were differentiated by assigning the designation MAC_{et} and MAC_{eb}, respectively.

RESULTS

Table 1 shows mean values, at each sampling site, for the six end-tidal concentrations tested. Curves

Table 1. Mean Halothane Concentrations in Each Group, and Percentages of Patients Moving during and after Intubation

<table>
<thead>
<tr>
<th>Number of Trials</th>
<th>Halothane Concentration (Per Cent)</th>
<th>Patients Moving (Per Cent)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inspirial measured in Nonbreathing Apparatus</td>
<td>Measured through Catheter in Endotracheal Tube</td>
</tr>
<tr>
<td>3</td>
<td>0.90 ± 0.01</td>
<td>0.80 ± 0.01</td>
</tr>
<tr>
<td>6</td>
<td>1.11 ± 0.03</td>
<td>1.00 ± 0.02</td>
</tr>
<tr>
<td>8</td>
<td>1.30 ± 0.03</td>
<td>1.21 ± 0.03</td>
</tr>
<tr>
<td>7</td>
<td>1.55 ± 0.10</td>
<td>1.42 ± 0.06</td>
</tr>
<tr>
<td>10</td>
<td>1.80 ± 0.11</td>
<td>1.66 ± 0.05</td>
</tr>
<tr>
<td>8</td>
<td>2.65 ± 0.01</td>
<td>1.80 ± 0.02</td>
</tr>
</tbody>
</table>
plotted on the basis of logit analyses of responses
in this patient population (fig. 1) revealed that MAC_EI
is 1.12 per cent; MAC_EII is 1.46 per cent. Based
on the individual slope equation, MAC_EII for 95 per
cent of this population equals 1.91 per cent. These
investigations were performed at an altitude of ap-
proximately 760 m (2,500 ft), while traditional MAC
values have been determined at essentially sea level.
After appropriate barometric corrections, MAC_EII at
sea level is calculated to be 1.33 per cent.

**DISCUSSION**

An inhalation induction often avoids the potential
psychologic trauma associated with venipuncture in a
child. However, proceeding to attempt tracheal in-
tubation with possibly insufficient anesthesia may re-
result in failure to visualize the cords, laryngospasm,
and excessive coughing or “bucking” after successful
insertion of the tube. Such clinical signs as fixed
and slightly dilated pupils, relaxation of the jaw,
and diaphragmatic breathing are usually imprecise
endpoints, and hardly apply with modern anesthetic
agents. In this study, using methods analogous to those for determining MAC, we have established
an estimate of the alveolar halothane concentration
necessary to prevent movement completely during
tracheal intubation in 50 per cent of children aged
2–6 years (MAC_EII). The homogeneity of anes-
thetic concentrations within each group (table 1) is
evidenced by the low standard deviations. The mean
ratios of inspired to end-tidal halothane concentra-
tions ranged from 1.10 to 1.18. These ratios agree
comfortably with those obtained by Gregory and
Nicodemos in previous MAC studies. The proximity of these ratios to unity suggests the absence of signif-
icant ventilation–perfusion abnormalities, which
would interfere with the accuracy of end-tidal gas
determinations. MAC was not determined in this
study; however, the aforementioned works by Greg-
ory and Nicodemos suggest MAC values ranging
from 0.91 to 1.07 per cent for this age group.
Therefore, at sea level, MAC_EII is approximately 1.33
MAC.

MAC_EII is of clinical value, since there are a number
of surgical situations which would demand a level
of anesthesia that not only allows adequate conditions
for laryngoscopy, but also prevents subsequent cough-
ing or “bucking.” Mechanical stimulation of lower
tracheal or carinal reflexes caused by the endo-
tracheal tube or by the sudden, irritative flow of dry
gases to these areas probably produces such events.
According to the classic guidelines of Guedel, later
modified by Gillespie, abolition of tracheal and cari-
nal reflexes requires a depth of anesthesia greater
than that needed for routine surgery. Unlike MAC,
therefore, MAC_EII is not a _sine qua non_ for surgical
anesthesia. The extents of reflex suppression elicited
by different anesthetics may vary widely, despite the
presence of sufficient anesthetic depth for surgical
manipulation.

MAC_EII has utility as a guideline for performing
a specific task with certain anesthetic agents. Based
on results obtained with halothane, one might specu-
late that the MAC_EII’s for other agents should be
greater than, or at least equal to, MAC. It would
be of interest to investigate the constancy of the
MAC_EII-to-MAC ratio. The determination of MAC_EII
in addition to MAC would provide another dimension
to the analysis of relative drug potencies.

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**Ventriculobronchial Fistula Complicating Venticuloperitoneal Shunt**

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Hydrocephalus of varied etiology, such as meningoi-
dymyelocele, aqueductal stenosis, brain tumors, con-
genital anomalies, meningitis, and trauma, neces-
sitates shunting of cerebrospinal fluid (CSF). Since
the introduction of the ventriculoperitoneal shunt (VP shunt) by Kausch in 1905, numerous other methods
have been developed to drain the CSF. These methods
include ventriculoatrial, ventriculopleural, ventriculo-
gallbladder, ventriculoureteral and ventriculo-fallo-
opian shunts. However, today VP shunt is the pre-