CARDIAC RHYTHM IN DENTAL ANAESTHESIA: A COMPARISON OF FIVE ANAESTHETIC TECHNIQUES

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SUMMARY

A comparison was made of the frequency of occurrence of arrhythmias and of the quality of anaesthesia produced by five standard dental anaesthetic techniques, four inhalational and one intravenous. Arrhythmias occurred most frequently with halothane and trichloroethylene, significantly less frequently with divinyl ether and methoxyflurane, and did not occur with methohexitone. Apart from the high frequency of arrhythmias halothane was the only agent to provide, consistently, anaesthesia of acceptable quality.

The frequent occurrence of abnormalities of cardiac rhythm during dental anaesthesia with halothane is well documented (Kaufman, 1965, 1966; Rollason and Dundas, 1966, 1970; Tolas et al., 1967; Tuohy, 1968; Fisch et al., 1969; Ryder, 1970; Alexander, 1971; Thurlow, 1969, 1972). By contrast, such abnormalities appear to be relatively rare when intravenous methohexitone is used (Christensen, Hebert and Driscoll, 1961; Rollason, 1967; Shafto, 1969; Mann et al., 1971). However, available evidence suggests that this agent may have other undesirable effects on the heart and circulation (Christensen, Hebert and Driscoll, 1961; Shafto, 1969; Wise et al., 1969; Mann et al., 1971). Moreover, the operating conditions provided by intravenous methohexitone, particularly when more than one dose is necessary, are rarely as good as those provided by halothane. Therefore a clinical trial was designed to compare the effects of halothane and methohexitone on heart rate and rhythm and to seek an inhalation agent which would be a possible alternative to halothane and which would have less effect on heart rhythm while still providing adequate operating conditions.

METHOD

Five dental anaesthetic techniques were compared:

1. Nitrous oxide/oxygen/halothane (Fluothane)
2. Nitrous oxide/oxygen/trichloroethylene (Trilene)
3. Nitrous oxide/oxygen/divinyl ether (Vinstethene)
4. Nitrous oxide/oxygen/methoxyflurane (Penthrane)
5. Intermittent intravenous methohexitone (Brietal)

Each technique was investigated in turn. No attempt was made at patient selection. Whilst a particular technique was under investigation it was used on all patients attending the routine out-patient general anaesthesia sessions, at the Newcastle Dental Hospital, for extraction of teeth. All patients were considered medically fit for outpatient anaesthesia and were only excluded from the trial if they requested a form of anaesthesia different from the one currently being used. Consent was sought only for the application of e.c.g. leads since all five techniques were regarded as being standard and acceptable in clinical practice.

There was wide variation in the expertise and experience of the anaesthetists administering halothane. The trichloroethylene, divinyl ether and methoxyflurane anaesthetics were given by anaesthetists with wide experience in dental anaesthesia. The intravenous anaesthetics were given mostly by two consultant anaesthetists accustomed to this technique.

Anaesthesia was induced and maintained in all four inhalational series using a Walton Mk V demand-flow machine, the accuracy of which was checked frequently. A minimum inspired oxygen concentration of 20% by volume was used with halothane, trichloroethylene and methoxyflurane. To obtain adequate anaesthesia with divinyl ether in adult patients it was necessary to reduce the inspired

oxygen concentration to 15% by volume. In three adult patients in the methoxyflurane series and in five in the trichloroethylene one it proved impossible to produce adequate anaesthesia without recourse to either intravenous supplements or the introduction of halothane. These cases were not included in the trial. A Rowbotham trichloroethylene vaporizer with a gauze wick was used to vaporize divinyl ether and trichloroethylene. Calibrated draw-over vaporizers were used for halothane and methoxyflurane (Cyprane Ltd). The technique used for the intravenous series was that described by Shafto (1969), but extended to include patients of all ages. All patients were in the sitting position.

Electrocardiograph leads (lead I or lead II) were applied with the patient awake and a preanaesthetic recording was obtained. The e.c.g. was recorded continuously from then until the patient awoke at the end of the procedure. A radiotelemetry system (M&IE Ltd) was used to display the e.c.g. on an oscilloscope and to record it on magnetic tape for subsequent playback and detailed study. The second channel of the tape was used to record a time sequence and commentary of events.

The durations of anaesthesia, surgery and recovery times were measured with a stopwatch. Recovery time was measured as the time from withdrawal of the anaesthetic to the first positive response to a request to open the eyes. The Student t-test was applied to test the significance of differences between group mean values.

RESULTS

644 patients, 340 male and 304 female, were investigated and were distributed between the anaesthetic groups as shown in table I. Their ages ranged from 2 to 69 years but 65% were under 11 years old and less than 10% were over 35. All five series were similarly matched for both sex (table II) and age (table III).

Arrhythmias.

Heart rhythm was classified as abnormal if one or more beats originated outside the sinu-atrial node. The "arrhythmias", therefore, ranged from single nodal or ventricular extrasystoles to runs of abnormal rhythm of nodal, ventricular or mixed nodal and ventricular origin lasting for much of anaesthesia and surgery. Sinus tachycardia was not classed as abnormal.

Table IV shows the overall frequency of occurrence of arrhythmias in the five anaesthetic series. The use of both divinyl ether and methoxyflurane significantly reduced the frequency of occurrence of arrhythmias compared with the use of halothane (P<0.05). Arrhythmias occurred as frequently with trichloroethylene as with halothane (P>0.05). The complete absence of arrhythmias in the methohexitone series was both striking and significant (P<0.01).

Table V shows the types of arrhythmias encountered. In the halothane group ventricular abnormalities were in a majority. The two patients with heart block were clinically extremely ill. Their block was complete and persistent. This contrasts with the three patients in the methoxyflurane series who were clinically well and whose block was partial and transient.

The use of trichloroethylene resulted in an arrhythmia pattern not unlike that of halothane, although nodal rhythms were more common. In this, and in both the ether series, the nodal rhythms tended to be rapid and unstable and differed from those associated with halothane which tended to be slow and stable.

The use of divinyl ether produced mostly nodal rhythms. The ventricular arrhythmias varied from single ectopics to occasional short runs of multifocal beats.

The arrhythmia pattern with methoxyflurane was a predominantly ventricular one but there was a
TABLE III. Distribution of cases by age group. Percent values relate to each anaesthetic group.

<table>
<thead>
<tr>
<th>Anaesthetic technique</th>
<th>0-11</th>
<th>12-23</th>
<th>24-35</th>
<th>36-47</th>
<th>48+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrous oxide/oxygen/halothane</td>
<td>132</td>
<td>32</td>
<td>25</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Nitrous oxide/oxygen/trichloroethylene</td>
<td>86</td>
<td>19</td>
<td>12</td>
<td>1</td>
<td>0.8</td>
</tr>
<tr>
<td>Nitrous oxide/oxygen/divinyl ether</td>
<td>63</td>
<td>25</td>
<td>9</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Nitrous oxide/oxygen/methoxyflurane</td>
<td>83</td>
<td>12</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Intermittent methohexitone</td>
<td>74</td>
<td>14</td>
<td>19</td>
<td>2</td>
<td>1.75</td>
</tr>
</tbody>
</table>

TABLE IV. Frequency of occurrence of arrhythmias.

<table>
<thead>
<tr>
<th>Anaesthetic technique</th>
<th>Number of patients with arrhythmias</th>
<th>Percentage of patients in anaesthetic group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrous oxide/oxygen/halothane</td>
<td>71</td>
<td>33</td>
</tr>
<tr>
<td>Nitrous oxide/oxygen/trichloroethylene</td>
<td>37</td>
<td>31</td>
</tr>
<tr>
<td>Nitrous oxide/oxygen/divinyl ether</td>
<td>21</td>
<td>20.5</td>
</tr>
<tr>
<td>Nitrous oxide/oxygen/methoxyflurane</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>Intermittent methohexitone</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Pulse rates.

The mean maximum pulse rates before and during induction of anaesthesia and during surgery for the five groups are shown in table VII. The initial pulse rates were fast in the inhalational groups and changed little with anaesthesia and surgery. There was no statistical difference between the four inhalational techniques (P>0.05) at any stage. The initial pulse rates were slightly slower in the methohexitone groups, increasing significantly on induction (P<0.01) and with a further significant increase (P<0.05) during extraction. Induction and extraction pulse rates in this group were also significantly faster than in any of the inhalation groups (P<0.05).

Recovery times.

Table VIII shows the mean recovery times in the normal and abnormal rhythm groups in each series. The range of recovery times in each series was too wide for either statistical analysis or any important conclusion to be reached. However, there was a consistent pattern of slower recovery following arrhythmias in all groups.

TABLE V. Types of arrhythmia. Percent distribution in each anaesthetic group.

<table>
<thead>
<tr>
<th>Anaesthetic technique</th>
<th>A-V nodal rhythm</th>
<th>Single focus ventricular extrasystoles</th>
<th>Multifocal ventricular extrasystoles</th>
<th>Mixed nodal and ventricular rhythms</th>
<th>Heart block</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrous oxide/oxygen/halothane</td>
<td>31</td>
<td>38</td>
<td>14</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>Nitrous oxide/oxygen/trichloroethylene</td>
<td>46</td>
<td>29.5</td>
<td>11</td>
<td>13.5</td>
<td>0</td>
</tr>
<tr>
<td>Nitrous oxide/oxygen/divinyl ether</td>
<td>71.5</td>
<td>9.5</td>
<td>9.5</td>
<td>9.5</td>
<td>0</td>
</tr>
<tr>
<td>Nitrous oxide/oxygen/methoxyflurane</td>
<td>19</td>
<td>57</td>
<td>0</td>
<td>9.5</td>
<td>14.5</td>
</tr>
<tr>
<td>Intermittent methohexitone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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TABLE VI. Patients showing arrhythmia. Percent distribution related to time of onset.

<table>
<thead>
<tr>
<th>Anaesthetic technique</th>
<th>Time of onset</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Induction</td>
</tr>
<tr>
<td>Nitrous oxide/oxygen/halothane</td>
<td>41%</td>
</tr>
<tr>
<td>Nitrous oxide/oxygen/trichloroethylene</td>
<td>46%</td>
</tr>
<tr>
<td>Nitrous oxide/oxygen/divinyl ether</td>
<td>48%</td>
</tr>
<tr>
<td>Nitrous oxide/oxygen/methoxyflurane</td>
<td>45%</td>
</tr>
</tbody>
</table>

Tachycardia often associated with it is still a matter for concern. Reference has been made to other adverse effects of methohexitone on the cardiovascular and respiratory systems (Christensen, Hebert and Driscoll, 1961; Rowlands et al., 1967; Wise et al., 1969; Mann et al., 1971), to post-operative restlessness (Shafto, 1969) and to the possibility of difficult operating conditions. These undesirable effects are little in evidence following a single small dose but become more prominent with increasing dose and duration of anaesthesia.

Trichloroethylene has no advantage to offer over halothane other than low cost. Arrhythmias are no less frequent. It is difficult to vaporize in quantity and its weak anaesthetic properties and high solubility make the rapid production of deep and tranquil anaesthesia difficult or impossible.

The use of divinyl ether significantly reduces the frequency of occurrence of arrhythmias compared with halothane. Nevertheless, it is an extremely difficult agent to use. Salivation is often troublesome. Deep anaesthesia is difficult to produce, especially in large and strong adults, without resorting to concentrations of oxygen of less than 20% by volume. Divinyl ether has an unpleasant smell. Each time it was used our theatre staff complained bitterly of both the smell and prolonged headaches.

Methoxyflurane has been suggested as a useful alternative to halothane in dental anaesthesia (Unkles and Murray Lawson, 1965; Meyer, Allen and Hooley, 1966; Rogerson, Rooms and Sayburn, 1967; Allen, 1968). It certainly produced fewer arrhythmias than halothane. Moreover, these arrhythmias were usually of a very transient nature. The high boiling point, low volatility and high blood and tissue solubility of methoxyflurane, make it an unsatisfactory agent for dental anaesthesia. Salivation was a frequent and troublesome side effect. Over-optimistic judgement of the duration of surgery sometimes led to inadequate anaesthesia.

DISCUSSION

Although most arrhythmias occurring during dental anaesthesia are probably benign, sudden and unexpected deaths do occur from time to time. Severe acute arrhythmias as a cause of these fatalities can seldom be satisfactorily excluded. Bourne (1970) quotes details of sixteen dental anaesthetic deaths in supposedly fit patients. In four of these ventricular fibrillation was demonstrated on e.c.g., and in twelve of the sixteen no obvious cause of death was found at postmortem. Therefore an anaesthetic technique which minimizes or eliminates arrhythmias has much to recommend it.

Of the five techniques investigated in this study, intermittent intravenous methohexitone is clearly the best in this respect, although the supraventricular...
which could not be quickly or sufficiently deepened by the use of methoxyflurane. The theatre staff complained of headaches following a methoxyflurane session as they did with divinyl ether.

Obviously no wholly satisfactory inhalational alternative to halothane exists at the present time. Methohexitone, though superior to halothane in its anti-arrhythmic properties, is of doubtful advantage in other respects. Preliminary studies of the use of methohexitone to induce anaesthesia which is then maintained with halothane suggest that this may reduce the occurrence of arrhythmias as compared with halothane alone. This is now being investigated by us as a possible choice for those who wish to obtain the benefits of halothane but who are opposed to the use of oral practolol premedication (Ryder, Charlton and Wemyss-Gorman, 1973).

ACKNOWLEDGEMENTS
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REFERENCES