CURARE AS AN ADJUVANT TO ANÆSTHESIA IN MILITARY PRACTICE

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Curare in various preparations has been in use as an adjuvant to anaesthesia since 1942 [1]. Unfortunately, supplies were not available during the war to enable it to be tried out under active service conditions.

The series presented in this article is that of 100 cases operated on in a large military hospital in the United Kingdom under peacetime conditions.

The preparation used has been “Tubarine” (Burroughs Wellcome)—tubocurarine chloride—and a constant technique has been employed throughout, for the most part associated with major abdominal surgical procedures.

Although no elaborate discoveries are claimed in this article, it was thought worth while publishing this series; as each case was carefully controlled with a B.P., pulse-rate, respiration-rate record.

TECHNIQUES

ABDOMINAL OPERATIONS.—Premedication was by alopan grain 1/3 (22.0 mgm.) and scopolamine grain 1/150 (0.44 mgm.) given one and a half hours prior to operation.

Induction was by pentothal sodium 3 to 6 mils. in a 5 per cent solution, followed by cyclopropane and oxygen in a closed circuit. Endotracheal intubation was performed in all cases; usually by the nasal route.

Dosage of curare: 10 to 15 mgm. of tubarine (B.W.) depending on the weight and general physique of the patient, was given intravenously synchronous with the first incision, followed by 3 to 5 mgm. as required by the needs of the surgical procedures, and repeated if necessary.

The maximum dose used in any one patient was 29 mgm. and the average dosage for each surgical procedure is shown in the accompanying table.

BRONCHOSCOPY AND OESOPHAGOSCOPY (Premedication as above).—Induction with pentothal sodium 10 mils. of a 5 per cent solution, followed by additional pentothal sodium given slowly to produce deep anaesthesia, consistent with adequate respiratory exchange; this amount varying between a further 4 and 8 mils.

Tubarine (B.W.) was then given intravenously in a dosage of 2 mgm. per stone body-weight, closed-circuit apparatus being at hand for artificial respiration with oxygen, should apnoea or undue respiratory depression occur. As soon as full curarization was effected (three to five minutes after injection).
provided the respiratory excursion was satisfactory, the surgeon was allowed full access to the patient. Cocainization of larynx or pharynx was not employed.

**Course of Anaesthesia**

Respiratory depression was not a marked feature in this series, though typical jerky diaphragmatic respiration was observed in almost every case, and "aided" respiration was employed in all cases in which the respiratory exchange was judged to be below normal.

Full controlled respiration was required only in four cases, for periods of apnea varying from five to fifteen minutes.

In no case was it found necessary to employ prostigmine as a respiratory stimulant.

<table>
<thead>
<tr>
<th>Cases</th>
<th>Average No.</th>
<th>Average age</th>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
<th>Serious</th>
<th>Emergence</th>
<th>Average duration</th>
<th>Average dosage of tubarine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partial gastrectomy</td>
<td>12</td>
<td>41</td>
<td>6</td>
<td>4</td>
<td>2</td>
<td>—</td>
<td>—</td>
<td>117 minutes</td>
<td>21.0 mgm.</td>
</tr>
<tr>
<td>Partial perforated peptic ulcer</td>
<td>6</td>
<td>30</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>—</td>
<td>—</td>
<td>60 minutes</td>
<td>16.3 mgm.</td>
</tr>
<tr>
<td>Intestinal obstruction</td>
<td>7</td>
<td>29</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>—</td>
<td>—</td>
<td>62 minutes</td>
<td>17.0 mgm.</td>
</tr>
<tr>
<td>Gastro-enterostomy</td>
<td>1</td>
<td>30</td>
<td>—</td>
<td>—</td>
<td>1</td>
<td>—</td>
<td>—</td>
<td>85 minutes</td>
<td>15.0 mgm.</td>
</tr>
<tr>
<td>Laparotomy</td>
<td>12</td>
<td>32</td>
<td>4</td>
<td>6</td>
<td>2</td>
<td>—</td>
<td>—</td>
<td>46 minutes</td>
<td>15.0 mgm.</td>
</tr>
<tr>
<td>Vagotomy</td>
<td>1</td>
<td>20</td>
<td>1</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>40 minutes</td>
<td>20.0 mgm.</td>
</tr>
<tr>
<td>Herniotomy</td>
<td>2</td>
<td>48</td>
<td>2</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>45 minutes</td>
<td>10.0 mgm.</td>
</tr>
<tr>
<td>Hysterectomy</td>
<td>2</td>
<td>35</td>
<td>—</td>
<td>1</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>88 minutes</td>
<td>11.7 mgm.</td>
</tr>
<tr>
<td>Splenectomy</td>
<td>1</td>
<td>19</td>
<td>—</td>
<td>1</td>
<td>—</td>
<td>—</td>
<td>1</td>
<td>75 minutes</td>
<td>22.5 mgm.</td>
</tr>
<tr>
<td>Partial colectomy</td>
<td>2</td>
<td>20</td>
<td>1</td>
<td>—</td>
<td>1</td>
<td>—</td>
<td>—</td>
<td>120 minutes</td>
<td>11.0 mgm.</td>
</tr>
<tr>
<td>Cholecystectomy</td>
<td>2</td>
<td>25</td>
<td>1</td>
<td>—</td>
<td>—</td>
<td>1</td>
<td>—</td>
<td>65 minutes</td>
<td>15.0 mgm.</td>
</tr>
<tr>
<td>Nephrectomy</td>
<td>11</td>
<td>27</td>
<td>7</td>
<td>2</td>
<td>2</td>
<td>—</td>
<td>—</td>
<td>44 minutes</td>
<td>14.3 mgm.</td>
</tr>
<tr>
<td>Nephrolithotomy</td>
<td>4</td>
<td>26</td>
<td>3</td>
<td>1</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>60 minutes</td>
<td>15.0 mgm.</td>
</tr>
<tr>
<td>Ureterolithotomy</td>
<td>2</td>
<td>22</td>
<td>2</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>43 minutes</td>
<td>12.5 mgm.</td>
</tr>
<tr>
<td>Transplantation of ureter</td>
<td>2</td>
<td>51</td>
<td>—</td>
<td>2</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>38 minutes</td>
<td>10.0 mgm.</td>
</tr>
<tr>
<td>Prostatectomy</td>
<td>9</td>
<td>31</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>—</td>
<td>—</td>
<td>51 minutes</td>
<td>12.4 mgm.</td>
</tr>
<tr>
<td>Renal sympathectomy</td>
<td>4</td>
<td>24</td>
<td>4</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>63 minutes</td>
<td>15.7 mgm.</td>
</tr>
<tr>
<td>Lumbar sympathectomy</td>
<td>5</td>
<td>30</td>
<td>4</td>
<td>1</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>61 minutes</td>
<td>15.0 mgm.</td>
</tr>
<tr>
<td>Appendectomy</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>—</td>
<td>2</td>
<td>6</td>
<td>49 minutes</td>
<td>11.9 mgm.</td>
</tr>
<tr>
<td>Bronchoscopy</td>
<td>3</td>
<td>31</td>
<td>3</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>15 minutes</td>
<td>20.0 mgm.</td>
</tr>
<tr>
<td>Esophagoscopy</td>
<td>4</td>
<td>27</td>
<td>3</td>
<td>—</td>
<td>1</td>
<td>—</td>
<td>—</td>
<td>20 minutes</td>
<td>18.7 mgm.</td>
</tr>
<tr>
<td>Laryngoscopy</td>
<td>2</td>
<td>23</td>
<td>2</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>15 minutes</td>
<td>13.7 mgm.</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>—</td>
<td>27</td>
<td>15</td>
<td>3</td>
<td>24</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>
The plane of general anaesthesia in this series, excluding the endoscopies, was never below Upper Plane II of the third stage (Guedel), and the usual depth maintained was Lower Plane I.

Neither bronchospasm nor hypotension, as described by several authors, were encountered [2], [3].

In a few cases there appeared to be a tendency for the systolic blood pressure to rise during the later stages of a long operation, probably associated with inefficient ventilation and consequent CO₂ retention (Chart A).

**Chart A.**

**Operation.** Nephrectomy for traumatic rupture of hydronephrotic kidney. Note tendency for B.P. to rise during second half of the operation.

Recovery of consciousness was rapid, the pharyngeal reflex being present in nearly every case before the patient left the operating table; full consciousness was recovered in fifteen to thirty minutes after return to bed.

A marked feature in these cases was the fact that operative stimuli which normally would be expected to produce some degree of operative shock had little or no effect on the patient's condition as assessed from B.P., pulse, and respiratory rate record (Chart B). In general, operating conditions were excellent. Respiratory movements were minimal, relaxation was complete, oxygenation was full and bleeding was not increased.

**Post-operative Morbidity**

<table>
<thead>
<tr>
<th>Deaths</th>
<th>Respiratory, Major</th>
<th>Respiratory, Minor</th>
<th>Circulatory</th>
<th>Alimentary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nil</td>
<td>3</td>
<td>17</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
Curare as an Adjuvant to Anesthesia in Military Practice

Chart B.

Operation. Partial Gastrectomy. Note readings unaffected by operative stimuli (traction on the stomach, etc.)

Respiratory Complications.—(a) Major: Of these one was a post-operative bronchitis following operation for closure of a perforated gastric ulcer, in a patient who already had an acute coryza; the second was a local atelectasis following nephrectomy; and the third, bronchitis due to inhalation of vomitus after ureterolithotomy.

(b) Minor: These included upper respiratory catarrh, tracheitis, etc., all of mild degree.

Circulatory Complications.—Two cases showed evidence of circulatory collapse soon after return to bed, possibly due to the delayed onset of surgical shock following the cessation of the curarizing action of "Tubarine."

Both cases were treated by posture and the exhibition of vasopressor drugs, and showed complete recovery after two and a half hours.

Alimentary Complications.—Three cases developed post-operative ileus, one following laparotomy for acute intestinal obstruction, and two following partial gastrectomy: all made a full recovery. The incidence of post-operative vomiting was small.

Reasons for the Employment of the Cyclopropane—Curare Technique

Fakehany [4] states "Curare is most effective when combined with Cyclopropane."

This technique was employed by us for the following reasons:

The type of patient, the average being a young or middle-aged man of good
physique, who required a powerful anaesthetic agent to maintain even a constant light third stage anaesthesia. 90 per cent of these patients were heavy cigarette smokers.

The ease with which "controlled" or "aided" respiration can be employed.

The high percentage of oxygen in the mixture, ensuring full oxygenation at all times.

The ease with which the depth of anaesthesia can be controlled. This is of particular importance towards the end of a lengthy operation, when, in order to have a conscious patient with adequate respiratory function and a protective laryngeal reflex on return to bed, it is preferable to obtain relaxation by deepening the anaesthesia, rather than by the administration of more curare [5].

The low post-operative morbidity, particularly the low incidence of major respiratory complications which so commonly occur after abdominal operations in military patients, particularly heavy smokers.

**Contra-indications**

It is emphasized that this technique, or indeed any technique involving the use of curarizing agents, should never be attempted unless the anaesthetist is familiar with the use of "aided" and "controlled" respiration, and is equipped with adequate apparatus to enable him to perform this when required.

In our small experience we would like to sound a warning against the employment of curarizing agents in any case in which a steep Trendelenburg position is employed by reason of: The danger of adding severe respiratory embarrassment due to the posture to the respiratory depression inevitably associated with curare. The possibility of costo-clavicular compression of the brachial plexus from the employment of shoulder rests in a heavy patient in the presence of the extreme muscular relaxation produced by the curare.

**Other Curarizing Agents**

Myanesin (B.D.H. Ltd.) has been employed by us in nine recorded cases (not included in the above series), but its use was not found to be entirely satisfactory on account of:—

1. Variability of effect.

2. The need for repeated serial injections, often irksome to the surgeon.

3. One case of hæmoglobinuria occurred in the post-operative period and in view of the recent reports [6, 7] it was decided to discontinue the trial of this drug for the present.

**Summary**

A series of 100 cases is presented, in which curare was used as an adjuvant to anaesthesia.

Reasons are given for the employment of a constant technique in military practice.

Highly satisfactory operative conditions, rapid post-operative recovery, and a low post-operative morbidity are evident in this series.
A warning is given against the use of this anaesthetic technique by other than experienced anaesthetists, equipped with adequate apparatus.

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REFERENCES