IMMEDIATE CHANGES IN PLASMA POTASSIUM, SODIUM AND CHLORIDE CONCENTRATIONS INDUCED BY SUXAMETHONIUM

I. M. BALI, J. W. DUNDEE AND R. A. E. ASSAF

SUMMARY

Four groups of healthy female patients were anaesthetized with either thiopentone, Althesin or nitrous oxide–oxygen with and without halothane. The concentrations of the plasma electrolytes were measured before and at varying times up to 10 min after the administration of suxamethonium 1 mg/kg. A small, but significant, biphasic increase in plasma potassium concentration was found when suxamethonium was administered to patients in whom anaesthesia was induced with thiopentone, Althesin and nitrous oxide–oxygen. The initial increase in plasma potassium concentration was greater in the Althesin group than in the other two groups. A more delayed, but sustained, increase in plasma potassium concentration was found following induction with nitrous oxide–oxygen–halothane. There were no significant changes in the plasma concentrations of sodium or chloride except in the halothane–nitrous oxide–oxygen series.

A measurable increase in plasma potassium concentration in the first 5 min after the administration of suxamethonium was demonstrated first by Klupp and colleagues in 1954. Since then, various authors have reported a small but significant increase in plasma potassium concentration (range 0.25 to 0.8 m-equiv/litre) following suxamethonium in normal anaesthetized patients (Paton, 1959; List, 1967; Weintraub, Heisterkamp and Cooperman, 1969; Evers, Racz and Dobkin, 1969; Koide and Waud, 1972; Stovner, Endresen and Bjelke, 1972; Haw, 1972). In addition, List (1967), Stovner, Endresen and Bjelke (1972) and Haw (1972) have drawn attention to the fact that different induction agents can have a protective influence, of varying degree, against the increase in plasma potassium concentration seen after the administration of suxamethonium to normal patients.

In a previous paper Bali and Dundee (1974a) discussed the immediate effects of the i.v. administration of induction agents on the plasma electrolyte concentrations, and showed that thiopentone caused a significant decrease in plasma potassium concentration as compared with Althesin or propanidid which at two dose concentrations failed to produce any significant changes. The present study was undertaken to evaluate the changes in plasma potassium, sodium and chloride concentrations caused by the administration of suxamethonium after the induction of anaesthesia with i.v. (thiopentone, Althesin) or inhalation (nitrous oxide–oxygen, with and without halothane) agents.

METHODS

The investigation was carried out on four groups of patients, each consisting of 20 healthy women undergoing minor gynaecological operations, who had agreed to participate in this study. None received any premedication.

In the first part of the study anaesthesia was induced with thiopentone 5 mg/kg or Althesin 50 μl/kg followed by nitrous oxide–oxygen. In the second part, anaesthesia was induced by inhalation methods using either 60–70% nitrous oxide in oxygen or 60–70% nitrous oxide in oxygen with the addition of 3–4% halothane.

The dose of suxamethonium was 1 mg/kg throughout. It was given 1 min after the i.v. induction and 3 min after commencing the inhalation agents. As soon as the relaxant took effect ventilation was continued using the nitrous oxide–oxygen mixture.

Immediately before the induction of anaesthesia an 18 s.w.g. plastic cannula (Medicut) was introduced under local anaesthesia into a major vein in the antecubital fossa and connected to a three-way tap. Blood samples were withdrawn via this cannula. Drugs were injected into an antecubital vein in the other arm. Figure 1 shows the time sequence...
of blood sampling and its relation to the anaesthetic and operative procedure. Blood specimens were taken at 1, 2, 3, 5, and 10 min after the onset of suxamethonium muscle fasciculations (usually first detected in 10–20 sec in the neck muscles). Anaesthesia was maintained with nitrous oxide and oxygen via a semiclosed circuit and respiration was controlled by manual compression of the reservoir bag.

Blood was immediately stored at 4°C and centrifuged at 2,500 r.p.m. for 5 min, within 1 hr of withdrawal. Plasma potassium, sodium and chloride concentrations were estimated using the Technicon auto-analyser SMA 6/60(4+2) interfaced to an IBM 1130 computer. The individual variation in duplicate analysis with this particular auto-analyser has been studied in detail. Based on this information, changes in excess of 0.1 m-equiv/litre for potassium, 2.0 m-equiv/litre for sodium and 1.0 m-equiv/litre for chloride were considered to be significant.

RESULTS

Table I shows that this study was carried out on four groups of patients which were broadly comparable with respect to age and weight.

As it would be impracticable to report the findings in full, attention will be focused on the changes in plasma potassium concentration, particularly where a significant change was found.

Figure 2 shows the average changes in plasma potassium concentration following suxamethonium in those patients in whom anaesthesia was induced with thiopentone and Althesin. Compared with the pre-induction concentration the average plasma potassium concentration did not change significantly during the first 5 min in patients in whom anaesthesia was induced with thiopentone but the increase was significant at 1 min (P<0.01) when Althesin was given. In contrast, the increase from the prerelaxant concentration was consistently significant in the thiopentone series (P<0.02–0.005) and at the 1st (P<0.001) and 3rd

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**Table I. Age and weight (mean±SEM) in four groups, each of 20 patients, in whom changes in plasma electrolyte concentrations were studied following the administration of suxamethonium 1 mg/kg.**

<table>
<thead>
<tr>
<th>Induction</th>
<th>Age (yr)</th>
<th>Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thiopentone 5 mg/kg</td>
<td>29±1.7</td>
<td>56±1.7</td>
</tr>
<tr>
<td>Althesin 50 μl/kg</td>
<td>28±1.8</td>
<td>58±2.2</td>
</tr>
<tr>
<td>N₂O–O₂</td>
<td>28±1.4</td>
<td>57±1.4</td>
</tr>
<tr>
<td>Halothane–N₂O–O₂</td>
<td>28±2.4</td>
<td>60±2.3</td>
</tr>
</tbody>
</table>

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**Fig. 2. Mean changes in plasma potassium concentration following suxamethonium 1 mg/kg administration in patients in whom anaesthesia was induced with thiopentone 5 mg/kg (---) or Althesin 50 μl/kg (--).**
PLASMA ION CONCENTRATIONS FOLLOWING SUXAMETHONIUM

(P<0.025) min when Althesin had been given. There was a biphasic response in both series and by 10 min the increase was significant in relation to both the pre-induction (P<0.02) and prerelaxant (P<0.005) concentrations.

There were no significant changes in the average plasma sodium or chloride concentrations in the patients receiving either of the i.v. induction agents.

Figure 3 shows the average changes in plasma potassium concentration following suxamethonium in those patients having an inhalation induction of anaesthesia. The administration of nitrous oxide-oxygen did not cause any change in the plasma potassium concentration. However, a significant increase occurred 1 min after the administration of the relaxant (P<0.05), but this had decreased to non-significant levels (P<0.20) at 5 min. There was a further significant increase at 10 min.

The pattern of change was quite different when halothane was used in addition to nitrous oxide and oxygen. The administration of nitrous oxide–halothane for 3 min caused an average decrease of 0.12 m-equiv/litre in the plasma potassium concentration, which was not statistically significant (t=1.73; P<0.10). Following the administration of suxamethonium there was a gradual increase in plasma potassium concentration which did not reach significant levels until 5 min after the relaxant had been given (P<0.02 from pre-induction and P<0.001 from prerelaxant concentrations). This increase in plasma potassium concentration persisted until the 10 min blood sample had been taken.

Table II gives the average of the peak changes in the potassium, sodium and chloride concentrations found within the first 5 min after the administration of suxamethonium 1 mg/kg. The changes in potassium concentration were highly significant throughout, except for the group which received halothane–nitrous oxide–oxygen. There was no significant change in plasma chloride concentration and, except for the halothane–nitrous oxide–oxygen series, there was no significant change in plasma sodium concentration. However, although statistically significant, this change was within the range of error of the method of analysis employed.

DISCUSSION

It is evident from the present investigation that an i.v. injection of suxamethonium 1 mg/kg in normal women patients results in a significant increase in the plasma potassium concentration with no changes in the plasma concentrations of sodium or chloride. The pattern of the changes observed with the two i.v. induction agents was similar to that seen when nitrous oxide–oxygen was given. Compared with Althesin the protective effect of thiopentone in preventing a marked increase in serum potassium in fit subjects given suxamethonium was significant and may be important in abnormal catabolic states.

Others studying this subject have investigated the changes in plasma potassium concentration at irregular intervals after the administration of suxamethonium in patients in whom anaesthesia had been induced with thiopentone. The magnitude of the changes reported by List (1967) and by Miller and his colleagues (1972) is similar to those reported here. The biphasic increase in plasma potassium concentration demonstrated here is in agreement with the findings of animal experiments reported by Klupp and colleagues (1954).

The most important findings in this study appear to be the effect of halothane in modifying the electrolyte changes which follow the administration of suxamethonium. Our findings confirm those of List (1967) who found that the inhalation of a mixture of nitrous oxide–oxygen–halothane caused a significant decrease in plasma potassium concentration. A number of other workers have observed a significant increase in plasma potassium concentration after suxamethonium in patients given halothane (with or without an i.v. induction agent), and table III is an analysis of their findings. Although none of these carried out as frequent sampling as was undertaken in the present study, they all demonstrated a delay in the peak effect comparable to that found in the present work and.
TABLE II. Peak changes (mean±SEM) in plasma electrolyte concentrations, calculated from pre-induction and prerelaxant concentrations, occurring in the first 5 min after suxamethonium 1 mg/kg in patients in whom anaesthesia was induced with different agents.

<table>
<thead>
<tr>
<th>Induction</th>
<th>Plasma electrolyte</th>
<th>Changes from pre-induction concn. (m-equiv/litre)</th>
<th>Changes from prerelaxant concn. (m-equiv/litre)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thiopentone</td>
<td>K</td>
<td>+0.25±0.06</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Na</td>
<td>−0.40±0.42</td>
<td>&lt;0.40</td>
<td>0.40</td>
</tr>
<tr>
<td></td>
<td>Cl</td>
<td>−0.20±0.44</td>
<td>&lt;0.70</td>
<td>0.50</td>
</tr>
<tr>
<td>Althesin</td>
<td>K</td>
<td>+0.32±0.05</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Na</td>
<td>−0.70±0.56</td>
<td>&lt;0.30</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td>Cl</td>
<td>+0.85±0.38</td>
<td>&lt;0.40</td>
<td>0.95</td>
</tr>
<tr>
<td>Nitrous oxide-oxygen</td>
<td>K</td>
<td>+0.31±0.04</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Na</td>
<td>−0.35±0.65</td>
<td>&lt;0.70</td>
<td>0.60</td>
</tr>
<tr>
<td></td>
<td>Cl</td>
<td>+0.22±0.44</td>
<td>&lt;0.80</td>
<td>0.90</td>
</tr>
<tr>
<td>Halothane-N₂O-O₂</td>
<td>K</td>
<td>+0.21±0.08</td>
<td>&lt;0.10</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td>Na</td>
<td>−0.45±0.37</td>
<td>&lt;0.50</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td>Cl</td>
<td>−0.80±0.53</td>
<td>&lt;0.20</td>
<td>0.10</td>
</tr>
</tbody>
</table>

different from the changes observed when an i.v. induction agent was given.

Tammisto and Airaksinen (1966a,b) and Tammisto, Leikkonen and Airaksinen (1967) have demonstrated an increase in creatine phosphokinase activity after administration of suxamethonium which was particularly marked when halothane was given. This has been confirmed by Bali and Dundee (1974b) who also demonstrated a higher incidence and greater severity of suxamethonium-induced muscle pain after halothane. This suggests that halothane may make the muscle cell membrane more prone to trauma by the suxamethonium-induced fasciculations with a resulting increase in plasma potassium concentration.

Although there is no direct evidence to support this view, one may be advised to avoid halothane when suxamethonium is to be given to patients with abnormal states such as burns, spinal cord lesions, atrophic myopathies and tetanus, where a greater than normal increase in potassium concentration could occur.

ACKNOWLEDGEMENTS

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REFERENCES


LES CHANGEMENTS IMMÉDIATS PRODUITS PAR LE SUXAMETHONIUM DANS LE POTASSIUM, LE SODIUM ET LE CHLORURE DU PLASMA

**RESUME**

Quatre groupes de patientes en bonne santé ont été anesthésiées avec du thiopentone, de l'althesin ou un mélange de protoxyde d'azote-oxygène avec ou sans halothane. La concentration des électrolytes du plasma a été mesurée avant, et à divers moments jusqu'à un maximum de 10 minutes après, l'administration de suxaméthonium à 1 mg/kg. On a découvert une augmentation biphasique réduite, mais significative, de la teneur en potassium du plasma lorsque le suxaméthonium était administré à des patientes chez lesquelles l'anesthésie était produite par l'aide de thiopentone, d'althesine et de mélange de protoxyde d'azote-oxygène. L'accroissement initial de la concentration de potassium du plasma était plus important dans le groupe à l'althesine que dans les deux autres groupes. On a noté une augmentation de la concentration de potassium du plasma, plus tardive mais soutenue, après anesthésie induite avec protoxyde d'azote-oxygène-halothane.

**RESUMEN**

Se anestesiaron cuatro grupos de pacientes femeninos sanos bien con tiopentón, altesin o óxido nítrico-oxígeno y sin halotano. Se midieron las concentraciones en electrolitos del plasma antes y a diferentes tiempos hasta 10 minutos después de la administración de 1 mg/kg de suxamétonium. Se encontró un pequeño, aunque significativo, aumento bifásico en la concentración de potasio del plasma cuando se administró suxamétonium en pacientes a los que se anestesió con tiopentón, altesin y óxido nítrico-oxígeno. El aumento inicial de la concentración de potasio del plasma cuando se administró suxamétonium en pacientes a los que se anestesió con tiopentón, altesin y óxido nítrico-oxígeno. El aumento inicial de la concentración de potasio del plasma fue mayor para el grupo Althesin que para los otros dos grupos. Se encontró un aumento más retrasado, aunque prolongado, de la concentración en potasio del plasma después de inducción con óxido nítrico-oxígeno-halotano.

**ZUSAMMENFASSUNG**


**SUMARIO**

Se anestesiaron cuatro grupos de pacientes femeninos sanos bien con tiopenton altesin o óxido nitroso-oxigeno con y sin halotano. Se midieron las concentraciones en electrolitos del plasma antes y a diferentes tiempos hasta 10 minutos después de la administración de 1 mg/kg de suxamétonium. Se encontró un pequeño, aunque significativo, aumento bifásico en la concentración de potasio del plasma cuando se administró suxamétonium en pacientes a los que se anestesió con tiopenton, altesin y óxido nitroso-oxigeno. El aumento inicial de la concentración de potasio del plasma fue mayor para el grupo Althesin que para los otros dos grupos. Se encontró un aumento más retrasado, aunque prolongado, de la concentración en potasio del plasma después de inducción con óxido nitroso-oxigeno-halotano.

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