PREOPERATIVE SERUM CHOLINESTERASE CONCENTRATION IN CHRONIC RENAL FAILURE

Clinical experience of suxamethonium in 81 patients undergoing renal transplant

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SUMMARY

Serum cholinesterase concentrations were measured in 181 patients in chronic renal failure. Significant differences in cholinesterase concentrations were not found in patients undergoing dialysis and changes appear to be independent of the method of treatment used. Clinical experience with suxamethonium to facilitate tracheal intubation was satisfactory in 80 patients undergoing renal transplant. Apnoea occurred in one patient who was found subsequently to have atypical cholinesterase inheritance.

Studies of patients in chronic renal failure suggest that some of them may have reduced serum cholinesterase activity (Robertson, 1966; Lee and Atkinson, 1973), but conflicting evidence is available concerning the influence of dialysis on cholinesterase activity (Holmes, Nakamoto and Sawyer, 1958; Desmond and Gordon, 1969; Thomas and Holmes, 1970).

This study was designed to determine the frequency of abnormal cholinesterase activity in patients with chronic renal failure, and to determine its relevance to clinical practice.

METHOD

Patients

Serum cholinesterase and serum potassium concentrations were measured before operation in 181 patients in chronic renal failure.

Fifty-two patients, managed by sodium, fluid and protein restriction, and 39 patients receiving peritoneal dialysis were anaesthetized for insertion of a shunt or arteriovenous fistula. The remaining 90 patients, receiving regular haemodialysis, were anaesthetized for renal transplantation, using a similar anaesthetic technique. Thiopentone sodium 150–300 mg and fentanyl 100 µg were given i.v. to induce anaesthesia, with suxamethonium 50–100 mg to facilitate tracheal intubation in 81 patients. In nine patients the trachea was intubated with the aid of pancuronium. Anaesthesia was maintained with nitrous oxide in oxygen; small increments of pancuronium, fentanyl and, in some cases, halothane 0.25–0.5% were given in addition.

Measurement of serum cholinesterase concentrations

In one hundred and fifty-five patients the method was based on benzyl choline hydrolysis described by Kalow and Lindsay (1955). Because of a change in technique during the period under review, in 26 transplant patients cholinesterase was estimated by measurement of the acid produced by the action of cholinesterase on acetyl choline (Rappaport, Fischl and Pinto, 1959).

Dibucaine numbers

Dibucaine numbers were measured by the method of Kalow and Genest (1957) and were estimated routinely in those patients who were found to have a reduced serum cholinesterase concentration.

RESULTS

Serum cholinesterase

The serum cholinesterase concentrations in the first three groups of patients, for whom the same method of cholinesterase estimation was employed (Kalow and Lindsay, 1955), were markedly similar in respect of the mean concentrations (table I). These three mean values were compared using Student's \( t \) test and no statistically significant difference was found. It was not possible to make any comparison with the data from the 26 patients undergoing haemodialysis in the fourth group.

The distribution of cholinesterase concentrations found in all the patients is shown in figure 1. Since two different methods for cholinesterase estimation were used, those patients who had been haemodialysed were divided into two groups (columns 3 and 4, fig. 1). Column 3, which shows the results from 64 patients (Kalow and Lindsay method), includes three
TABLE I. Comparison of serum cholinesterase concentrations in patients with uraemia

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Method of estimation</th>
<th>Mean cholinesterase concn ± SD (normal range 0.62–1.37 units. litre(^{-1}))</th>
<th>Mean duration of dialysis ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>No dialysis (52)</td>
<td>Kalow and Lindsay (1955)</td>
<td>0.84 ± 0.31 (0.30–1.45)</td>
<td>n.s. 0</td>
</tr>
<tr>
<td>Peritoneal dialysis (39)</td>
<td>Kalow and Lindsay (1955)</td>
<td>0.84 ± 0.26 (0.36–1.40)</td>
<td>n.s. 2.2 ± 2 (0.5–11 months)</td>
</tr>
<tr>
<td>Haemodialysis (64)</td>
<td>Kalow and Lindsay (1955)</td>
<td>0.87 ± 0.56 (0.12–3.4)</td>
<td>n.s. 18.9 ± 15.3 (1–60 months)</td>
</tr>
<tr>
<td>Haemodialysis (26)</td>
<td>Rappaport, Fischl and Pinto (1959)</td>
<td>66.8 ± 22.7 (36–134 units. litre(^{-1}))</td>
<td>18 ± 2.4 (1–52 months)</td>
</tr>
</tbody>
</table>

* Student’s \(t\) test; n.s. = not significant.

† Cholinesterase concentration in patients undergoing peritoneal dialysis compared with duration of dialysis. \(n = 39; r = 0.15\) (n.s.).

‡ Cholinesterase concentration in patients undergoing haemodialysis compared with duration of dialysis. \(n = 64; r = 0.1\) (n.s.).

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Fig. 1. The distribution of cholinesterase concentrations with reference to treatment of patients in chronic renal failure. Two methods of cholinesterase estimation were used in the patients undergoing haemodialysis (columns 3 and 4).
very high values. These may be a result of a laboratory error, or genuinely high values. If the mean and distribution of the other 61 values are calculated (0.77 ± 0.32) the probabilities of these outlying points belonging to the same population are < 0.000005 in all three cases. Therefore it appears possible that they form a distinctly separate population of patients.

The method of dialysis and duration of treatment between groups were considered as a possible influence on cholinesterase concentrations. Comparison of the duration of haemodialysis and cholinesterase values had a correlation coefficient of 0.1 (n = 64) and for peritoneal dialysis a similar comparison gave a value of 0.15 (n = 39) and excludes this hypothesis (table I).

Insufficient samples from normal patients were available to permit our laboratory to give a mean and standard deviation for their method of estimation, so a normal range is used. When the data of the 181 patients were analysed eight values (4.4%) were increased, and three of these have been mentioned already. Forty-two patients (23.2%) had values less than the normal range.

Table II gives details of the percentage of patients with values below normal in each group. The four patients (2.2%) with low dibucaine and cholinesterase values have been excluded.

Table II. Distribution of reduced cholinesterase concentrations in all the patients in the present study

<table>
<thead>
<tr>
<th>Treatment (no.)</th>
<th>% with reduced cholinesterase</th>
<th>Reduced cholinesterase and dibucaine number</th>
</tr>
</thead>
<tbody>
<tr>
<td>No dialysis (52)</td>
<td>21.2 (11)</td>
<td>1.9% (1)</td>
</tr>
<tr>
<td>Peritoneal dialysis (39)</td>
<td>12.8 (5)</td>
<td>2.6% (1)</td>
</tr>
<tr>
<td>Haemodialysis (90)</td>
<td>28.9 (26)</td>
<td>2.2% (2)</td>
</tr>
<tr>
<td>All groups</td>
<td>23.2 (42)</td>
<td>2.2% (4)</td>
</tr>
</tbody>
</table>

Table III. Analysis of four patients with atypical cholinesterase inheritance. Each received suxamethonium 50 mg at induction of anaesthesia

<table>
<thead>
<tr>
<th>Serum cholinesterase concentration (units.litre⁻¹)*</th>
<th>Dibucaine number</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>No dialysis</td>
<td>0.36</td>
<td>58</td>
</tr>
<tr>
<td>Peritoneal dialysis</td>
<td>0.62</td>
<td>50</td>
</tr>
<tr>
<td>Haemodialysis</td>
<td>0.20</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>0.12</td>
<td>55</td>
</tr>
</tbody>
</table>

* Normal range 0.62–1.37 units.litre⁻¹.

**Fig. 2. The distribution of dibucaine numbers in 90 patients with chronic renal failure.**

**Dibucaine numbers**

Dibucaine numbers were measured in 90 out of 181 patients (49.7%). Their distribution is shown in figure 2, showing a mean of 76 ± SD 8. Fourteen patients were found to have a dibucaine number between 50 and 70 and, in three, this was associated with a marked reduction of serum cholinesterase. A fourth patient showed borderline reduction of cholinesterase.

Results from the four patients with atypical cholinesterase inheritance are shown in table III. All received suxamethonium 50 mg during the induction of anaesthesia. The two smallest cholinesterase concentrations were found in the haemodialysis group, but this may not be significant as it was the largest group sampled. Nevertheless, the values are very low and it is perhaps surprising that problems were encountered only in the fourth patient (table III), who is discussed as a case report at the end of the Results section.

**Potassium**

The mean serum potassium concentration before operation in 181 patients was 4.12 ± 0.5 mmol.litre⁻¹.
with a range of 2.4–6.3 mmol.litre\(^{-1}\). In the six patients with a potassium concentration of 5.5 mmol.litre\(^{-1}\) or more, treatment with cation-exchange resins and glucose–insulin infusions were used to reduce the serum potassium concentration before induction of anaesthesia. There was no clinical or electrocardiographic evidence suggesting problems attributable to potassium abnormalities in any of the patients who underwent anaesthesia.

**Muscle relaxants**

Suxamethonium 50–100 mg was used in 81 out of 90 patients undergoing renal transplant. In six patients in whom the serum potassium was increased before operation, and three in whom it was normal, pancuronium was used to facilitate tracheal intubation and to provide muscle relaxation. There was no difficulty in the antagonism of pancuronium but one patient had prolonged neuromuscular block after suxamethonium.

**Case report**

A 50-year-old woman with chronic renal failure associated with polycystic kidney disease was admitted for renal transplantation. She had rheumatic heart disease with predominant aortic incompetence. She had received regular haemodialysis, before this admission, via an arterio-venous shunt in her leg. The anaesthetic used for this procedure comprised thiopentone sodium, nitrous oxide in oxygen and halothane. The patient’s condition before operation was good and investigations revealed the following blood or serum concentrations:

- Hemoglobin 7.9 g.dl\(^{-1}\)
- Total protein 61 g.litre\(^{-1}\)
- Albumin 30 g.litre\(^{-1}\)
- Globulin 31 g.litre\(^{-1}\)
- Calcium 2.8 mmol.litre\(^{-1}\)
- Sodium 134 mmol.litre\(^{-1}\)
- Potassium 4.7 mmol.litre\(^{-1}\)
- Chloride 116 mmol.litre\(^{-1}\)
- Bicarbonate 19 mmol.litre\(^{-1}\)
- Creatinine clearance 22.5 ml.min\(^{-1}\)
- Blood urea 172 mmol.litre\(^{-1}\)
- Plasma creatinine 55 pmol.litre\(^{-1}\)

The patient was premedicated with phenazocine 1 mg and atropine 0.6 mg. Anaesthesia was induced with thiopentone sodium 125 mg and suxamethonium 50 mg was given to facilitate tracheal intubation. Spontaneous respiration returned after 30 min. The remainder of the procedure was uneventful. The patient’s preoperative cholinesterase concentration was not available at the time of transplant but was later found to be 0.12 units.litre\(^{-1}\) with a dibucaine number of 55.

**DISCUSSION**

A feature of this study is the similarity between the mean cholinesterase values, lying within the normal range, in the three groups of patients. Comparison of the distributions of values between the three groups shows that they are statistically inseparable. The majority of values lie within the normal range, but the finding that 23.2% of patients had a value below normal is interpreted to be a response to chronic renal failure.

Conflicting evidence is available concerning the role of haemodialysis on concentration of cholinesterase. Holmes, Nakamoto and Sawyer (1958) found minimal depression of the concentration in many patients and although a few had a marked decrease, very low values were not reported. In contrast, Thomas and Holmes (1970) compared pre- and post-dialysis values in 100 patients undergoing haemodialysis and found that 31 were less and 64 greater after dialysis. Desmond and Gordon (1969) found that haemodialysis had no effect. This study shows that patients undergoing dialysis were not distinguishable from patients receiving conservative treatment for chronic renal failure, and the type and duration of dialysis were not found to have a significant influence on cholinesterase concentrations.

Although two very low cholinesterase values were found, they occurred in association with low dibucaine numbers; the combination of atypical cholinesterase inheritance and chronic renal failure may explain this.

The unpredictability of serum cholinesterase values in chronic renal failure led Wyant (1967) to report that he was not prepared to use suxamethonium. However, two large series by Samuel and Powell (1970) and Aldrete and others (1971) report the use of suxamethonium in 93 and 226 transplant operations respectively, without problems of apnoea or an increase in potassium concentration. Katz, Kountz and Cohn (1967) used a suxamethonium infusion (1 mg/kg) to provide relaxation for 20 out of 24 transplant operations without adverse effects. Clinical experience supports the use of suxamethonium, but comparison is difficult as none of these authors gave details of cholinesterase concentrations. Only Samuel and Powell (1970) reported serum potassium concentrations in their series, and emphasize the dangers of administration of suxamethonium in the presence of an increased serum potassium concentration.
Renal transplantation is often an emergency operation and the anaesthetist may wish to use suxamethonium to facilitate tracheal intubation. One factor influencing the choice of suxamethonium is the possible variation in the concentration of cholinesterase. In 81 patients receiving suxamethonium at the time of their transplant, 28.9% had reduced values. Problems were not encountered except in one patient who was found to have atypical cholinesterase inheritance. Suxamethonium does not appear to be contraindicated in patients with chronic renal failure. It should be noted that clinical problems relating to hyperkalaemia did not occur, but suxamethonium was not given to patients with potassium values greater than 5.5 mmol./litre.\(^1\)

ACKNOWLEDGEMENTS

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REFERENCES


CONCENTRACION PREOPERATIVA DE CHOLINESTERASE SERICA EN EL FRACASO RENAL CRONICO

Expérience clinique du suxaméthonium sur 81 malades subissant une transplantation rénale

RESUME

On a mesuré les concentrations de cholinestérase sérique sur 181 malades souffrant d'insuffisance rénale chronique. On n'a pas trouvé de différences importantes dans la cholinestérase sur les malades soumis à une dialyse et les variations ont semblé être indépendantes de la méthode de traitement utilisée. L'expérience clinique avec le suxaméthonium pour faciliter l'intubation trachéale a donné des résultats satisfaits sur 80 malades subissant une transplantation rénale. L'apnée s'est produite sur un malade pour lequel on a trouvé par la suite qu'il avait une cholinestérase atypique héréditaire.

DIE VOROPERATIVE SERUM-CHOLINESTERASEKONZENTRATION BEI CHRONISCHEN NIERENLEIDEN

Klinische Erfahrungen mit Suxamethonium bei 81 Patienten im Falle von Nierentransplantation

ZUSAMMENFASSUNG


CONCENTRACION PREOPERATIVA DE COLINESTERASA SERICA EN EL FRACASO RENAL CRONICO

Experiencia clínica del suxametonio en 81 pacientes sometidos a trasplante renal

SUMARIO

Se midieron las concentraciones de colinesterasa sérica en 181 pacientes aquejados de fracaso renal crónico. No se hallaron diferencias significativas en las tasas de colinesterasa de pacientes sometidos a diálisis y los cambios parecen ser independientes del método de tratamiento utilizado. La experiencia clínica con suxametonio para facilitar la intubación tráqueal fue satisfactoria en 80 pacientes sometidos a trasplante renal. Se produjo apnea en un paciente que, subsiguientemente, resultó tener una herencia colinesterásica atípica.
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