SERUM POTASSIUM CHANGES DURING INDUCTION OF ANAESTHESIA

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SUMMARY

Serum potassium levels of 53 patients before and after induction with halothane and oxygen, halothane, nitrous oxide and oxygen, and thiopentone, showed a significant decrease after reaching the first surgical plane. After the administration of the depolarizing agent suxamethonium serum potassium levels increased significantly more in the two halothane groups than in the thiopentone group. It is thought that both halothane and thiopentone reduce the number of depolarizations, whereas suxamethonium causes an acute increase in the number of depolarizations. Other factors that could influence serum potassium, such as decrease or increase in blood sugar, alkalosis or acidosis, were also investigated. It is concluded that they did not play a significant role in the measured potassium changes.

Release of potassium from muscle tissue (Klupp et al., 1954) and elevated serum potassium levels have been observed in animal experiments (Galindo and Davis, 1962) following administration of suxamethonium and may represent a major cause of cardiac arrhythmias in man during anaesthesia (Davis, Helmer and Murphy, 1964). A frequency of 20 per cent or more of such incidents has been observed with the use of this muscle relaxant (Lupprian and Churchill-Davidson, 1960; Craythorne, Turndorf and Dripps, 1960) whereas no such complications have been reported to occur with other relaxants. Investigations were undertaken to study serum potassium levels in humans during induction of anaesthesia when thiopentone or halothane was used, alone or in combination with suxamethonium, to determine the effect of this muscle relaxant on serum potassium levels.

MATERIAL AND METHODS

Serum potassium levels were measured during induction of anaesthesia in 53 fasting patients; 46 patients were scheduled for elective heart surgery and 7 for other thoracic operations. Patients were included in this study only if the intracellular (erythrocyte) and serum levels of potassium and other electrolytes were within the normal range. Severely cyanotic or decompensated patients were excluded. If a patient was receiving glycoside therapy (Cedilanid—Sandoz), medication was stopped 4 days before operation. None of the patients had received any diuretic or antihypertensive drug within 2 weeks of operation.

Intramuscular pentobarbitone sodium (Nembutal—Abbott) 1–2 mg/kg was given 90 min before induction to all patients. Three venous blood samples (K₁, K₂, K₃) were drawn from each patient. The pre-operative sample (K₁) was obtained immediately before induction of anaesthesia. The 53 patients were divided into five groups:

Group I (10 patients) received halothane (1.2–1.8 per cent) with a 4 l./min flow of oxygen. Ages ranged between 11 and 54. The mean induction time was 9 minutes. The second sample (K₂) was taken after plane 1 of the third stage (Guedel) had been reached. The third sample (K₃) was drawn 3 minutes after intravenous administration of suxamethonium (Lysthenon—Stickstoffwerke) 1 mg/kg.

Group II (10 patients) received halothane (1.2–1.8 per cent) with a 4 l./min flow of oxygen as in group I. Ages ranged between 8 and 56. The mean induction time was 9 minutes. No suxamethonium was given during the time of observation. The second sample was taken 3 minutes after the start of anaesthesia, and the
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third 1 minute after the first plane of the third stage had been reached.

Group III (10 patients) received halothane (1.2–1.8 per cent) with nitrous oxide 4 l./min and oxygen 2 l./min. The range of ages was 5 to 63. The mean induction time was 7 minutes. The second sample was taken after plane 1 of the third stage had been reached, and the third 3 minutes after intravenous administration of suxamethonium (1 mg/kg).

Group IV (13 patients) received thiopentone (Pentothal—Abbott) in a dose of 5 mg/kg in 2.5 per cent solution. During the period of observation no other anaesthetics were administered. The second sample was taken 3 minutes after thiopentone injection, and the third 3 minutes after intravenous administration of suxamethonium (1 mg/kg).

Group V (10 patients) received thiopentone 5 mg/kg as in group IV. No suxamethonium was given during the time of observation. The range of ages was between 17 and 61. Samples were taken 3 and 6 minutes after thiopentone injection.

Respiration was spontaneous or assisted during induction; after suxamethonium administration ventilation was controlled with 100 per cent oxygen. In all experiments a semiclosed circle system with carbon-dioxide absorption was used. The halothane vaporizer was placed outside the circle.

The cubital vein was cannulated. In groups I and II the cannula was kept open by an exact-fitting stilette; in groups III, IV and V a 5 per cent dextrose drip was used, the quantity infused never exceeding 20 ml.

For duplicate estimations of serum potassium 10 ml of blood was needed per sample. Blood samples from each patient were allowed to stand and coagulate for 30–45 minutes. They were then centrifuged for 10 minutes at 2,500 r.p.m. The serum was then removed quickly. Haemolysis did not occur in any specimen. The potassium determinations were done by the same technician using a Zeiss PF 5 flame photometer having a reproducibility within ±1.5 per cent. Repeated checks and the variance of our duplicate estimates showed that our potassium data were well within this range of reproducibility.

Blood sugar levels were estimated in group I according to the method of Crecelius-Seifert (1928). The normal range of this method is between 80–120 mg/100 ml. Samples were taken at the same time as blood samples for potassium estimations. No anticoagulant was used, specimens being analyzed immediately.

Blood gases determined according to the method of Astrup and associates (1960) were estimated in 5 patients of group I after the surgical plane had been reached. Samples of finger capillary blood were analyzed with the Astrup micro-equipment (Radiometer—Kopenhagen).

RESULTS

These are shown in table I and figures 1 and 2. In each of the five groups induction of anaesthesia was associated with a statistically significant decrease of serum potassium (paired Student t test). The mean changes were between −7 and −10 per cent. No statistically significant difference could be detected between the different groups after induction of anaesthesia (Student t test).

![Fig. 1](image-url)

Mean values for serum potassium in Groups I, III and IV expressed as percentages of the pre-operative values. The mean induction time in the group given halothane-oxygen (group I) was 9 minutes, in the group given halothane-nitrous oxide and oxygen (group III) 7 minutes, and in the thiopentone group (IV) 3 minutes. Suxamethonium (SCC) 1 mg/kg was given intravenously when the first plane of the third stage was reached.

--- halothane, oxygen.
--- thiopentone.
--- halothane, nitrous oxide, oxygen.
K+ potassium.

After suxamethonium administration (groups I, III, IV) serum potassium rose significantly. In both halothane groups (I, III) the mean increase
was approximately +7 per cent (P<0.01); in the thiopentone group (IV) it was +2.3 per cent (P<0.05). No statistically significant difference could be found between groups I and III but a highly significant difference (P<0.01) was seen when each of the halothane groups (I, III) was compared with the thiopentone group after suxamethonium administration.

Group V was studied to find out whether or not serum potassium continued to fall after the first plane of stage three had been reached. Such a continued downward trend would tend to obscure or decrease a potassium rise after suxamethonium administration. As can be seen in table I and figure 2, there was no significant change in group V, 6 minutes after thiopentone induction. Group II was included to study the course of serum potassium levels during induction with halothane. Serum potassium had already decreased significantly (P<0.01) after 3 minutes; 10 minutes after the start of halothane anaesthesia only minor and insignificant fluctuations of serum potassium occurred as compared with the levels measured at 3 minutes.

The mean of 53 pre-operative serum potassium values was 4.15 m.equiv/l.; SD 0.33 (SE 0.05). Blood glucose levels of patients in group I were measured (a) pre-operatively, (b) after reaching plane 1, and (c) 3 minutes after suxamethonium had been administered. The mean values and

![Fig. 2](image)

**FIG. 2**
Mean values of serum potassium in groups IV and V. Thiopentone 5 mg/kg was used to induce anaesthesia in both groups. Suxamethonium (SCC) 2 mg/kg was given intravenously to the patients in group IV (broken line) after plane I was reached. Suxamethonium was not given to the patients in group V (continuous line).

| Table I |
|-----------------|---------------|-----------------|-----------------|-----------------|---------------|
| **Group** | **Anaesthetic agents** | **Age mean and range (yr)** | **Number of patients** | **K₁, mean and SE (m.equiv/l.)** | **K₂−K₁, significance** | **K₂, mean and SE (m.equiv/l.)** | **K₂−K₁, significance** | **K₃, mean and SE (m.equiv/l.)** |
| I | Halothane | 32.9–54 | 10 | 4.23 | −0.30 | P<0.01 | 3.93 | +0.30 | 4.23 |
| | Oxygen | 11–54 | 10 | 0.11 | P<0.01 | 0.11 | P<0.01 | 0.12 |
| | Suxamethonium | | | | | | | |
| II | Halothane | 27.2–56 | 10 | 4.03 | −0.28 | P<0.01 | 3.75 | +0.02 | 3.77 |
| | Oxygen | 8–56 | 10 | 0.05 | P<0.01 | 0.06 | not-signif. | 0.06 |
| III | Halothane | 30.5–63 | 10 | 4.10 | −0.42 | P<0.01 | 3.68 | +0.27 | 3.95 |
| | Nitrous oxide, oxygen | | | | | | | |
| | Suxamethonium | 5–63 | 10 | 0.07 | P<0.01 | 0.08 | P<0.01 | 0.08 |
| IV | Thiopentone | 34.7–61 | 13 | 4.20 | −0.39 | P<0.01 | 3.81 | +0.09 | 3.90 |
| | Suxamethonium | 7–61 | 10 | 0.11 | P<0.01 | 0.12 | P<0.01 | 0.13 |
| V | Thiopentone | 40.7–61 | 10 | 4.19 | −0.35 | P<0.01 | 3.84 | −0.03 | 3.81 |
| | | 17–61 | 10 | 0.13 | P<0.01 | 0.08 | not signif. | 0.10 |

K₁, Pre-operative values.
K₂, Values after plane 1 of stage III had been reached (groups I, III, IV and V) or 3 minutes after start of anaesthesia (group II).
K₃, Levels 3 minutes after suxamethonium administration (groups I, III and IV); samples obtained 7 minutes (group II) and 3 minutes (group V) after the second sample, no suxamethonium being given.
their standard errors (SE) are as follows: (a) 109 mg/100 ml (±5.4); (b) 115 mg/100 ml (±4.9); (c) 117 mg/100 ml (±5.7). After reaching the surgical plane the mean values of pH, Pco₂, and standard bicarbonate were as follows: pH 7.366 (range 7.30–7.44); Pco₂ 44 mm Hg (range 38.5–50.5); standard bicarbonate 24.2 m.equiv/l. (range 23.0–26.8).

**DISCUSSION**

A fall of serum potassium has been described previously, after barbiturate-induced sleep in man and experimental animals (Cloetta, Fischer and van der Loeff, 1934; Dobkin, Byles and Neville, 1966) and after ether induction in experimental animals (Robbins and Pratt, 1936).

In this study a significant fall of serum potassium was observed after halothane-oxygen, halothane-nitrous oxide and oxygen, and thiopentone induction. A statistically significant difference in the magnitude of the decrease of serum potassium after induction of anaesthesia could not be detected between any of the groups. After the administration of the depolarizing agent suxamethonium, serum potassium rose significantly less after thiopentone induction than after halothane induction.

The serum potassium level is thought to be determined, at least partly, by the constant ionic fluxes across membranes of cells. Anaesthetics are believed to decrease the number of depolarizations, thus prolonging repolarization time. A net decrease of serum potassium results. The depolarizer suxamethonium causes an acute increase in muscular activity with a resultant increase in serum potassium. The significant difference in the potassium rise after suxamethonium administration suggests a difference in the mode or site of action of halothane and thiopentone induction than after halothane induction.

A possible source of error could be introduced by changes in the excretion of hormones from the adrenal cortex, although urinary excretion of potassium is not thought to play a significant role during the short time of induction. Two other factors that also could influence serum potassium were investigated. An insulin-induced blood sugar decrease during induction that could decrease serum potassium (Leak and Starr, 1962) was not seen in this study. Blood glucose increased slightly but consistently during the period of observation. This was probably a sign of an increase in sympathetic activity during induction and after suxamethonium administration. The higher sympathetic activity may have partly contributed to the serum potassium rise after suxamethonium administration (O’Brien et al., 1954; Galindo and Davis, 1962).

The small dose of pentobarbitone given 90 minutes before induction of anaesthesia was chosen in an attempt to reduce apprehension and higher sympathetic activity before operation in otherwise unpremedicated patients. As all patients were awake, co-operative, and did not seem excited, this fault can probably be neglected.

Blood gas studies after halothane induction were within normal range or showed a slight respiratory acidosis, probably due to the respiratory depressant effect of halothane. Only an alkalosisis (respiratory or metabolic) could reduce serum potassium (Keuskamp, 1965).

Although this study was confined to a selected group of patients, the consistency of the observations indicates that the changes may be important in other circumstances.

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**REFERENCES**


ALTERATIONS DU POTASSIUM SERIQUE AU COURS DE L'INDUCTION D'ANESTHESIE

ZUSAMMENFASSUNG


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