STUDY THE EFFECT OF SURGICAL STRESS ON SERUM POTASSIUM AND SERUM CALCIUM LEVEL

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Abstract

Background: This study was randomized clinical trial carried out in 100 patients to study the effect of surgical stress on serum potassium and calcium and to relate these changes to age of the patient and duration of surgical stress.

Materials and Methods: The study was done in the Department of General Surgery SMS Medical College, Jaipur from June 2015 to June 2017. Patients equally distributed in two groups A and B on the basis of timing of collection of sample.

Blood was taken from the patients who were operated under spinal anaesthesia only, so that the chemical effect of anesthetic was as minimal as possible. For comparison few cases were investigated who were operated under general anaesthesia. In all the patients operated under spinal or general anaesthesia same drug and techniques were used to overcome bias.

Observations and Results: In the study we observed that variation in serum electrolyte seen in period of stress. Range of hypokalemia and hypocalcemia were 2.8 to 3.7 meq/lit and 7.6 to 8.4 mg% respectively in group A and hypokalemia and hypocalcemia were 3.0 to 3.4 meq/lit and 7.6 to 8.4 mg% respectively in group B. Maximum incidence of hypokalemia and hypocalcemia seen during 30-60 minutes duration of operation.

Conclusion: Surgical stress is main cause of fluctuation in blood calcium, and blood potassium levels in surgical ward. The variation consists of increase or decrease of both electrolytes because of activation of the pituitary adrenocortical systems and maximally seen in immediate post operative period.

Keywords: Calcium (Ca^{+2}), Potassium (K^{+}), Serum electrolytes, Surgical stress

Introduction

This study was randomized clinical trial carried out in 100 patients of various age and sex groups to study the effect of surgical stress on serum potassium and calcium and to relate these changes to age of the patient and duration of surgical stress.

MATERIALS AND METHODS

The study was done in the Department of General Surgery SMS Medical College And Hospital, Jaipur from June 2015 to June 2017. All the patients equally distributed in two groups on the basis of timing of collection of sample.

Group A - In first 50 cases blood sample were drawn, (1) 24 hrs before operation, (2) before and (3) after operation (4) 48 hrs after operation and on (5) 7th day.

Group B - In second 50 cases first three samples were as above, 4th sample was drawn after 24 hrs and on 5th day after operation. To find out any changes occur during this time.

The behavior of changes in calcium and potassium under surgical stress studied in relation to different age group and duration of stress:

-Five different age groups were selected on the basis of age, as follows:

Group I— Age group 10-20 yrs (7 cases)

Group II - Age group 20-30 yrs (30 cases)

Group III - Age group 30-40 yrs (30 cases)

Group IV - Age group 40-50 yrs (16 cases)

Group V - Age group 50 & above yrs (17 cases)

-On the basis of duration of surgery three groups were made as follows:

1. Duration of operation 0-30 minutes (30 cases)

2. Duration of operation 30-60 minutes (50 cases)

3. Duration of operation 60 minutes and above (20 cases)
Patients in above groups equally distributed in group A & B.

Definition of Surgical stress (operative stress)

It is operative period starts from induction of anaesthesia to closer of skin incision.

Inclusion criteria:

1. Patients feeling and having a sense of well being apart from local ailment for which they were admitted.
2. On clinical examination, alimentary, respiratory, cardiovascular, renal system and nervous system were normal.
3. Routine laboratory examination like hemogram and urinalysis did not show any abnormality.

Exclusion criteria:

There was no selection of any particular disease age or sex. Cases admitted for elective surgery were selected from the surgical wards. Surgical emergencies excluded only elective surgical patients taken.

Methods

Five samples of blood were taken from each patients; the first sample 24 hours before the operation, second and third samples just before and after the operation respectively, fourth sample after 48 hours, and fifth after 7 days of operation. This was the scheme followed in first fifty cases. In the second group of cases, first, second and third samples were taken as in the first group but the fourth sample was taken 24 hours after operations and the fifth sample on the 5th day after the operation. This change was adopted to find out what happens in the (1) first twenty four hours (2) the changes which occur between the 2nd and the 7th day after operation.

Blood was taken from the patients who were operated under spinal anaesthesia only, so that the chemical effect of anesthetic was as minimal as possible. The second sample of blood in cases of spinal anaesthesia was taken as soon as the anesthetic had become effective. For comparison few cases were investigated who were operated under general anaesthesia (Induction IV Inj. and maintenance by Nitrous oxide and oxygen). In all the patients operated under spinal or general anaesthesia same drug and techniques were used to overcome bias.

Method of collection of sample

In all 5 cc. of blood was withdrawn each time in a dry sterile syringe (3 cc of blood was collected in a sterile vial as whole blood and 2 cc in an oxalated vial). It has been stated that blood for potassium determination should be drawn without a tourniquet to prevent high results due to release of intracellular potassium resulting from local tissue anoxia. Farber et al state that the venous plasma potassium level was not affected by stasis, but increases

transiently by even slight exercise in veins draining the exercised muscles. So it was meticulously followed that no tourniquet was applied, no exercise of the limb while the blood was drawn. Serum and plasma used to be separated within 1-2 hours of withdrawal and stored at 4°C.

Collection of serum: Disposable syringes with needles were 5 ml of blood was collected by I.V. puncture of antecubital vein. This blood was collected into the serum tube and it was then kept in a warm place until the clot has retracted and serum separated. The separated serum was then poured into a centrifuge tube and any suspected cells were removed by centrifuging at a speed of 3000 r.p.m. for 15 minutes. The fluid (serum) then obtained was stored at a temperature of 5-6°C.

- All the investigation done in Central Pathology Laboratory, SMS Medical College And Hospital , Jaipur, Rajasthan under the guidance of biochemistry department.
- Normal serum value of calcium 9 to 11 mg% and potassium 3.8 to 5.0 meq/l taken, as given in CPL investigation form, for present study.
- Estimation of serum electrolyte was done by automated analyzer.

Observations and Results

A total of 100 patients were enrolled in study and divided in two groups on the basis of timing collection of sample. Observations were made on the patients who were operated under spinal anaesthesia and 9 cases that underwent operations under general anaesthesia were also investigated for comparison. The normal values of calcium and potassium confirmed with standard values in our CPL. The values of preoperative blood and the beginning of operation work almost same and were normal. The variation in level was observed during operation and after operation. However, it was observed in some cases that changes occurred right from the beginning of operation. In some cases there was no change in the levels of calcium, potassium as a result of stress. It was observed that in majority of cases calcium and potassium levels show a fall during the operation (surgical stress). In this study incidence of hypokalemia seen in 70% of cases, hyperkalemia seen in 25% and potassium was normal in 5% cases and incidence of hypocalcemia 73%, hypercalcemia seen in 20% cases and was normal in 7%.

Maximum incidence of hypokalemia and hypocalcemia seen during 30-60 minutes duration of operation. Level of serum calcium comes to normal limit in 24-48 hrs post operatively and serum potassium comes back to normal level by 5th to 7th post operative day.

Table 1: Relationship in duration of surgery and changes in serum K level in immediate post-operative sample

Age Group	No. of Patients	Duration of Surgery (in minutes) (Group – A)									No. of Patients	Duration of Surgery (in minutes) (Group – B)								
		0-30			30-60			>60				0-30			30-60			30-60		
		Fall	Rise	Normal	Fall	Rise	Normal	Fall	Rise	Normal		Fall	Rise	Normal	Fall	Rise	Normal	Fall	Rise	Normal
I	4	2	1	0	1	0	0	0	1	0	4	2	0	0	0	1	0	0	0	0
II	15	5	2	0	7	0	0	0	0	0	15	2	3	0	8	1	0	2	0	0
III	15	4	1	0	5	1	0	2	2	0	15	2	0	0	5	2	0	3	2	0
IV	8	2	2	0	2	0	0	2	0	0	8	0	0	0	4	1	0	2	1	0
V	8	1	2	0	3	0	1	0	0	1	8	0	0	0	3	2	3	1	0	0
Total	50	14	8	0	18	1	1	4	3	1	50	6	3	0	20	7	3	8	3	0

Table 2: Relationship between duration of surgery and changes in serum Ca⁺² levels in immediate post-operative sample

Age Group	No. of patients	Duration of Surgery (in minutes) (Group – A)									No. of patients	Duration of Surgery (in minutes) (Group – B)								
		0-30			30-60			>60				0-30			30-60			>60		
		Fall	Rise	Normal	Fall	Rise	Normal	Fall	Rise	Normal		Fall	Rise	Normal	Fall	Rise	Normal	Fall	Rise	Normal
I	4	0	3	0	1	0	0	0	0	0	3	1	1	0	0	1	0	0	0	0
II	15	6	0	1	7	0	0	0	1	0	15	4	1	0	7	0	1	2	0	0
III	15	4	1	0	5	1	0	2	2	0	15	2	0	0	6	2	0	3	2	0
IV	8	2	2	0	2	0	0	2	0	0	8	0	0	0	4	1	0	2	1	0
V	8	1	0	2	3	0	1	1	0	0	9	0	0	0	5	1	2	1	0	0
Total	50	13	6	3	18	1	1	5	3	0	50	7	2	0	22	5	3	8	3	0

Table 3: Duration of operation and variation of serum K⁺ and Ca⁺² in immediate post operative sample

Group – A								Group– B							
Duration (mins)	No. of patients	K ⁺			Ca ⁺²			No. of patients		K ⁺			Ca ⁺²		
		Fall	Rise	Normal	Fall	Rise	Normal			Fall	Rise	Normal	Fall	Rise	Normal
0-30	22	14	8	0	13	6	3	9		6	3	0	7	2	0
30-60	20	18	1	1	18	1	1	30		20	7	3	22	5	3
>60	8	4	3	1	5	3	0	11		8	3	0	8	3	0

Table 4: Patients of various diseases included in study

S.No.	Disease	Number
1.	Hernia	24
2.	BPH	15
3.	Burget's disease	9
4.	Hydrocele	7
5.	Appendicitis	7
6.	Anorectal fistula	5
7.	Hemorrhoids	4
8.	Varicocoele	4
9.	Vesical calculus	3
10.	Burn contracture	3
11.	Others	19

Discussion

Potassium

Values of serum electrolyte were in normal limits in first 2 samples i.e. 24 hrs before operation sample and just before induction sample in both the groups. Maximum changes in serum electrolyte were observed in third sample (immediate post-operative sample) in both the group. In both group A & B, in all age group, in all the patients a fall in serum potassium seen at 48th hrs in group A and at 24th hrs in group B. Serum potassium comes in normal limit on 7th post-op day in group A and on 5th post-op day in group B.

Changes in serum potassium

In **group A**, fall in the level of potassium seen in 36 patients (72%), rise seen in 12 patients (24%) and was normal in 2 patients (4%).

Range of fall of serum potassium was 3.0 to 3.7 meq/Lt in various age group, range of rise of potassium was found 5.2-5.3 meq/Lt in various age group and normal range was 4 - 4.2 meq/Lt. In more than 75% of patients, in all age group similar trends seen in fall of K^+ seen except >50 yrs age group where fall in K^+ seen only in 50% of patients.

In **group B** fall in the level of potassium seen in 34 patients (68%), rise seen in 13 patients (26%) and was normal in 3 patients (6%).

Range of fall of serum potassium was 3.0 to 3.4 meq/Lt in various age group, range of rise of potassium was found 5.1-5.4 meq/Lt in various age group and normal range was 4-4.2 meq/Lt.

In more than 65-77% of patients, in all age group similar trends seen in fall of K^+ seen except >50 yrs age group where only in 44% of patients fall in K^+ seen.

Hence in present series which was conducted on 100 patients it was found that there was decrease in potassium level in 70 patients (70%), increase in 25

patients (25%) and was normal in 5 patients (5%). [Table 1]

I. Fall in serum potassium - Hypokalemia

It has been observed that there is decrease of potassium during and after operation in most of the cases. Manzailla et al (1953) said that this sustained decrease of potassium may be explained by the stimulating action of surgical stress on the pituitary, cortico-adrenal and medullo-adrenal systems, the lack of ingestion of potassium because of fasting and the increased and continued excretion of potassium in the urine. There is rapid and progressive activation of the pituitary - adrenocortical axis in response to the stress of surgical trauma.[1]

Cuthbertson (1932) said that metabolic disturbances are independent of the use of anaesthetics but manipulation produces more metabolic changes than direct injury.[2,3,4,5]

Darrow (1950) found low potassium from 4th to 9th post operative days. He found symptoms of hypokalemia in some cases. The present work also suggests that metabolic changes are due to adreno cortical hyperfunction.

II. Rise in serum potassium

The rise of serum potassium during stress have been mentioned by Winkler and Hoff (1943) in dogs. Manzanilla et al (1953) found rise in serum potassium during surgical stress but they do not put forward any possible explanation for it.[1] In the present series it was noticed in some cases that there was rise in potassium level during stress. At this stage it is difficult to put forward a possible explanation for this as this change is not related to any particular age, sex, disease or operation.

Mac-Phee (1953) observed serum potassium concentration appeared to be variable and showed no pronounced change. In general, the concentration of potassium in the serum was slightly elevated during some part of

postoperative period. There was increase excretion of potassium in urine in post operation period.[6,7]

More work needs to be done on this subject along with estimation of sodium also with a proper record of balanced diet, drugs, condition of the patient etc. Then it might be possible to put forward some explanation as to why potassium behaves in a different pattern in only some cases.

Eliel et al (1952)³⁴ show fall of potassium below levels associated with low phosphorus. This lowering of serum potassium gradually came up to normal up to 8th day but low serum potassium was observed up till 26th postoperative day in some cases. This was accounted for by hyperadrenal activity. This bears a striking resemblance to the findings in patients of Cushing's syndrome (Spontaneous hyperadrenocorticism).[8]

Calcium

In both group A & B, serum calcium was within normal limit in first and second sample in all age group. In immediate post-operative sample maximum changes in serum electrolyte were observed in both the group. Fourth sample in group A serum calcium comes to normal level at 48 hour and in group B comes normal at 24th hour post operatively.

Changes in serum calcium

In **group A** fall in the level of calcium seen in 36 patients (72%), rise seen in 10 patients (20%) and was normal in 4 patients (8%). Range of fall of serum calcium was 7.6 to 8.4 mg(%) in various age group, range of rise of calcium was found 11.1-11.4 mg(%) in various age group and normal range was 9-10 mg(%).

In all age group similar trends were seen for hypocalcemia except for age group 10-20 yrs where hypocalcemia seen in only 33% cases, fall seen in all other group it was ranged from 63% to 80%.

In **group B** fall in the level of calcium seen in 37 patients (74%), rise seen in 10 patients (20%) and was normal in 3 patients (6%).

Range of fall of serum calcium was 7.6 to 8.4 mg(%) in various age group, range of rise of calcium was found 11.1-11.4 mg(%) in various age group and normal range was 9-10 mg(%).

In all age group similar trends seen for hypocalcemia except for age group 10-20 yrs where hypocalcemia seen in only 50% cases fall seen in all other group it was ranged from 66% to 81 %.

Hence in present series which was conducted on 100 patients it was found that there was decrease in calcium

level in 70 patients (70%), increase in 25 patients (25%) and was normal in 5 patients (5%).[Table 2]

Albright (1943) had expressed the opinion that the osteoporosis following trauma must be considered a manifestations of alarm reaction.[9] Eliel, Pearson and white (1952) observed in 71 year old man undergoing major surgery; (1) Low serum calcium observed in postoperative period (2) Raised phosphorus for first four days and then gradual fall. Low serum potassium gradually increasing they attribute all this to hyperfunction of adrenocortical system.[8]

Manzanilla et al (1953), observed low serum calcium and raised serum phosphorus during stress. Even in the cases in which the general factors mentioned were responsible for the variation observed in this work, it does explain the reactions of increases and decreases, since it has been established that the homeostatic anteropituitary-cortico adrenal mechanism does not lose its capacity with age.[1]

Discussion on duration of operation and variation in SERUM K⁺ AND Ca⁺²

I. Duration of operation 0-30 mins.

In this group total 31 cases were studied which includes 22 patients from group A and 9 patients from group B. Fall in serum K⁺ seen in 20 patients(64.5%), rise seen in 11(33%) patients. Fall in serum Ca⁺² seen in 20 patients (64.5%), rise seen in 8 patients (24%) was normal in 3 patients (9%).

II. Duration of operation 30-60 mins.

In this group total 50 cases were studied which includes 20 patients from group A and 30 patients from group B. Fall in serum K⁺ seen in 38 patients (78%), rise seen in 08 patients (16%) and was normal in 4 patients (8%). Fall in serum Ca seen in 40 patients (80%), rise seen in 6 patients (12%) was normal in 4 patients (8%).

III. Duration of operation >60 mins.

In this group total 19 cases were studied which includes 8 patients from group A and 11 patients from group B. Fall in serum K⁺ seen in 12 patients (63%), rise seen in 06 patients (32%) and was normal in 01 patient (5%). Fall in serum Ca⁺² seen in 13 patients (68%), rise seen in 6 patients (33%).

The changes which were seen according to duration of operation were also quite interesting. The peak changes were seen between 30 minutes to 60 minutes. There were very little changes between 0-30 minutes and it is thought that it takes some time to start the adrenocortical hyperfunction and even after it begins it takes some time to manifest itself as metabolic changes; that is why little changes are seen in short duration. As the duration goes on increasing the change are also marked but this does not

continue indefinitely. After some time there is stabilization of effect. [Table 3]

Table 4 shows total number of 100 patients of various diseases included in study.

Conclusion

1. Surgical stress is main cause of fluctuation in blood calcium, and blood potassium levels in surgical ward.
2. The variation consists of increase or decrease of both electrolytes.
3. There seems to be no relation between the characteristics of the operative stimulus and the pattern of variation of blood calcium, potassium.
4. Fasting, diarrhea, vomiting with lack of ingestion of potassium, increased and continued urinary excretion of potassium and the possible resultant dehydration are other factors that may produce low serum potassium.
5. The variations are explained by the activation of the pituitary corticoadrenal systems.
6. Pre operative electrolytes were within normal limit.
7. Maximum variation seen in immediate post operative period.

8. Calcium comes to normal limit within 24 hours of operation.

9. Hypokalemia remain sustained up to 4-5th post-operative day.

10. Maximum variation seen during 30-60 mins. of operative stress.

Bibliography

1. Manzanilla et al. J. Internation. Coll. Surg. 20:573, 1953.
2. Cuthbertson, D.P: Biochem. J. 24: 1244, 1930.
3. Cuthbertson, D.P: Lancet 2: 433, 1942.
4. Cuthbertson, D.P. Lancet, 1:433, 1942.
5. Chung F, Mezei G. Factors contributing to a prolonged stay after ambulatory surgery. Anesth Analg 1999; 89:1352-9.
6. Mac Phee, I.W. B.M.J. 1:1023, 1953.
7. Mac phee, F. Br. Med. J. 1:1023, 1953.
8. Eliel, P.L.; Hellman, L., Pearson, H.O. & Katz, B. Proc. 2nd Clin. ACTH Conf. New York, Blakiston 1951.
9. Albright I; Josiah Macy, Jr. Foundation Conf. on Bone and Wound Healing 3rd meeting New York 1943.