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Hypocalcemia in the Critically Ill Child

MOHAMMED S. ABU ALAM, M.D.;
MOHAMMED BADAWI, M.D.; MOHAMMED AWAD, M.D.;
HALA GAAFAR, M.D.; MAMDOUH SAKAR, M.D.;
and MAGDA BADAWY M.D.

The Paediatric and Chemical Pathology Departments,
Faculty of Medicine, Cairo University.

Abstract

This study was carried out on 39 critically ill infants and children at the New Children's Hospital of Cairo Univeristy to detect the frequency of hypocalcemia and derangements in calcium homeostasis among the critically ill children. The children were grouped into four groups: cardiac, respiratory, neurological and renal, with 10 normal infants and children as a control group. Determination of total serum calcium, serum ionized calcium, arterial blood pH and serum albumin were done. Results showed that total serum calcium was in all groups, serum ionized calcium was significantly lower in all groups except the neurological one, albumin was low in the renal group only, arterial pH was different from the control group in all other groups except the cardiac one. It was also observed that decreased serum albumin leads to decreased total calcium, increased pH leads to decrease ionized calcium and vice versa. Correlation between total and ionized calcium showed a + ve significant correlation in all groups except the renal group. Therefore, we stress that hypocalcemia is a common, unrecognized problem in the critically ill paediatric patient. The total serum calcium concentration is a poor predictor for those patients while serum ionized calcium value is a better predictor for the more clinically relevant cases. For that reason, we recommend measuring serum ionized calcium in critically ill children and consequently calcium administration, specially in those suffering from multisystem derangements, even if the total serum calcium is within normal value.

Introduction

CALCIUM is the most abundant element in the human body [1] . Calcium in serum exists in three fractions: protein bound (30 - 50%), diffusible non- ionized (5 - 15%) and ionized calcium (40 - 60%) which is metabolically active and can be regulated [2] . The seriously ill child or infant is

vulnerable to alterations in calcium homeostasis which is a major problem leading to metabolic derangements (if untreated), mainly serious cardiac, pulmonary, and neurologic sequelae [3].

The aim of this work is to study the frequency of hypocalcemia and derangements in calcium homeostasis among the seriously ill children.

Subjects and Methods

This study was carried out on 39 seriously ill infants and children. Their ages ranged from 4 mo. to 13 yr. The study was carried out at the New Children's Hospital, Cairo University. The studied subjects were classified according to their clinical condition into four groups: cardiac (12 cases), respiratory group (12 cases), neurological group (5 cases) and renal group (10 cases).

Ten clinically normal infants and children matched for age and sex were included in the study as controls. Cases known to have frank hypo- or hypercalcemia were excluded from the study.

All studied cases were subjected to: history; complete clinical examination; determination of serum ionized calcium, serum total calcium, arterial blood pH, serum albumin and other necessary investigations needed for each individual.

Data obtained were analyzed for correlation between total serum calcium and ionized calcium, albumin and arterial pH and also, between ionized calcium and albumin and pH in each group including the control group.

Results

The main results shown in Tables 1-5 demonstrate that:

Total calcium and albumin showed a positive significant correlation in all groups ($p < 0.05$).

Ionized calcium and arterial pH showed a negative significant correlation in all groups ($p < 0.05$).

Total and ionized calcium showed positive significant correlation in all groups except the renal group.

The results of the Student "t" test comparing the control data to that of the different studied groups showed that :

Serum total calcium in all groups was significantly lower than the control group (Table 1).

Serum ionized calcium was also lower in the studied than the control group except the neurological group (Table 2).

Albumin showed no significant difference between the control group and the studied groups except the renal one which showed a statistically significant decrease in albumin as compared to the control (Table 3).

Arterial pH showed statistically significant difference from the control group in

all the studied groups except the cardiac one (Table 4).

Correlation between total serum calcium and albumin showed positive significant correlation in all groups, i.e. diminished albumin leads to decreased total calcium.

Correlation between ionized calcium and arterial pH showed a negative significant correlation in all groups, i.e. increased pH leads to decrease ionized calcium and vice versa.

Correlation between total and ionized calcium showed a positive significant cor-

Table (1):Results of the *t-test* Comparing Total Calcium in Different Groups to the Control Group.

Group studied	*t*	*p*	Significance
Chest	5.91535.62	< 0.01	Highly signifcant
Cardiac	84	< 0.001	Highly significant
Neurological	2.7988	< 0.05	Significant
Renal	5.8409	< 0.001	Highly significant

Table (2):Results of the *t-test* Comparing Iononized Calcium in Different Groups to the Control Group .

Group studied	*t*	*p*	Significance
Chest	2.4617	< 0.05	Signifcant
Cardiac	2.1130	< 0.05	Significant
Neurological	1.8914	> 0.05	Non- Significant
Renal	3.8067	< 0.05	Significant

Table (3): Results of the *t*-Test Comparing albumin in Different Groups to the Control Group .

Group studied	*t*	*p*	Significance
Chest	1.1936	> 0.05	Non Significancant
Cardiac	1.1891	> 0.05	Non-Signifcant
Neurological	1.1891	> 0.05	Non- Significant
Renal	2.717	< 0.05	Significant

Table (4). Results of the *t*-Test Comparing Arterial pH in Different Groups to the Control Group.

Group studied	*t*	*p*	Significance
Chest	3.0814	< 0.05	Significant
Cardiac	0.6543	> 0.05	Non-significant
Neurological	2.3558	< 0.05	Significant
Renal	2.2959	< 0.05	Significant

Table (5). Results of the *t*-Test Comparing Norm-Albuminemic to Hypo-Albuminemic Diseased Childern.

Item studied	*t*	*p*	Significant
Total calcium	5.3135	< 0.05	Significant
Ionized calcium	2.9798	> 0.05	Non-significant
Albumin	8.7834	< 0.0001	HighlySignificant
pH (arterial)	2.5105	< 0.05	Significant

relation in all groups except the renal group.

T-test comparing normo-to hypoalbuminemic patients showed significant difference in total calcium, such difference was not evident when comparing the ionized fraction (Table 5).

Discussion

Hypocalcemia is a frequent problem in seriously ill adults [4]. Furthermore, neonates, especially those with low birth weight, frequently suffer from hypocalcemia [5].

The aim of this work was to determine the frequency and impact of hypocalcemia in paediatric patients admitted to the I.C.U. for serious systemic illness.

Hypocalcemia is an important metabolic problem, since untreated, it may lead to a serious cardiac [6], pulmonary [7], neurological [8] and metabolic [3] sequelae.

In critically ill patients, acidosis decreases protein binding (increases serum ionized calcium) while alkalosis increases it (decreases serum ionized calcium) [9].

Abnormalities in parathyroid hormone or vitamin D metabolism also affect serum calcium level [9], serum albumin, the main binding protein to calcium affects greatly the total rather than the ionized calcium [10].

Our study demonstrated that total serum calcium was lower in all studied groups compared to the control group ($p < 0.05$). Cardenas-Rivero et al. [11] in 1989, reported that hypocalcemia on admission to their paediatric I.C.U. was a common problem in critically ill children.

Serum ionized calcium was also low ($p < 0.05$) except in the neurological group ($p > 0.05$). This was also true with Sanchez et al, [12] on determination of ionized calcium in a group of 15 actually ill children. In fact, most of available literature did agree with our results concerning total and ionized calcium levels when compared to normal control group.

Serum albumin showed a lower level ($p < 0.05$) in the renal group compared to normal control group. Zaloga et al [9] had reported that patients with renal failure have lower albumin levels, while cardiac patients have normal serum albumin level.

Correlation between total serum calcium and albumin showed +ve significant correlation in all groups ($p < 0.05$) , i.e. diminished albumin leads to decrease total calcium. this is in agreement with Zaloga et al. [9] who reported that serum albumin concentrations were < 3.5 gm/dl in 70% of the hypocalcemia patients.

Increase in pH leads to decrease in ionized calcium level (more binding of ionized calcium to proteins) and vice versa. this was reported by Zaloga et al. [9] (pH < 7.45).

Correlation between total and ionized calcium revealed a +ve significant correla-

tion in all groups ($p < 0.05$) except the renal group ($p > 0.05$). This may be explained by the excess loss of albumin due to renal affection.

*t-test comparing normo- to hypo-*albuminemic patients showed significant difference in the total calcium ($p < 0.05$), such a difference was not evident when comparing the ionized fraction. This is in agreement with Zaloga et al. [9] who reported that the hypoalbuminemic group (< 3.5 gm/dl) had a significantly lower total calcium, but disagree with him as regard the ionized fraction which was also decreased in his studied series. This could be explained on the basis that the ionized calcium level is not affected by the albumin level, also the method adopted by Zaloga et al. [9] in calculation of ionized calcium was the one depending on total calcium, total proteins and pH which is less accurate than the direct estimation method (Blood gas analyzer) used in our study.

We conclude that hypocalcemia is a common, often unrecognized problem in the critically ill paediatric patient. The total serum calcium concentration is a poor predictor of the more clinically relevant serum ionized calcium value. For that reason, we recommend that serum ionized calcium concentration should be measured in critically ill children and consequently calcium administration should be an adjuvant therapy in those children as a routine specially in those suffering from multi-system derangements, even if the total serum calcium is within normal value.

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