Original Research Article

Correlation between actual and pH corrected ionic calcium in critically ill pediatric patients

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Abstract

Introduction: Many authors have tried to prove a causal relationship between hypocalcemia and increased mortality in ICUs. For many years correction of ionic calcium for albumin level and magnesium levels has been done. In vivo the importance of calculated ionic calcium for changes in pH has not been very well studied. **Objective:** The objective of our study is to find out if ionic calcium values (iCa) need to be corrected and calculated for in vivo acid base imbalances in ICU settings. **Methods:** The study was a time bound prospective study done from November 2016 to May 2017 in PICU of Dr. B.R.A.M. Hospital, Raipur, Chhattisgarh. The ABGs and ionic calcium of all the critically ill children were collected according to inclusion & exclusion criteria. The iCalevels of the ABG machine was considered as the actual iCa value and the iCa values were corrected for pH of 7.4 using the standard formula. The differences in ionic calcium levels and corresponding calculated ionic calcium levels were statistically analysed for significance using "paired t test". **Results:** A total of 239 reports were studied, 80 records were acidotic, 78 exhibited normal pH and 81 had alkalosis. The difference between ionic calcium (iCa) and corrected ionic calcium (iCa_c) values were found significant [p=0.022] for moderate and severe acidosis. However, normal pH group [p=0.05186] and alkalosis group [p=0.0729] had insignificant differences. **Conclusion:** iCa, especially the actual iCa from the ABG reports should be considered for the treatment purposes specially in the case of acute acidosis.

Keywords: Calcium, Ionic calcium; Acid base imbalance

Introduction

Calcium is one of the most abundant minerals in the body [1], the importance of this element in the functioning of our skeletal system, blood coagulation mechanisms and maintenance of cell membrane integrity is well known. Acid base imbalances especially metabolic acidosis and alkalosis can alter the calcium albumin binding and affect the total calcium levels even in the presence of normal albumin levels [2,3]. The free and the biologically active form of calcium is called the ionic calcium and constitutes about 45 to 50% of the total calcium in the plasma [1].

Ionic calcium is maintained between 1.15 to 1.33 mmol/l by the parathormone and the activated vitamin D3, and is the most preferred test in critical situations. Total and calculated ionic calcium correlate poorly to the iCa levels and should not be used [4] in patients with acid base imbalances, renal and cardiac diseases. Studies show that the ionized calcium changes with the change in the pH of the specimen in vitro, causing a decrease in the ionized calcium concentration with an increase in the pH[5]. Animal studies have shown that acute changes in blood pH is the major determinant of changes in ionic calcium [6] because the binding of calcium to albumin is pH sensitive [7].

The changes in pH are inversely proportional to the ionic calcium levels and there may be a change of 5% for 0.1 unit change in pH[8]. So, strict collection techniques have to be followed in the sample collection for ionic calcium. The availability of bed side ABGs with inbuilt electrodes for ionic calcium since 1990s have made the assessment of ionic calcium easier in nearly all the ICUs. Few machines can give you corrected ionic calcium levels for the in vitro changes in

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pH[9], but very little is known about the effect of pH changes on iCa levels in vivo. This study was undertaken to study the effect of severe acid base imbalance on the ionic calcium levels.

Material and Methods

Type, Site and Duration of Study: The study was done in the PICU of Dr. B.R.A.M. HOSPITAL, Raipur, Chhattisgarh. It was a time bound prospective study done over 7 month period from November 2016 to May 2017.

All children hospitalized in PICU in Dr. BRAMH of age group >1month-14 years. from November 2016 to May 2017 participated in this study as per the inclusion and exclusion criteria.

Sampling Methods & Collection: The data was collected according to hospital records according to a predesigned proforma and approved by local ethics committee, which waived the need for an informed consent. ABGs were done as per treatment protocol, under aseptic conditions anaerobically by collecting blood in pre- heparinized radiometer syringes and immediately analyzed via ABL-80 radiometer. Age of the child was recorded in completed months or years.

The pH, ionic and serum calcium levels were recorded from hospital records and lactate levels >2 mmol/dl and hypoalbuminemia were excluded from study.

Inclusion Criteria: Age group: >1 mth-14years patients admitted for critical care in PICU of Pt. J N M Medical College Raipur and have acid base abnormality.

Exclusion Criteria

- Critically ill patients with no acid base imbalance
- Critically ill patients with hypoalbuminemia, anasarca and high lactate levels>2 mmol/dl

Data Collection: The data was collected according to hospital records according to a predesigned proforma and approved by local ethics committee, which waived the need for an informed consent. ABGs were done as per treatment protocol, under aseptic conditions anaerobically by collecting blood in pre- heparinized radiometer syringes and immediately analyzed via ABL-80 radiometer. Age of the child was recorded in completed months or years. The pH, ionic and serum calcium levels were recorded from hospital records and lactate levels >2 mmol/dl and hypoalbuminemia were excluded from study.

Corrected ionic calcium was calculated using the formula

iCa corrected= iCa-actual {1-0.53[7.4-pH-actual]}

The calculations were done separately for children with alkalosis, acidosis and normal pH.

Statistical Analysis- The values of actual and the calculated iCa were tabulated using the SPSS version of Microsoft excel 2013. The differences in ionic calcium levels and corresponding corrected ionic calcium levels were calculated and statistically analysed for significance using “paired t test”. The data was divided into acidotic, normal pH and alkalotic groups. Mean values were calculated for each group and p-value calculated for significance.

Results

The present study was conducted in the Paediatric ICU of Pt. J.N.M Medical College Raipur. Over a period of 7 months total 239 reports were studied, 80 records were acidotic, 78 exhibited normal pH and 81 had alkalosis.

In acidotic group significant [p=0.022] difference between ionic calcium and corrected ionic calcium values was found. However, there were statistically insignificant differences in normal pH group [p=0.05186] and alkalosis group [p=0.0729].

Table-1: Table comparing p-values of the study groups.

pH	mean value of		P- value	Significance
	ionic calcium	Corrected ionic calcium		
<7.35	1.030841463	0.925760265	0.0222	Significant
7.35-7.45	0.953466667	0.955820267	0.05186	Insignificant
>7.45	1.02962963	1.101559118	0.0729	Insignificant

Fig. 1

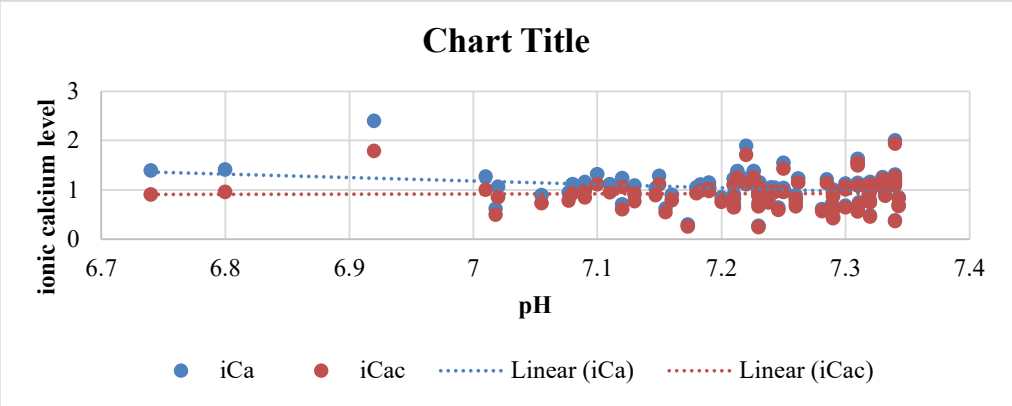

Fig-1: Graph showing comparison between ionic and corrected ionic calcium with change in pH in acidotic states

Fig. 2

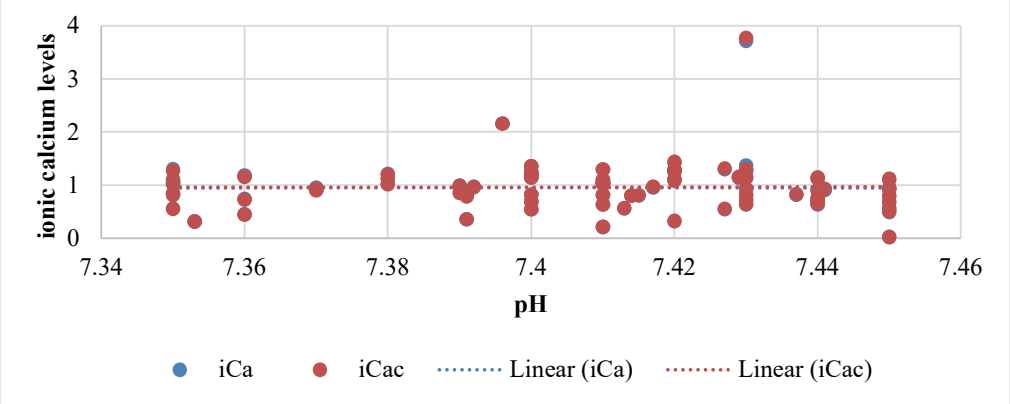

Fig-2: Graph showing comparison between ionic and corrected ionic calcium with change in pH in normal pH states

Fig. 3

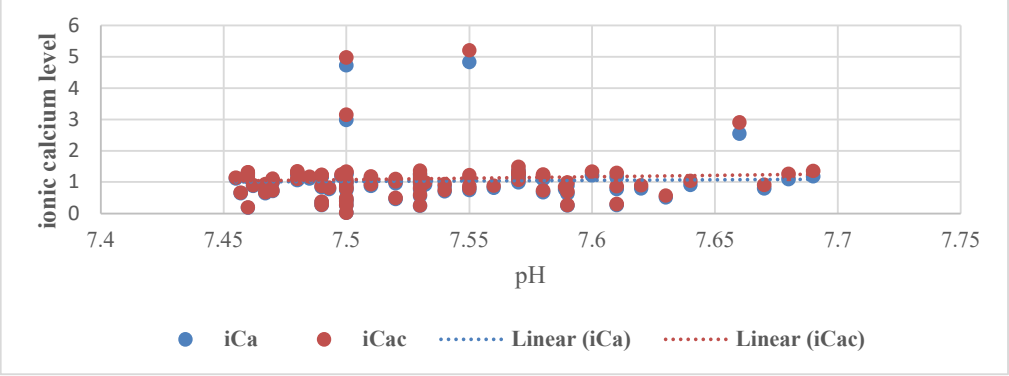

Fig-3: Graph showing comparison between ionic and corrected ionic calcium with change in pH in alkalotic states

The significant differences between ionic [iCa] and corrected ionic calcium [iCa_c] values in patients in acidosis complies that acidosis leads to underestimation of prevalence of hypocalcaemia. The underestimation is more marked at severe acidotic states. The iCa and iCa_c values were not significantly different in normal pH and alkalosis.

Discussion

Acid base imbalances are very common in critically ill pediatric patients, as also is electrolyte imbalance. The pediatrician needs to be armed with appropriate knowledge to deal with such situations meticulously. Singhi S C in 2003 found that the incidence of hypocalcemia and hypomagnesemia is high in sick pediatric patients and hypocalcemia is associated with significant increase in the mortality more so if hypocalcemia co-exists with hypomagnesemia [10,11] Ionic calcium is the biologically active form that is important in various metabolic activities of the body [8]; it is maintained in the plasma in a narrow range from 1.12 to 1.23 mmol regulated by Vitamin D and Parathyroid hormones [13]. For the purpose of the present study the any patient with a single episode of hypocalcemia was labelled as hypocalcemia. The incidence of hypocalcemia in our study was 73.5% which was comparable with a study done by Singhi SC et al [10,11] and various other studies show that the incidence is around 12 to 90%.

Acidosis is known to affect the secretion of parathyroid hormone and causes increased resorption of bones[14]. Acute metabolic alkalosis is associated with exaggerated hypocalcemia in intensive care [6]. The relationship of pH and calcium metabolism is linear and can be calculated correctly using the simple calculations [8].

The collection criteria of blood samples is stringent; the changes in the pH in vitro during travelling may cause a change in the calcium levels [12], hence, now the machines are coming with inbuilt software to correct the iCa levels to a pH of 7.4 to alleviate the changes caused during transport [9]. Moreover after late 1990s all the ABG machines have ionic electrodes that give the ionic calcium, and the iCa levels in the ABG are considered accurate to be used in critical care.The CLSI recommendations for ionized calcium measurements are [12]:

1. Ionized calcium should be reported as the actual measured iCa.
2. Use a pH-adjusted iCa only to correct the CO2 losses.

People have been working on to study the effects of calcium supplementation on the morbidity mortality and correction of calcium levels for years now bot we have not considered this aspect has not been studied in the present study, as the decision to correct or not to correct the calcium levels should be based on various factors like pH, Magnesium levels, Albumin levels and the QTc and not only on the iCa levels.

We aimed to study the relevance of ionic calcium actual and the report received by correction for pH; as to which is better in the case of acid base imbalance in critically ill children. Our results show that although the difference was insignificant in the patients with alkalosis; it was significant in the presence of moderate to severe acidosis. Alkalosis is usually associated with the exacerbation of hypocalcemia and prolonged QTc; but there is no significant difference between the actual and the calculated ionic Calcium levels;

Whereas, as far as acidosis is concerned the calculated values may be lower than that of the actual values; there it is essential to study whether it is an underestimation of calcium levels; by further studying the effects on ECG; the clinical signs of hypocalcemia are usually subtle andcan be easily missed in the very sick children.

Conclusion

So, this study concludes that there is no need for pH correction of iCa levels; but greater care should be taken in the intensive care units if severe acidosis or alkalosis.

Contribution of author

KR: Selection of topic for research, review of literature, writing of manuscript, SP: tabulation and statistical analysis, PB: review of literature, compilation of work, AV: data collection, review of literature.

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