Original Article

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Biochemistry Section

Correlation between Arterial and Venous Blood Electrolytes in Acute Exacerbation of Chronic Obstructive Pulmonary Disease: A Cross-sectional Study

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ABSTRACT

Introduction: Acute Exacerbation of Chronic Obstructive Pulmonary Disease (AECOPD) is a common health problem coupled with huge mortality and morbidity across the world. Acute exacerbation in COPD patients leads to electrolyte disturbances. Routinely, electrolytes are measured from venous blood. Electrolytes can also be measured from whole blood by blood gas analyser along with blood gases measurement.

Aim: To study the correlation between venous and arterial blood electrolytes in AECOPD patients.

Materials and Methods: The cross-sectional study was conducted at Clinical Biochemistry Laboratory, Government Medical College and Sir Takhtsinhji General Hospital, Bhavnagar, Gujarat, India, from December 2013 to May 2014. Arterial and venous blood were taken at same time from 150 patients of AECOPD and analysed for electrolytes (sodium, potassium and ionised calcium) in arterial blood gas analyser. Correlation of arterial and venous blood electrolyte levels was done by Pearson's correlation.

Results: This study comprised 109 (72.67%) male and 41 (27.33%) female AECOPD patients. Mean age of subjects was 59.01±11.42 years. Mean level of arterial sodium was 143.1±8.81 mmol/L and venous sodium was 144.8±8.47 mmol/L (p-value=0.0973). Mean level of arterial potassium was 3.53±0.73 mmol/L and venous potassium was 3.19±0.56 mmol/L (p-value <0.0001). Mean level of arterial ionised calcium was 0.83±0.13 mmol/L and venous ionised calcium was 0.76±0.17 mmol/L (p-value <0.0001). Correlation coefficient values for sodium, potassium and ionised calcium were 0.878, 0.762 and 0.537, respectively.

Conclusion: Arterial sodium and potassium can be used as a substitute of venous sodium and potassium in management of AECOPD patients, while arterial ionised calcium should not be used in place of venous ionised calcium in management of such patients.

Keywords: Arterial blood gas analyser, Ion selective electrode, Ionised calcium, Potassium, Sodium

INTRODUCTION

Worldwide, Chronic Obstructive Pulmonary Disease (COPD) is a major health problem with high mortality as well as morbidity. COPD is a common, preventable and treatable lung disease that is characterised by persistent airflow limitation and respiratory symptoms that is due to airway and/or alveolar abnormalities usually caused by significant exposure to noxious particles or gases [1]. COPD is an umbrella term used to cover chronic bronchitis, emphysema and chronic asthma. COPD exacerbation is an event in the natural course of the disease that is characterised by a change in the patient's baseline dyspnea, cough and sputum that is beyond normal day to day variations, is acute in onset and warrants a change in regular medication [2].

Regional COPD working group estimated an overall prevalence rate of 6.3% with a range from 3.5-6.7% [3]. In India, crude prevalence of COPD is about 4.2% in 2016 [4]. Patients of Acute Exacerbation of Chronic Obstructive Pulmonary Disease (AECOPD) presents with acute respiratory infections (cough, increase volume and purulence of sputum), oedema, fever, rapid worsened dyspnea, altered sensorium and other co-morbid illnesses. Altered sensorium in these patients may occur due to respiratory failure and metabolic abnormalities like hepatic dysfunction, uremia and electrolyte disturbance [5].

Majority of mortality and morbidity among AECOPD patients happens because of the co-morbid conditions related to it like dyselectrolytemia [6,7]. Electrolyte disturbance should be detected by its measurement as early as possible to prevent mortality and morbidity in such patients. Usually, electrolytes are measured in serum obtained from venous blood by electrolyte analyser in around 20-30 minutes, which may delay in assessing electrolyte disturbance in such patients.

Acute exacerbation in COPD is associated with nonuniform ventilation and ventilation perfusion mismatching leading to hypoxia and hypercarbia [8]. Management of AECOPD patient requires arterial blood gas analysis as it is gold standard to obtain information about oxygenation, ventilation and acid base status of body [9]. Arterial puncture may be complicated by local pain, infection, arterial injury, haemorrhage, thrombosis with distal ischaemia, peripheral emboli formation [10]. Electrolyte levels can also be checked simultaneously with blood gases and pH in arterial blood within five minutes by blood gas analyser. Thus, it overcomes delay in Turnaround Time (TAT) of electrolyte measured from venous blood.

Some previous published study shows good correlation between arterial and venous blood electrolyes [11,12], while some observed poor correlation between electrolyte measured from arterial and venous blood [13,14]. So, this study aimed to evaluate arterial and venous blood electrolytes (sodium, potassium and ionised calcium) level in AECOPD patients and to check correlation between arterial and venous blood electrolyte values.

MATERIALS AND METHODS

The cross-sectional study was conducted at Clinical Biochemistry Laboratory, Government Medical College and Sir Takhtsinhji General Hospital, Bhavnagar, Gujarat, India. Subjects were recruited from Emergency Department as well as from the tuberculosis and chest ward of hospital. All subjects were recruited from December 2013 to May 2014. Ethical approval was taken from Human Ethics Committee, Government Medical College, Bhavnagar {R.No. IRB (HEC) 259/2012 Biochemistry no.12/2012.}.

The participants were 150 previously diagnosed COPD patients presented with acute exacerbation. Patients were diagnosed of

COPD by history and spirometry findings of lung function. Pulmonary function tests showing low FEV1 with FEV1/FVC ratio (<70%) was used as a diagnostic criterion for COPD [15].

Inclusion criteria:

- Patients of both genders and age more than 40 years
- Patients with prior diagnosis of COPD by pulmonary function test presenting with acute exacerbation
- AECOPD confirmed by obtaining history from the patient like recent increase in cough, wheezing, volume and purulence of sputum or shortness of breath necessiting a change in regular medication like corticosteroids or antibiotics.

Exclusion criteria: Patients with diabetes mellitus, renal failure, congestive heart failure, pneumothorax, restrictive pulmonary disease, pulmonary embolism and those having unstable haemodynamic status were excluded.

Study Procedure

After taking informed consent from all participants, 1 mL arterial blood from radial artery and 1 mL venous blood from antecubital vein were collected simultaneously in heparinised syringe. Samples were transported in icepacks to the central biochemistry laboratory where both arterial and venous blood were analysed in Eschweiler blood gas analyser for Na^+, K^+ and Ionised calcium. Arterial Blood Gas (ABG) analyser analyser was checked daily by performing internal quality controls. Eschweiler blood gas analyser uses direct Ion Selective Electrode (ISE) principle for determination of the activity of ions (sodium, potassium and ionised calcium) in aqueous media were analysed by method [16].

STATISTICAL ANALYSIS

Graph pad Prism 5.0 software was used for statistical analysis of result data. Result data are presented as mean±SD. Study results were compared by using t-test. Arterial and venous values of the study parameters of patients were correlated by Pearson's correlation coefficient test. All tests were applied at 95% confidence interval. Significance of the test results were decided according to p-value (p-value <0.05=significant, p-value <0.001=highly significant and p-value ≥0.05=not significant).

RESULTS

This study comprised 109 (72.67%) male and 41 (27.33%) female AECOPD patients. Mean age of subjects was 59.01±11.42 years [Table/Fig-1].

Age (years)	No. of cases	Percentage (%)
41-50	44	29.4
51-60	48	32.0
61-70	35	23.3
71-80	17	11.3
81-90	06	4.0
Total	150	100
Mean±SD	59.01±11.42 years	

[Table/Fig-1]: Age distribution of subjects.

Significant difference was found in arterial and venous values of potassium and ionised calcium (p-value <0.0001), but difference in sodium values was not significant (p-value=0.0973) [Table/Fig-2].

Parameter	Arterial blood (n=150)	Venous blood (n=150)	p-value (t-test)
Sodium (Na^+) (mmol/L)	143.1±8.81	144.8±8.47	0.0973
Potassium (K^+) (mmol/L)	3.53±0.73	3.19±0.56	<0.0001
Ionised calcium (Ca^{++}) (mmol/L)	0.83±0.13	0.76±0.17	<0.0001

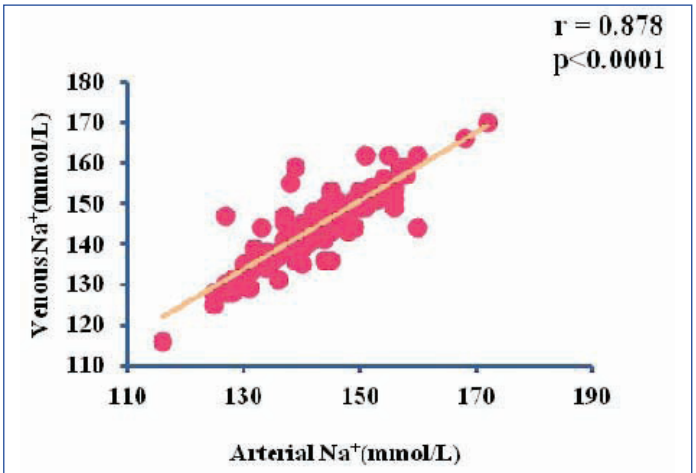
[Table/Fig-2]: Study parameters in arterial and venous blood of patients.

The sodium level was lower in arterial samples than venous samples, but potassium and ionised calcium level showed an opposite trend. Correlation coefficient values for sodium, potassium and ionised calcium were 0.878, 0.762 and 0.537, respectively [Table/Fig-3].

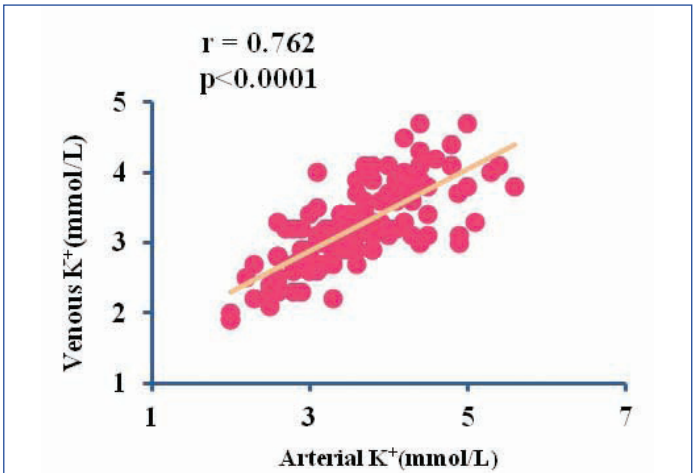
Parameter	Pearson coefficient (r)	p-value
Na^+	0.878	<0.0001
K^+	0.762	<0.0001
Ionised Ca^{++}	0.537	<0.0001

[Table/Fig-3]: Correlation of study parameters of arterial and venous blood in patients.

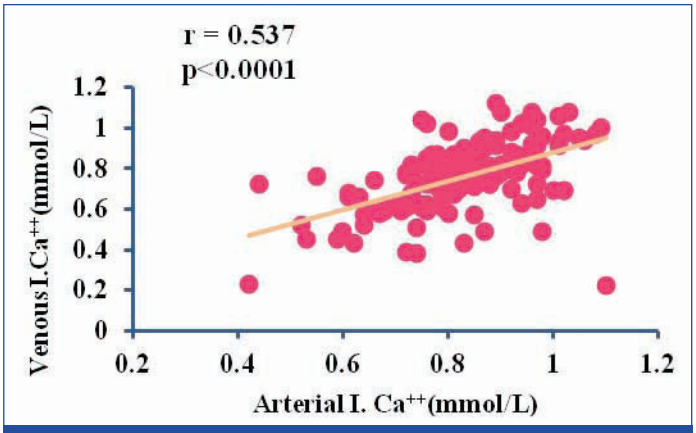
Sodium and potassium showed strong positive correlation between arterial and venous blood values while ionised calcium shows moderate correlation [17]. Relationship between arterial and venous values of sodium, potassium and ionised calcium are plotted in [Table/Fig-4-6], respectively. Relationship analysis shows venous



[Table/Fig-4]: Correlation between arterial and venous blood sodium.



[Table/Fig-5]: Correlation between arterial and venous blood potassium.



[Table/Fig-6]: Correlation between arterial and venous blood ionised calcium.

values can be derived from arterial values by formula. Venous blood sodium can be derived from arterial blood sodium by linear regression formula,

Venous blood sodium=0.8442×arterial blood sodium+23.96.

Venous blood potassium can be derived from arterial blood potassium by linear regression formula,

Venous blood potassium=0.5844×arterial blood potassium+1.128.

DISCUSSION

Electrolyte levels should be measured and corrected during treatment of AECOPD to decrease mortality [6]. TAT of electrolyte reports can be reduced by its measurement from arterial blood by point of care instrument like ABG analyser rather than from venous blood by conventional method [18]. In addition ABG analysis is done in all AECOPD patients to check the acid base and ventilation status of body, so along with that electrolytes can also measured which alleviate venous blood sampling and processing for same purpose. This will help in cost effectiveness in clinical practices.

Results of the present study shows that mean value of arterial sodium is lower than venous blood sodium, while mean value of potassium and ionised calcium in arterial blood is higher than venous blood values. A study found higher levels arterial potassium as compared to venous potassium, which is comparable to the index study [18]. Lower mean arterial sodium than venous sodium, was observed by Nanda SK et al., and Gupta S et al., similar to this study [11,19]. Jain A et al., compared arterial blood gas and venous sodium and potassium values and reported no significant difference between potassium values but statistical significant difference between sodium values. They concluded that potassium values obtained from the arterial blood gas analysis can be used to make critical decisions in intensive care unit [20]. In the present study, difference between arterial and venous sodium was not significant while arterial and venous potassium and ionised calcium was statistically significant. The study conducted by Quinn LM et al., observed no significant difference between sodium and potassium values in venous and arterial blood within physiological range, but results should be interpreted with caution (if potassium >5 mmol/L) and measurements should be verified with standard venous samples [21]. Chacko B et al., observed significant difference between arterial and venous sodium with moderate correlation, while arterial and venous potassium was significantly different with good correlation [22].

The present study results shows sodium and potassium values positively correlated in arterial and venous blood of AECOPD patients with strong correlation. Arterial and venous blood level of ionised calcium positively correlated with moderate correlation. Awasthi S et al., found excellent correlation between sodium and potassium of arterial and venous blood, which supports present study findings [23]. Bilkovski RN et al., observed excellent correlation in the measurement of ionised calcium between venous and arterial blood gas samples [24]. A good correlation between arterial and venous potassium was observed by Wongyingsinn M et al., and concluded arterial potassium can be used as a guideline of treatment inplace of conventional venous potassium [25]. Uysal E et al., observed strong correlation for arterial blood gas analyser measurements of sodium, potassium, haemoglobin, haematocrit and glucose but only moderate correlation for chloride levels between arterial and venous blood. Although, these parameters as measured by a blood gas analyser found reliable in critical decision making but must be confirmed by core laboratory result [26]. Chhapola V et al., concluded that if arterial samples are collected in liquid heparinised containers, arterial blood gas analysers underestimate sodium and potassium levels [27].

Limitation(s)

Results of both arterial and venous blood electrolytes were limited to blood gas analyser only. Both arterial and venous blood samples were collected using conventional syringes containing liquid heparin. The use of dried heparin syringes could improve the accuracy of the results.

CONCLUSION(S)

Arterial sodium and potassium are strongly correlated with venous sodium and potassium, while arterial ionised calcium shows moderate correlation with venous ionised calcium. Arterial sodium and potassium can be used as a substitute of venous sodium and potassium in management of AECOPD patients, while arterial ionised calcium should not be used in place of venous ionised calcium in management of such patients.

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