EXCELLENT PUBLISHERS

International Journal of Current Research and Academic Review

ISSN: 2347-3215 Volume 2 Number 8 (August-2014) pp. 118-124

www.ijcrar.com

Arterial to $ETCo_2$ difference in patients with acute renal failure

Rozbeh Rajaei Ghafori[1], Ali Taghizadieh[1]*, Nafiseh Farhan[1], Jalal Etemadi[2], Hassan Solimanpoor[1], Farzad Rahmani[1] and Mohammad Mirzaaghazadeh[3]

[1]Emergency Medicine Department, Faculty of Medicine, Tabriz University of medical sciences, Tabriz, Iran
[2]Chronic Kidney Disease Research Center, Tabriz University of Medical Sciences, Tabriz, Iran
[3]Internal Medicine Department, Faculty of Medicine, Tabriz University of Medical Sciences, Iran
**Corresponding author*

KEYWORDS

Renal Failure, Metabolic Acidosis, Capnography

A B S T R A C T

One of the most common disorders in patients with renal failure is metabolic acidosis, and if that is refractory to medical therapy, is indicated for initiation of dialysis treatment. There are challenges on how to measure acidosis-y-alkalosis levels. Capnography is non-invasive device to measure end-tidal carbon dioxide partial pressure. The aim of this study was to investigate the relationship between the levels of end-tidal carbon dioxide acidosis with acidosis level in patients with acute renal failure. In a cross-sectional and descriptive - analytical study that performed in emergency ward of Tabriz University of Medical Sciences on patients with renal failure, correlation of end-tidal carbon dioxide levels with acidosis level in patients with acute renal failure evaluated. 12(55.6%) of patients were male and 12(44.4%) of them were female. Mean age of male patients was 56.69 ± 21.77 year and in female patients was 55.756 ± 12.90 year. Mean Co_2 level with Capnography in patients was 16.03 ± 6.57 and mean Co_2 level with ABG in patients was 26.85 ± 5.55. Significant direct liner correlation was found between Co_2 level with Capnography with PH, PCo_2, HCo_3 and BE level in ABG. In patients with acute renal failure, Cut-off-Point ET-Co_2 with Ph=7.3 and Hco3=15 Was calculated 24.

Introduction

ARF (Acute Renal Failure) is referred to the rapid decline of kidney function that causes the retention of nitrogenous substances and blood biochemical disorder so that an increase in serum Creatinine and blood urea is its symptoms (1-3).

The risk of ARF (Acute renal failure) will be considered, if the serum Creatinine level is twice the maximum of normal (considering the age) (4). Although the most prominent symptoms of acute renal failure are anuria and oliguria, but they are found in less than

half of ARF patients (5). The incidence of AKI (Acute kidney injury) has been recently replaced to the ARF and its prevalence is reported as 25/0% in normal population, 18% in hospitalized patients and 30-60% in critically ill patients. The prevalence of AKI is equal to the MI (Myocardial infarction) incidence (7). The AKI is independently associated with the increased risk of death which is linearly dependent on the severity of AKI (8). The high rate of mortality (28%) is observed in the AKI patients hospitalized in ICU compared with the patients without a diagnosis of AKI (8.1%). Furthermore, the hospitalization period for the AKI patients is more (7days vs. 3 days) (9). ABG (Arterial Blood Gas) sampling is an invasive and painful procedure for the patient which is also time-consuming for the medical staff (5).

This approach sometimes leads to spasms, and damage to the artery wall. Absolute contraindications for ABG sampling include the following:

Insufficiency of blood flow in the distal extremities, Reynaud's syndrome, Burger's disease and full-thickness burn Relative contraindications for ABG sampling include the following:

Previous surgery in the mentioned area (particularly Cut Down), coagulation disorders, skin infections in the mentioned area and atherosclerosis (11)

The end-tidal partial pressure of carbon dioxide ($ETCo_2$) has a closely relationship with arterial carbon dioxide pressure. The relationship been approved with Capnography through the nose in normal children has. This relationship has also been confirmed in DKA (diabetic ketoacidosis) children who have a substantial drop in arterial CO_2 levels. Patients with metabolic acidosis have deep and rapid ventilation which leads to a fall in alveolar CO_2 pressure and also reducing the amount of CO_2 in arterial pressure. This compensatory response could reduce the acidemia severity which is considered as a predictable method. Based on this close relationship, $ETCO_2$ could be used in order to determine the severity of acidosis in patients with metabolic acidosis.

Capnography is a non-invasive device to measure $ETCO_2$. It has a connector which is attached into the intubated patients' endotracheal tube and near the non-intubated patients' mouth. Information obtained from the probe is collected by the sensors and would be analyzed by the device and finally the results (respiratory rate in 1 minute, the end-tidal pressure of carbon dioxide) would be displayed in monitor. However, in Emergency hospitals the Capnography is not used as a routine, non-invasive method for assessing ventilation in emergency hospitals (12). Although most of these researches have been conducted on the pediatric age group or further studies in larger sample size has been suggested, the Capnography is still recommended as a non-invasive and readily available method to evaluate the presence and severity of acidosis. However, no study has been conducted to examine the relationship between the levels of $ETCO_2$ by use of Capnography and the need for emergency dialysis on the patients with renal insufficiency.

Whereas the ABG sampling is an invasive and painful procedure for the patient which is also expensive method or time-consuming for the medical staff and also it could be occasionally associated with an increased patient morbidity, thus in this research it was decided to investigate the association between the severity of acidosis and $ETCO_2$

levels and also the need for emergency dialysis for the patients with renal insufficiency hospitalized in the emergency ward of Imam Reza hospital at Tabriz.

The aim of this study was to investigate the relationship between the levels of end-tidal carbon dioxide with the acidosis severity on the patients with acute renal insufficiency.

Materials and methods

In a descriptive prospective study conducted in Emergency Department at Medical Sciences of Tabriz University on the patients with renal insufficiency, the relationship between the ($ETCO_2$) level with the acidosis severity and also the need for emergency dialysis on the patients with acute renal insufficiency. According to the study criteria, 27 patients were selected among patients with acute renal insufficiency and enrolled to this research. In this study, all patients were candidates for emergency dialysis. In this study, after recording the vital signs and obtaining the written consent, all patients who were candidates for emergency dialysis were enrolled.

Capnometry was initially performed by use of the portable Capnography device in the emergency ward (respironics) and the ($ETCO_2$) level was recorded. The ABG sampling and the Capnography were simultaneously performed for all patients. The calibrate ABG device was used for ABG analysis in all cases. Capnography device was calibrated by experts and Capnometry was performed for all the patients.

The Exclusion criteria included the following:

The cases with high blood sugar level over 200, pulmonary edema and COPD patients. Then the levels of electrolytes, urea and Creatinine were measured and recorded. The blood PH level and acidosis rate were measured by use of the arterial blood gas analyzer machine after obtaining the ABG or VBG and the results were recorded. There was no ethical problem due to the noninvasive interventions performed in our study.

Result and Discussion

In this study, a comparison was made between levels of $ETCO_2$ and arterial blood bicarbonate in 27 patients visiting the emergency department of Imam Reza Hospital. The patients were experiencing acute renal failure with metabolic acidosis and the following results were obtained following the comparison:

Of the patients under study, 15 patients (55.6%) were male and 12 (44.4%) were female. The mean age of male and female patients was 56.69 ± 21.77 years and 55.75 ± 12.90 years, respectively (P=0.898) (Diagram I).

The CO_2 levels of patients measured through Capnography and ABG were 16.03 ± 6.57 and 26.85 ± 5.55, respectively (P<0.001). Capnography showed a CO_2 level that was significantly 10.81 ± 5.31 units less than the value obtained through ABG (Arterial Blood Gas).

The relationship of CO_2 level measured through Capnography with PH levels (P=0.216 and r=0.246), PCO_2 levels (P<0.001 and r=0.628), HCo_3 levels (P<0.001 and r=0.745), and BE levels (P=0.052 and r=0.401) of arterial blood of participants was found to be a linear direct significant relationship.

Table I presents experimental findings obtained from patients while Diagram II

shows the range of CO_2 levels of patients measured through Capnography and ABG.
The cut-off point of ETCo2 levels calculated for PH=7.3 and HCo_3=15 using the ROC curve was 24 in patients with acute renal failure (Diagrams III and IV).

Metabolic acidosis is commonly determined using the ABG method, but taking arterial blood samples is an aggressive, painful, time-consuming and costly method with side effects. Hence, it sounds rational to employ an alternative non-aggressive method to determine the presence of metabolic acidosis. The natural balance between acids and bases is vital to proper function of cells. The balance is maintained by lungs, kidneys, and serum physiological buffers. Disorders such as vomiting, diarrhea, respiratory failure, and renal dysfunction as well as intake of toxic substances can disturb the balance between acids and bases and thus endanger human life. Therefore, proper diagnosis and treatment of these life threatening factors is only possible by measuring and calculating acids and bases contents. In case of acid-base imbalance, it is necessary to take quicker and further actions and even hospitalize the patient.

Review of previous research suggests that Capnography is recommended as a non-aggressive and available means of assessing the presence and intensity of acidosis (13). Today, Capnography is considered a valuable method for diagnosis and effective treatment of some critical conditions such as bronchospasm, the need for muscle relaxants in unconscious patients, central apnea, and assessment of respiration using bags and masks (14-18).

Moreover, ABG is costly for patients and time-consuming for emergency department personnel. It is also an aggressive and painful procedure and sometimes even leads to an increase in morbidity of patients. Hence, it sounds rational to replace this method with a non-aggressive means of assessing the presence and intensity of acidosis in patients.

Nagler et al. analyzed the relationship between the levels of $PETco_2$ and serum bicarbonate for concentrations less than 17, 15 and 13 through Capnography. They stated that there is a significant direct relationship between these two variables. They also recommended using Capnography as a non-aggressive means of assessing the intensity of acidosis in children with gastroenteritis (19).

Fauzia Aniskhan et al. analyzed the results of arterial blood sample examinations to determine the levels of CO_2 through Capnography. They stated that there is a moderate relationship between $PaCO_2$ and $ETCO_2$ and suggested that this relationship requires complementary research on more samples (20).

Hasani et al. carried out a study on 40 patients under CABG and examined levels of $PaCo_2$ and $ETCO_2$. They stated that there is a significant direct relationship between the aforementioned two parameters before and after operations (r=0.754 and r=0.685). They suggested that it is possible to measure PaCo2 through Capnography instead of taking arterial blood samples (21).

The present study revealed the existence of a significant direct relationship between levels of CO_2 obtained through Capnography and levels of PCO_2 of arterial blood samples ($P<0.001$ and r=0.628).

Mutlu Kartal et al. conducted a study on non-intubated patients with metabolic acidosis and examined the levels of $ETCO_2$, $PaCO_2$ and HCO_3. These researchers reported a moderate relationship between the aforementioned parameters.

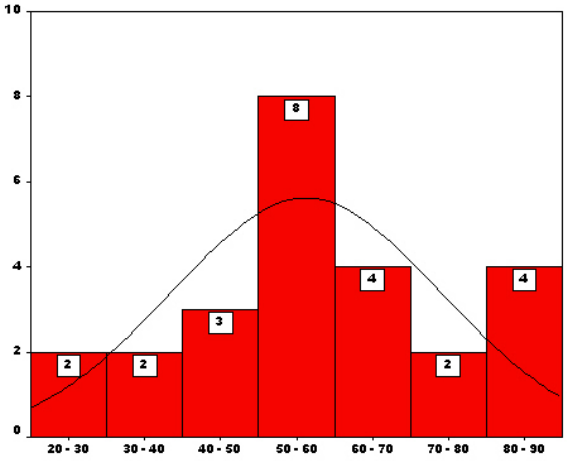

Diagram I: Age distribution of patients

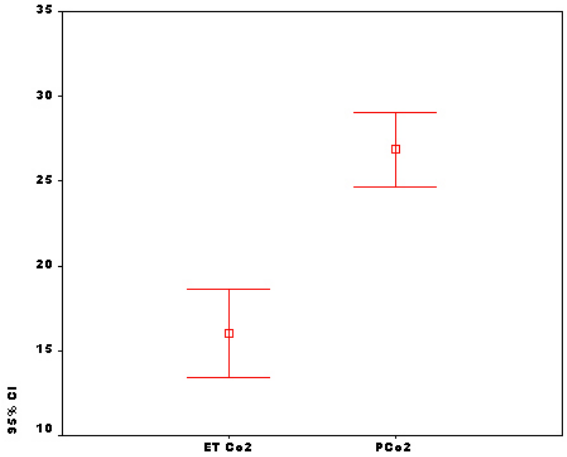

Diagram II: Distribution of $ETCO_2$ and PCO_2 of patient with metabolic acidosis due to renal failure

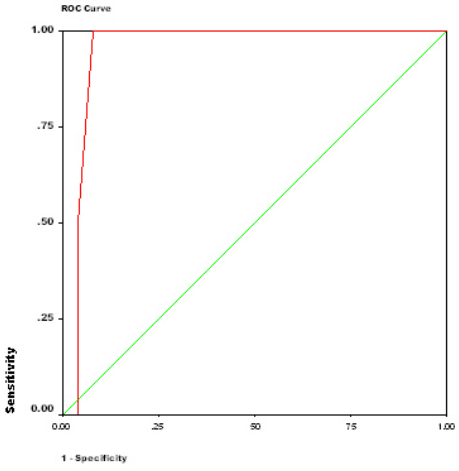

Diagram III: ROC diagram of ETCo2 of patient with ARF base on PH=7.3(Cut off point=24)

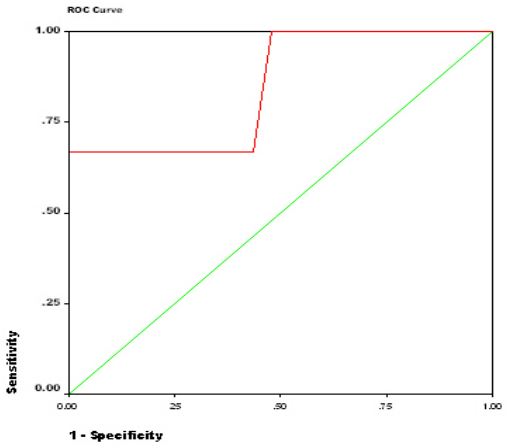

Diagram IV: ROC diagram of ETCo2 of patient with ARF base on HCo3=15(Cut off point=24)

They concluded that it is possible to predict metabolic acidosis and mortality of patients using $ETCO_2$ levels (22).

Solana Garcia et al. recommended using Capnography as a non-aggressive means of measuring acidosis in children suffering from acute diarrhea and dehydration (23). In another study by Dierdre et al. the levels of $ETCO_2$ was measured in patients susceptible to DKA (Diabetic Ketoacidosis). They stated that there is a significant relationship between ETCO2 and blood bicarbonate in patients with DKA (24).

The present study also showed a significant direct relationship between levels of CO2 obtained through Capnography and HCO_3 of arterial blood ($P<0.001$ and $r=0.745$). Agus et al. studied Capnography results to determine the intensity of acidosis in patients susceptible to DKA (25). In another study by Gilhorta et al., the results of Capnography and VBG of participants were examined. These researchers argued that a combination of Capnography and clinical assessments may help predict DKA. They concluded that more studies with more samples were required to be able to extend the results (26).

Table.I Laboratory finding of patients with acute renal failure

	Gender		P
	Male	Female	
HB	9.96 ± 2.02	11.71 ± 1.44	0.018
BUN	142.93 ± 84.35	163.67 ± 88.68	0.541
Cr	10.57 ± 5.19	8.54 ± 3.88	0.271
Na^+	137.93 ± 4.43	138.92 ± 5.76	0.620
K^+	5.49 ± .71	5.55 ± .82	0.849
BS	133.79 ± 44.24	113.70 ± 28.79	0.192
PH	7.23 ± .19	7.22 ± .09	0.854
HCO_3	10.77 ± 3.98	11.85 ± 2.98	0.457
PCO_2	26.17 ± 5.57	27.71 ± 5.67	0.487
BE	-15.01 ± 5.06	-11.91 ± 10.24	0.337

Conclusion

The mean levels of CO_2 obtained through Capnography and ABG were 16.03 ± 6.57 and 26.85 ± 5.55, respectively. The mean level of CO_2 of patients measured through Capnography was significantly less than the level of CO_2 obtained through ABG. The level of CO_2 of patients measured through Capnography is significantly 10.81 ± 5.31 units less than results of ABG. In addition, the relationship of CO_2 levels with levels of PH, PCO_2, BE, and HCO_3 of arterial blood samples was shown to be direct and significant.

References

1. Solymani M, Askari M. 2004. Critical care nursing in dialysis, CCU and ICU. 2nd ed. Tehran: Bushra Publication.
2. Strivastava RN, Bagga A. 2005. Acute renal failure, In: Strivastava RN, Bagga A. Pediatric nephrology, 4th eds, New Delhi, Jaypee Brothers: 201-25.
3. Andreoli SP. 2004. Clinical evaluation and management of acute renal failure. In: Avner ED, Harmon WE, Niadet P. Pediatric nephrology, 5th ed. Philadelphia: Lippincott Williams & wilkins: 1233-46.
4. Bailey D, Phan V, Litalien C, Ducruet T, Merouani A, Lacroix J, et al. Risk factors of acute renal failure in critically ill children: A prospective descriptive epidemiological study. Pediatr Crit Care Med. 2007; 8(1):29-35.
5. Devarajan P, Goldstein SL, Acute renal failure In: Kher KK, Schnarper HW, Makker SP. Clinical Pediatric nephrology, 2th ed, London: Informa 2006: 363-74.
6. Bellomo R, Ronco C, Kellum JA, Mehta RL, Palevsky P, Acute Dialysis Quality Initiative workgroup. Acute renal failure – definition, outcome measures, animal models, fluid therapy and information technology needs: the Second International Consensus Conference of the Acute Dialysis Quality Initiative (ADQI) Group. Crit Care. 2004;8:R204–12.
7. Singbartl K, Kellum JA. AKI in the ICU: definition, epidemiology, risk stratification, and outcomes. Kidney Int. 2012; 81:819–25.
8. Kellum JA, Bellomo R, Ronco C. Kidney Attack. JAMA. 2012 May 9. [Epub ahead of print]
9. Ricci Z, Cruz D, Ronco C. The RIFLE criteria and mortality in acute kidney injury: A systematic review. Kidney Int. 2008;73:538–46.
10. Piccinni P, Cruz DN, Gramaticopolo S, Garzotto F, Dal Santo M, Aneloni G, et al; NEFROINT investigators. Prospective multicenter study on epidemiology of acute kidney injury in the ICU: a critical

care nephrology Italian collaborative effort (NEFROINT). Minerva Anestesiol. 2011;77:1072–83.
11. Rambod H. Chronic renal failure. Sci Dial Patient Nurs Phys. 2008;3(36):1-2. [Persian]
12. Dave Milzman and Tim Jancbar(2010). Arterial Puncture and Cannulation. In: James R. Roberts: Clinical Procedures in Emergency Medicine,1,5. Saunders,United States of America.349-363.
13. Soleimanpour, Hassan, Changiz Gholipouri, Samad EJ Golzari, Farzad Rahmani, Majid Sabahi, Allan R. Mottram, Lawrence A. DeLuca et al. "Capnography in the Emergency Department." Emergency Med 2 (2012): e123.
14. Mutlu K. et al(2011). ETCO2: a predictive tool for excluding metabolic disturbances in nonintubated patients. American Journal of Emergency Medicine,2011(29).65-69.
15. Ron M. Walls(2010). Airway. In: John A. Marx: Rosen's Emergency Medicine,2, 7. Mosby, Philadelphia,3-22.
16. Hassan Soleimanpour, Changiz Gholipouri, Jafar R Panahi, et al (2011) Role of anesthesiology curriculum in improving bag-mask ventilation and intubation success rates of emergency medicine residents: a prospective descriptive study BMC Emerg Med. Jun 16;11:8.
17. Hassan Soleimanpour, Shaker Salari Lak, Hamidreza Mehryar, et al (2011) The Effect of Using Packed Gauze in the each buccal cavity of Edentulous Patients on facility of Bag Mask Ventilation after removing dentures Urmia Medical Journal 22(3):195-202.
18. Soleimanpour H, Sarahrudi K, Hadju S, Golzari SEJ (2012) How to Overcome Difficult-Bag-Mask-Ventilation: Recents Approaches. Emergency Medicine, 2:e116
19. Soleimanpour H, Panahi JR, Mahmoodpoor A, Ghafouri RR. Digital intubation training in residency program, as an alternative method in airway management. Pak J Med Sci, 2011;27(2):401-404
20. Nagler J, Wright RO, Krauss B.(2006). End-tidal carbon dioxide as a measure of acidosis among children with gastroenteritis. Pediatrics.118(1).260-267.
21. Fauzia A, Mueenullah K, Shemila A.(2007). Arterial to End-Tidal Carbon Dioxide Difference in Neurosurgical Patients undergoing Craniotomy: A Review of Practice. Journal of Pakistan Associatio,57(9).446-448.
22. End tidal CO2 versus arterial CO2 monitoring in patients undergoing coronary artery bypass graft. Hassani E, Farasatkish R, Heydarpour E, Totoonchi MZ, Mahoori AR. Tehran University Medical Journal, 2009;67(9) : 650-654
23. Mutlu K. et al(2011). ETCO2: a predictive tool for excluding metabolic disturbances in nonintubated patients. American Journal of Emergency Medicine,2011(29).65-69.
24. Solana García MJ. Et al(2008). Use of capnography in acute gastroenteritis. Annals of Pediatrics,68(4). 342-345.
25. Deirdre M. Fearon, Dale W. Steele(2002). End-tidal Carbon Dioxide Predicts the Presence and Severity of Acidosis in Children with Diabetes. Academy of Emergency Medicine,9(12), 1373-1378.
26. Agus MS, Alexander JL, Mantell PA(2006). Continuous non-invasive end-tidal CO2 monitoring in pediatric inpatients with diabetic ketoacidosis. Pediatrics Diabetes,7(4).196-200.
27. Gilhotra Y, Porter P.(2007). Predicting diabetic ketoacidosis in children by measuring end-tidal CO2 via non-invasive nasal capnography. Journal of Paediatric Child Health,43(10).677-680.