IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 13, Issue 9 Ver. VII (Sep. 2014), PP 37-43
www.iosrjournals.org

Etiologies and Outcomes of various types of Acid-Base Disorders in Respiratory intensive care unit

J.V.Praveen[1], V.V.Ramana Reddy[2], Ganeswar behera[3], D.S.S.Sowjanya[4], B.K.Prithvi[5], G.Ramya[6],
[1]assistant professor, [2]professor, [3]professor and HOD, [4 5 6]postgraduate students
Department of Pulmonary Medicine, Maharajah's Institute of Medical Sciences, NTR University of health sciences, India.

Abstract:
Objective: *Acid-base disorders (ABDs) are usually correlated with high rates of morbidity and mortality. The objective of this study was to analyze the causes, outcomes, and types of ABDs in patients presenting at the Respiratory intensive care unit (RICU).*
Material and Methods: *We prospectively analyzed data from 80 patients who presented between july2012 and august 2014. Data on age, gender, chief complaint, diagnosis and outcomes in the RICU were collected for ABD cases.*
Results: *Of the 80 cases with an ABD, 32 patients (40%) had simple ABD and 48 patients (60%) had mixed ABD. The most common ABD was a mixed respiratory acidosis and metabolic alkalosis (RACMAL) (n=28, 35%). All ABD types were most commonly observed in patients over 60 years of age. In cases of ABD, COPD was the most common diagnosis (30%). Of the ABD cases, 44 patients (55%) were treated and discharged without needing ventilator support (invasive or noninvasive). 20 patients (25%) improved with NIV (non invasive ventilation), 7 patients (8.75%) recovered after receiving IV (invasive ventilation) while 9 patients (11.25%) died even with IV. Death was more commonly observed in cases with mixed metabolic and respiratory acidosis (MACRAC) (n=4). The most common etiology among intubated and survived cases is COPD (chronic obstructive pulmonary diseases) (n=5, 71.42%), and among intubated and expired cases is ARDS (acute respiratory distress syndrome)/ sepsis (n=7, 77.78%)*
Conclusion: *ABDs are quite common in patients presenting at the RICU, especially among patients in a critical condition (71%). Mixed RACMAL was the most commonly noted ABD. COPD was the most common diagnoses in ABD patients followed by pneumonia and ARDS. Mortality was more common in cases with a mixed MACRAC. High mortality was seen in the ARDS/sepsis cases. This knowledge may provide important information concerning the diagnosis, treatment and early prognosis of patients.*
Key words: *Acid-base disorders, types, RICU, etiology, outcomes*

I. Introduction

Acid-base homeostasis is crucial to the normal function of body. If acid-base disorder (ABD) is not detected timely, it may lead to serious or potentially fatal conditions(1).Arterial blood gas (ABG) testing is widely used in RICU to evaluate metabolic and respiratory functions (pCO2, pH and pO2). In addition, this test can help to guide the diagnosis and treatment of many patients and can offer details concerning the severity of a case (1). It is usually correlated with high rates of morbidity and mortality (2). The types, causes, treatments and outcomes of ABD in patients presenting at the RICU have not been extensively reported.

In general, it is difficult to make the diagnosis of ABD, effectively manage its treatment and fully understand the complications associated with this condition and its impact on organ function. ABD should be suspected in every patient with abnormal vital signs. The four main types of ABDs (respiratory and metabolic acidosis, respiratory and metabolic alkalosis) are described as simple ABD, while having two or more simple ABDs together is defined as mixed ABD (3). The aim of this study is to analyze the types, causes, treatment and outcomes of ABD in patients admitted to the RICU, and to explore whether an early diagnosis of ABD in critical illness would improve prognosis.

II. Material And Methods

In this prospective observational study, we included adult patients presenting at the RICU of the Maharajah's Institute of Medical College between july2012 and august 2014. A total of 105 patients who presented with various complaints were enrolled in the study. Exclusion criteria are as follows: those patients who died on or before arrival; those who were transferred out of critical care area within two hours of arrival;

patients with "Do Not Resuscitate" orders; trauma patients, those with missing data, and inappropriate blood gas samples.

2.1 Study Protocol

The age, gender, primary disease, underlying problems, complications, duration of stay in RICU, treatment given and outcome were collected. ABG samples were collected immediately after presentation to the RICU. Adult patients who required ABG on the basis of their clinical condition were included in the study. ABG samples were taken from the femoral or radial artery. The samples were collected in heparinized syringes, and the Tests were run on the blood gas analysis analyzer (EPOC alere ABG analyser) (Fig. 1). ABG results were interpreted by our teaching assistants and checked by the senior professor. Analysis of the ABG included pH values, the partial pressure of arterial carbon dioxide (PaCO2), partial pressure of the arterial oxygen (PaO2), bicarbonate (HCO3), and the anion gap (AG). The pH values of 7.35-7.45 and ABG values, including PaO2 80-100 mmHg, PaCO2: 35.0-45.0 mmHg HCO3: 22.0-26.0 mEq/L, and AG=12±4 mEq/L were considered to be within normal ranges (4).

A pH <7.35 combined with an increase in PaCO2 (>45) or a decrease in HCO3 (<22) is defined as either respiratory or metabolic acidosis, respectively. A pH >7.45 combined with a decrease in PaCO2 (<35) or an increase in HCO3 (>26) is defined as respiratory or metabolic alkalosis, respectively (5). Accordingly, ABD was divided into eight groups: respiratory or metabolic acidosis, respiratory or metabolic alkalosis and mixed metabolic Respiratory acidosis **(**MACRAC), Metabolic Respiratory Alkalosis (MALRAL), Metabolic Acidosis Respiratory Alkalosis (MACRAL), Mixed Metabolic Alkalosis Respiratory Acidosis (MALRAC).

Figure 1 EPOC alere ABG analyzer used in MIMS

III. Results

3.1 Demographic Features

Outcomes for the ABG were normal in 25 (23.80%) of 105 patients who presented to the RICU, while ABD was diagnosed in 80 patients (76.19%). Of the 80 patients with ABD, 76.71% (n=61) were male and 23.29% (n=19) were female. (Fig 2) ABDs were more common in males.

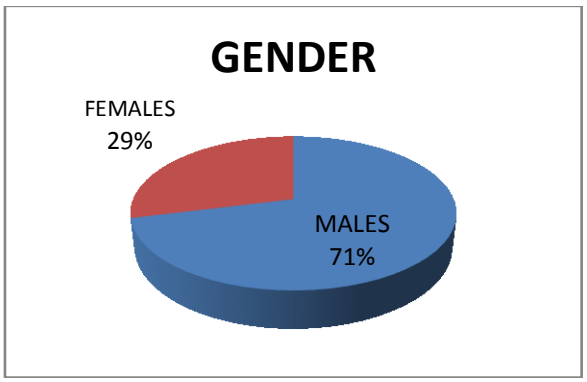

Figure 2 Gender distribution among ABD's in RICU cases

The mean age of patients was 56.7±19.1 years (range 26-70, median 64 y). When the age distribution was considered, the incidence of ABD was as follows: age groups of 60 and over (n=31, 38.75%), 50-60 (n=28, 35.7%), 40-49 (n=13, 16.2%), 30-49 (n=5, 6.7%) and 15 -29(n=4, 5%). All acid-base disorders, regardless of type, occurred more commonly in patients over 60 years of age (Fig. 3).

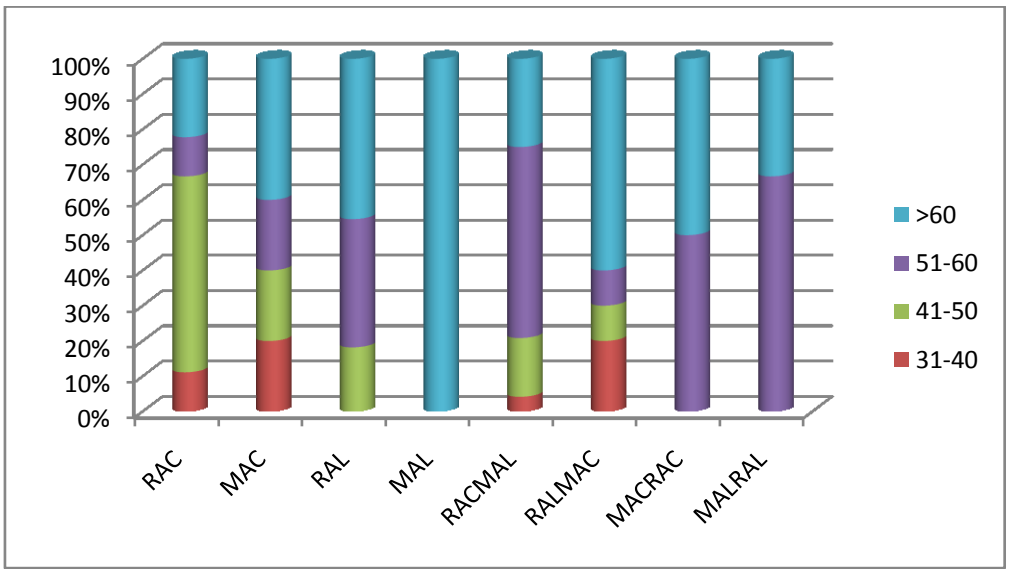

Figure 3 Distribution of ABDs according to age

3.2 ABD Types

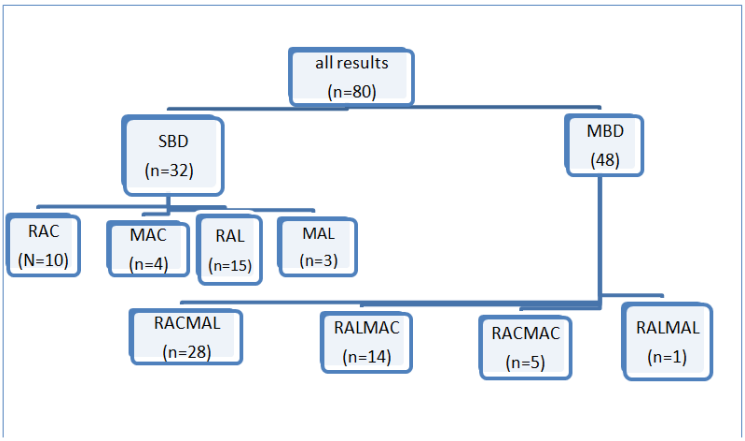

Figure 4 Types of the ABD's in blood gas drawn in the study.

Of the 80 patients with acid-base disorder, simple acid base disorder (SABD) was found in n=32, 40% and mixed acid base disorder (MABD) was noted in n=48, 60%. The most common MABDs was mixed respiratory acidosis and metabolic alkalosis (RACMAL) (n=28, 35%). The other mixed acid-base disorders included mixed respiratory alkalosis and metabolic acidosis (RALMAC), which was noted in n=14, 17.5% of the sample; mixed metabolic and respiratory acidosis (MACRAC), which was noted in 6.25% of the sample; and mixed metabolic and respiratory alkalosis (MALRAL), which was noted in 1.25% of the sample (Fig 6).

3.3 ABDs and the Outcomes

Of the ABD cases, 44 patients (55%) were treated and discharged without needing any ventilator support (invasive or noninvasive). 20 patients (25%) improved with NIV (non invasive ventilation). In 16 (20%) cases NIV was not useful and Invasive mechanical ventilation was considered. Out of these 7 patients (8.75%) recovered after receiving IMV (invasive mechanical ventilation) while 9 patients (11.25%) died even with IMV (table 1). Death was more commonly observed in cases with mixed metabolic and respiratory acidosis (RACMAC) (n=4) (Fig 6).

Table 1 Etiological contribution to outcomes of ABD'S

Discharged after Medical / non ventilator management (44)	**NIV (20)**	**IMV DEATH (9)**	**IMV SURVIVED (7)**
Copd =12 MPLEF = 9 Pneumonia = 5 Empyema = 5 Ptb = 4 Bronctss=4 Lung cancer = 3 Ipf = 1 Br. asthma =1	Copd=5 Pneumonia=3 Ild=3 Tb=2 Cpe=2 Upe=2 MPLEF=1 Lung cancers=1 Ards=1	ARDS/ sepsis = 7 MPLEF = 1 Pneumonia = 1	Copd=5 ARDS = 1 Pneumonia=1

*NIV=non invasive ventilation, IMV= invasive mechanical ventilation

Mixed RACMAL is the most common (n=28) ABD presentation in the RICU in our study. 12 cases without any ventilator support and 10 cases with NIV were improved in the mixed RACMAL cases. This ABD is associated with highest survival in intubated patients (71.42%, n=4). Mixed RACMAC is associated with highest mortality rate (80%, n=4) in our study. The explanation for this is probably mixed acid-base disorder, with both metabolic and respiratory components leading to dangerous extremes of low pH. Of the 10 respiratory acidosis cases, 9 cases improved and were discharged while 1 case died. All 4 cases with metabolic acidosis survived, 1 case needed IMV. Of the respiratory alkalosis cases, all cases recovered well. 4 cases (23.67%) required NIV. All the 3 cases with metabolic alkalosis survived, 1 needed NIV. Only one case presented as mixed MALRAL in RICU, which improved with medication. Of the 14 mixed RALMAC cases, 21.36 % cases were kept on IMV with mortality rate of 66.67%. The mortality rate among the SABD's was very low (n=1, 3.25%) when compared to MABD's (Table2).

Table 2 Outcomes of various ABD'S

ABD	**Discharged after Medical management**	**NIV**	**IMV DEATH**	**IMV SURVIVED**
SABD (32)				
RAC (10)	COPD = 2 MPLEF=2 Bronctss=1	COPD=1 MPLEF=1 UPE=1	ARDS/Sepsis=1	Copd=1
MAC (4)	MPLEF=1 Pneumonia=2			Pneumonia=1
RAL (15)	Copd=3 Empyema=3 Ptb=3 ARDS=1 MPLEF=1	Copd=1 Pneumonia=1 UPE=1 CPE=1		
MAL (3)	Bronctss=2 Copd=1			
MABD (48)				
RACMAL (28)	Copd=4 Bronctss=1 Lung cancer=2 MPLEF=2 Br. asthma=1 Pneumonia=1 Ptb=1	Copd=4 Ptb=2 ILD=2 Pneumonia =1 CPE=1	ARDS/Sepsis=1 MPLEF=1	COPD=4
RALMAC (14)	Pneumonia = 3 Copd=2 MPLEF=1 ILD=1 Empyema=1 Ptb=1	ILD=1 Pneumonia=1	ARDS/Sepsis=2	ARDS/Sepsis=1
RACMAC (5)		ARDS=1	ARDS/Sepsis=3 Pneumonia=1	
RALMAL (1)	Lung cancer=1			
	44 (55%)	**20(25%)**	**9(11.75%)**	**7(8.75%)**

*copd= chronic obstructive lung disease, MPLEF= malignant pleural effusion, Bronctss= Bronchiectasis, ILD= interstitial lung diseases, ARDS= acute respiratory syndrome, Ptb= pulmonary tuberculosis, UPE= uremic pulmonary edema, CPE= cardiogenic pulmonary edema.

When the correlation of ABD types with the eventual disposition of the patient (i.e., discharged, NIV, intubated and died cases) were examined, there were statistically significant differences in the outcomes between the groups ($p<0.05$). Highest mortality was seen in MABD's (16.67%) when compared to SABD'S (3.12%) (Table2). The possible explanation for this is that in mixed acid-base disorders— independently coexisting disorders can lead to dangerous extremes of pH resulting in death of the patient.

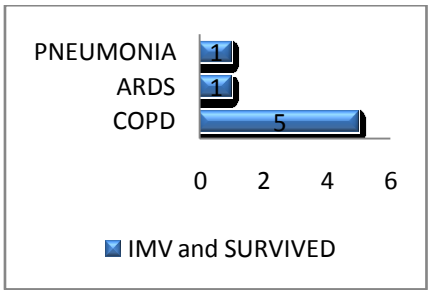

Figure 4 Etiologies in the IMV and survived patients

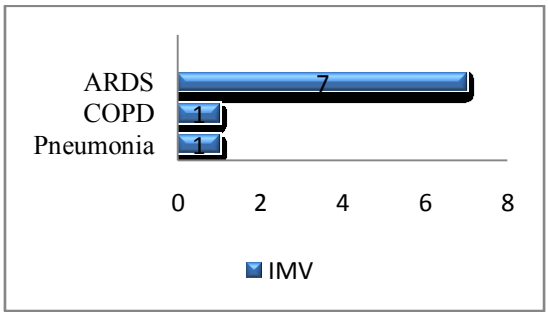

Figure 5 Diagnosis in IMV and expired patients

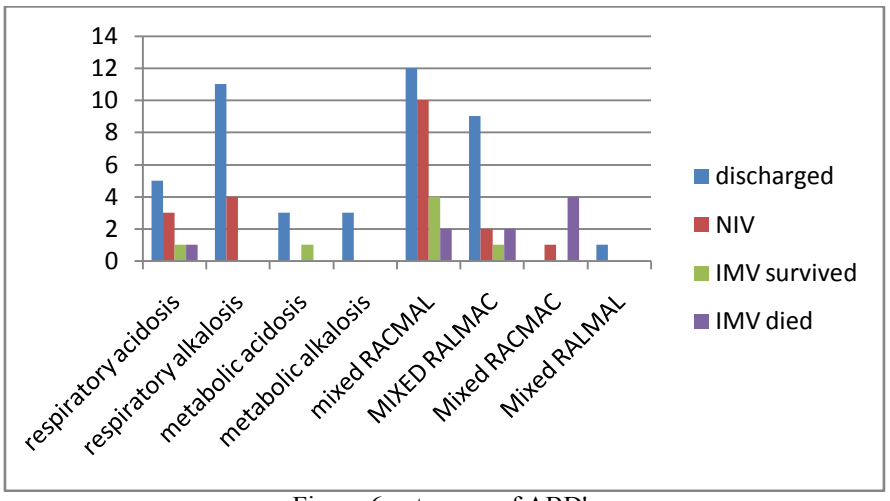

Figure 6 outcomes of ABD's

Table 3 Etiological diagnosis in ABD cases

	RAC	MAC	RAL	MAL	RACMAL	RALMAC	RACMAC	RALMAL
COPD(24)	5	0	4	1	12	2	0	0
Pneumonia(10)	0	3	1	0	1	4	1	0
ARDS/ sepsis(10)	1	0	1	0	1	2	5	0
Malignant pleural eff (8)	2	1	1	0	3	1	0	0
Pulm. koch's(6)	0	0	3	0	2	1	0	0
Bronchiectasis(5)	1	0	0	2	2	0	0	0
IPF (4)	0	0	0	0	2	2	0	0
Empyema(4)	0	0	3	0	0	1	0	0
Lung cancer(4)	0	0	0	0	3	0	0	1
CPE (2)	0	0	1	0	1	0	0	0
UPE (2)	1	0	1	0	0	0	0	0
Br. asthma(1)	0	0	0	0	1	0	0	0

The most common etiology of ABD's in RICU is COPD followed by pneumonia and ARDS. The highest survival and mortality rates among intubated cases are seen in COPD (chronic obstructive pulmonary diseases) (n=5, 71.42%), and ARDS (acute respiratory distress syndrome)/ sepsis (n=7, 77.78%) cases respectively (Fig 4, 5).

IV. Discussion

It is well known that various ABD are very common in critical illness. Prompt correction of ABD and treatment of the underlying causes as soon as possible is the key to reduce morbidity and mortality. It suggests that we should pay more attention to the diagnosis and management of ABD for critical patients. Although ABDs are quite common in the respiratory ICU and are generally associated with morbidity and mortality, the precise incidence and prevalence of ABDs have not been fully determined in patients presenting at the respiratory ICU'S. Many of the studies that have been conducted on this topic have included critical patients in multidisciplinary intensive care units and emergency departments but there are no studies particularly in Respiratory ICU's (6).

In the present study, our sample size included 105 patients, and the mean age of patients was 60.7 $\pm$ 17.17 years. ABD was noted to occur more commonly in patients of advanced age, which is probably due to the increased incidence and severity of respiratory diseases in this age group. The elderly are more prone to suffer from renal insufficiency and/or chronic obstructive pulmonary disease. Furthermore, medication with various drugs, such as diuretics, often affects the acid-base balance in the elderly (9). ABDs were more common in males. In our study, 40% of ABD patients were defined as SABD and 60% were characterized as MABD. Of the cases with SABD, patients had higher rates of respiratory alkalosis (n=15, 46.87%), while mixed RACMAL (58.43%) was defined as the most common MABD. The most common ABD among patients who presented to RICU's was RACMAL. The importance of identifying these disorders lies in their diagnostic and therapeutic implications. Knowing the types and incidence of ABDs may provide clues for the diagnosis, treatment and early prognosis of patients, as ABDs reflect the seriousness of the underlying pathology and are responsible for morbidity and mortality in sick persons (10).

As a general rule, the symptoms and signs of the underlying disease that give rise to the observed ABD dominate the clinical picture. These symptoms commonly include shortness of breath, hyperventilation, drowsiness, confusion, coma, shock, weakness, nausea, tremors, muscle twitching, and muscle spasms (11). In the present study, patients presented at the RICU with numerous symptoms, although the most common cause of presentation in the cases with ABD was dyspnea. In addition, complaints of poor general health, cough, expectoration, fever, chest pain, altered mental status nausea/vomiting, and abdominal pain were frequently observed. If the patient does not have a serious illness and an acid-base disorder is treated in its early stages, such as at the onset of the symptoms, treatment is usually successful, and serious problems can be avoided.

In a study on patients presenting at a MDICU, respiratory alkalosis and acidosis were the most common types of ABD (12). In another study, mixed MACRAL and MALRAC were the most common types of ABD in all patients who presented to ED, including those who had dyspnea. However, in our study mixed RACMAL was the most common ABD in the RICU.

It was found that MA was a stronger predictor of mortality as compared to RA, with odds ratio being 2.05 and 1.24, respectively. In addition, only MA was an independent predictor of mortality. This substantiates the fact that presence of MA is an indicator of poor outcome, as compared to RA. MA actually is a reflection of non-pulmonary organ dysfunction such as circulatory failure or renal failure, whereas RA depicts hypercapnic pulmonary organ failure. It has also been shown that mortality increases remarkably with development of associated organ dysfunctions in presence of respiratory failure (8).

Certain illnesses and conditions can increase one's risk for SABD and MABD, including cardiorespiratory arrest, sepsis, drug intoxication, diabetes mellitus, overuse of diuretics, excessive vomiting or diarrhea, and organ failure (specifically renal, hepatic, and pulmonary failure) (11). Exacerbation of COPD/asthma, pneumonia, pleural effusions and bronchiectasis account for the majority of emergency consultations for patients with acute dyspnea and ABD (12). In our study, acute exacerbation of COPD was the most common diagnosis in patients with ABD. The other common diagnoses included pneumonia, empyema, malignancies, ARDS/sepsis, interstitial lung diseases and bronchiectasis. In cases of exacerbation of COPD, the most common causes of ABD included RACMAL resulting from hypercarbia, compensatory metabolic alkalosis that develops in response to respiratory acidosis. In pneumonia's the common ABD was metabolic acidosis alone or associated with respiratory alkalosis.

In heart failure, various ABDs can develop due to the renal loss of hydrogen ions, the reduction in the effective circulating volume, hypoxemia and renal failure. This issue explains the occurrence of metabolic alkalosis, metabolic acidosis, respiratory alkalosis, and respiratory acidosis alone or in combination (13). In our study heart failure cases presented with RAL and RACMAL ABD's. Both the underlying disease and the

therapeutic interventions used to treat them can contribute to the development of ABDs in patients with malignancies.

In our study, vomiting and the use of steroids might cause metabolic alkalosis in cases with pneumonia and the exacerbation of COPD. Underlying pathologies in the cases of mixed MACRAC included ARDS and sepsis. The treatment for ABD is based on resolving the underlying cause and possibly restoring the pH balance to physiological levels (14, 15). The most-frequently used treatment options in our study include IV hydration, oxygen, inhaler therapy (inhaler steroid and b_2 agonist) and antibiotics. Some conditions that cause metabolic acidosis, such as diabetes and kidney disease, require careful treatment and management. Therefore, dialysis, insulin infusion, intubation/ventilation support and CPR are performed in such cases. The underlying pathology of ABD is crucial for mortality and morbidity, as well as for determining whether to discharge or hospitalize a patient. Previous studies have shown that the pH (7.35 or less) is a predictor of the need for hospitalization, ICU treatment, in-hospital outcomes, long-term survival and mortality in both patients with pulmonary and other causes of dyspnea (15). Several reports confirm that mixed metabolic and respiratory acidosis are associated with mortality (16). In our study also, death was most commonly observed in MACRAC cases. Although these disturbances may not be the direct cause of mortality,

The prevention, prompt detection and correction of these conditions could contribute to an improved prognosis. The vast majority of patients who died or decided to be hospitalized were MABD cases. Of the various forms of MABD, mixed MACRAC was the most complicated and challenging, often resulting in serious morbidity or mortality.

V. Conclusion

Acid-base disorders are common in patients presenting at the RICU, especially among very sick patients. Thus, ABGs should definitely be evaluated in the management of such patients. Of the ABDs, MABD is the most common. A mixed respiratory acidosis and metabolic alkalosis were the most commonly diagnosed ABDs. Respiratory alkalosis was more common among SABD cases. All types of acid-base disorders are observed primarily in patients over 60 years of age. Discharge and hospitalization were decided primarily for cases with mixed RACMAL. Mortality occurred more frequently in the mixed MACRAC cases. This knowledge may provide important clues in the diagnosis, treatment and early prognosis of these patients.

References

[1] Austin K, Jones P. Accuracy of interpretation of arterial blood gases by emergency medicine doctors. Emerg Med Australas, 22, 2010, 159-65.
[2] Kelly AM. Review article: Can venous blood gas analysis replace arterial in emergency medical care. Emerg Med Australas 22, 2010,493-8.
[3] Walmsley RN, White GH. Mixed acid-base disorders. Clin Chem, 31,1985,321-5.
[4] Boniatti MM, Cardoso PR, Castilho RK, Vieira SR. Acid-base disorders evaluation in critically ill patients: we can improve our diagnostic ability. Intensive Care Med, 35(13), 2009, 77-82.
[5] Song ZF, Gu WH, Li HJ, Ge XL. The incidence and types of acid-base imbalance for critically ill patients in emergency. Hong Kong J Emerg Med 19(1),2012,3-7.
[6] Lee SG, Cheong JH, Kim JE, Song SH, An SJ, Lee DW, et al. Analysis of the acid-base disorders of critically ill patients in the medical intensive care unit. Korean J Med, 73, 2007, 399-406.
[7] Adrogué HJ, Madias NE. Management of life-threatening acid-base disorders. Second of two parts. N Engl J Med 338(2), 1998, 107-11.
[8] Vasilyev S, Schaap RN, Mortensen JD. Hospital survival rates of patients with acute respiratory failure in modern respiratory intensive care units. An international, multicenter, prospective survey. Chest 107, 1995, 1083-8.
[9] Nabata T, Morimoto S, Ogihara T. Abnormalities in acid-base balance in the elderly. Nihon Rinsho 50, 1992, 2249-53.
[10] Adrogue HJ,Disorders of acid-base balance. In Robert W. Schrier (Ed.), Atlas of Diseases of the Kidney. ISN (Informatics Commission and NKF cyberNephrology; 1999). Chapter 6.
[11] Rutledge TF. Acid-base disturbances in the emergency department: Part 2: Making the diagnosis. Can Fam Physician 37, 1991, 2469-75.
[12] Burri E, Potocki M, Drexler B, Schuetz P, Mebazaa A, Ahlfeld U, et al. Value of arterial blood gas analysis in patients with acute dyspnea: an observational study. Crit Care 15, 2011, R145.
[13] Frangiosa A, De Santo LS, Anastasio P, De Santo NG. Acid-base balance in heart failure. J Nephrol 19(9), 2006,115-20.
[14] Miltiadous G, Christidis D, Kalogirou M, Elisaf M. Causes and mechanisms of acid-base and electrolyte abnormalities in cancer patients. Eur J Intern Med 19, 2008, 1-7.
[15] Levin KP, Hanusa BH, Rotondi A, Singer DE, Coley CM, Marrie TJ, et al.Arterial blood gas and pulse oximetry in initial management of patients with community-acquired pneumonia. J Gen Intern Med 16, 2001, 590-8.
[16] Kirby BJ, McNicol MW. Results of cardiac resuscitation in one hundred patients: effects on acid-base status. Postgrad Med J 43, 1967, 75-80.