# Acid-Base Disorders in the Emergency Department: Incidence, Etiologies and Outcomes

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## 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, types and incidences of ABDs in patients presenting at the emergency department (ED).

**Material and Methods:** We prospectively analyzed data from patients who presented between January 2011 and May 2011. Data on age, gender, chief complaint, and diagnosis in the ED were collected for ABD cases.

**Results:** Of the 736 cases with an ABD, 173 patients (23.5%) had simple ABD and 563 patients (76.5%) had mixed ABD. The most common ABD was a mixed metabolic acidosis and respiratory alkalosis (MACRAL) (n=408, 55.4%). All ABD types were most commonly observed in patients over 65 years of age. Dyspnea was the most common complaint among ABD patients who presented at the ED (44.4%). In cases of ABD, pneumonia was the most common diagnosis (16.3%). Of the ABD cases, 379 patients (51.6%) were discharged, while 318 patients (43.2%) were hospitalized. Death was more commonly observed in cases with mixed metabolic and respiratory acidosis (MRAC) (n=6) and MACRAL (n=11).

**Conclusion:** ABDs are quite common in patients presenting at the ED, especially among patients in a critical condition (71%). Mixed MACRAL was the most commonly noted ABD. Dyspnea and pneumonia were the most common diagnoses in ABD patients. Mortality was more common in cases with a mixed MRAC and MACRAL. This knowledge may provide important information concerning the diagnosis, treatment and early prognosis of patients. *(JAEM 2014; 13: 4-9)*

**Key words:** Acid-base disorders, emergency medicine, causes, outcomes

## Introduction

Arterial blood gas (ABG) testing is widely used in emergency departments to evaluate metabolic and respiratory functions ($pCO_2$, pH and $pO_2$). In addition, this test can help guide the diagnosis and treatment of many patients and can offer details concerning the severity of a case (1, 2).

Acid-base balance is important in the healthy maintenance of the cellular functions of the body. ABDs are common in outpatients, especially among hospitalized patients. It is usually correlated with high rates of morbidity and mortality (3, 4). The incidence, types, causes, treatments and outcomes of ABD in patients presenting at the ED 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, 5).

The objective of this study was to examine the outcomes, treatment, causes, types and incidence of ABD in patients admitted to the ED.

## Material and Methods

### Study Design

In this prospective observational study, we included adult patients presenting at the ED of the Uludağ University Hospital, between January and May 2011. A total of 1037 patients who were over the age of 18 and presented with various complaints were enrolled in the study. Exclusion criteria were identical during both recruitment periods, and are as follows: under18 years of age; trauma patients, those with missing data, inappropriate blood gas samples or patients who died prior to arrival.

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Informed consent form was filled by the patients since our hospital has been accredited by the International Joint Commission. All the participants gave their informed consent prior to taking blood from the patients. No additional blood samples were taken for this study. Therefore, we did not apply to the ethical committee.

**Study Protocol**

All patients underwent an initial clinical assessment that included a history, physical examination, vital signs (pulse rate, blood pressure, respiratory rate, temperature) and oxygen saturation measured by pulse oximetry. ABG samples were collected immediately after presentation to the ED once an attending emergency physician had assessed the patient. 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 by an emergency physician according to clinical availability. The samples were collected in identical heparinized syringes, and the syringes were quickly sent to the laboratory via a pneumatic tubing system. Tests were run on the cobas b 221 system and Omni S6 (Roche Diagnostics, Mannheim, Germany) blood gas analysis machines. ABG results were interpreted by our teaching assistants and checked by the senior emergency officer to avoid any discrepancies in practice during the study period.

Analysis of the ABG included pH values, the partial pressure of arterial carbon dioxide ($PaCO_2$), partial pressure of the arterial oxygen ($PaO_2$), bicarbonate ($HCO_3$), and the anion gap (AG). The pH values of 7.35-7.45 and ABG values, including $PaO_2$ 80-100 mmHg, $PaCO_2$: 35.0-45.0 mmHg, and $HCO_3$: 22.0-26.0 mEq/L, were considered to be within normal ranges. The AG was calculated using the standard formula of $AG=Na+K-(HCO_3+Cl)$. The respective normal values for AG with relatively wide ranges reported by most laboratories and studies are 16±4 mEq/L (if K is considered) and 12±4 mEq/L (if K is not considered) (6-8). Clinicians were advised to use the normal AG values reported by the laboratory. The AG was used to divide acidosis into two primary types: wide gap and normal gap. A pH <7.35 combined with an increase in $PaCO_2$ (>45) or a decrease in $HCO_3$ (<22) is defined as either respiratory or metabolic acidosis, respectively. A pH >7.45 combined with a decrease in $PaCO_2$ (<35) or an increase in $HCO_3$ (>26) is defined as respiratory or metabolic alkalosis, respectively (4, 9). Accordingly, ABD was divided into eight groups: normal, respiratory or metabolic acidosis, respiratory or metabolic alkalosis and mixed ABDs.

**Statistical Analysis**

Analysis of the data was carried out using the Microsoft Excel XP and Statistical Package for Social Science (SPSS) 13.0 software. Descriptive statistics of the study variables were calculated. All data were expressed as the mean±standard deviation (S.D.), minimum-maximum value, median value or as a percentage (%). Pearson Chi-Square ($\chi^2$), Yates's corrected Chi-square and Fisher's Exact Chi-Square tests were used to compare categorical variables. Chi-square and binominal tests were used to compare rates. P values less than 0.05 were considered statistically significant.

## Results

**Demographic Features**

Outcomes for the ABG were normal in 301 (29%) of 1,037 patients who presented to the ED, while ABD was diagnosed in 736 patients (71%). Patients with ABD were included in the study. Of the 736 patients with ABD, 53.5% (n=394) were male and 46.5% (n=342) were female. The mean age of patients was 60.7±17.1 years (range 19-94 y, median 64 y). When the age distribution was considered, the incidence of ABD was as follows: age groups of 65 and over (n=343, 46.6%), 50-65 (n=226, 30.7%), 34-49 (n=88, 12%) and 18-34 (n=79, 10.7%).

**ABD Types**

Of the 736 patients with acid-base disorder, simple acid base disorder (SABD) was found in 23.5% and mixed acid base disorder (MABD) was noted in 76.5%. Of the patients with SABD, metabolic acidosis was defined in 7.1%, metabolic alkalosis in 3.4%, respiratory acidosis in 3% and respiratory alkalosis in 10%. The most common MABDs were mixed metabolic acidosis and respiratory alkalosis (MACRAL) (n=408, 55.4%). The other mixed acid-base disorders included mixed metabolic alkalosis and respiratory acidosis (MALRAC), which was noted in 16.6% of the sample; mixed metabolic and respiratory acidosis (MRAC), which was noted in 3.3% of the sample; and mixed metabolic and respiratory alkalosis (MRAL), which was noted in 1.2% of the sample (Figure 1). The AG was analyzed in 493 (67%) ABD cases. AG was evaluated in 345 (71.3%) of 484 cases with metabolic acidosis. AG was found to be normal in 75 patients (21.7%) and increased in 270 patients (78.3%).

All acid-base disorders, regardless of type, occurred more commonly in patients over 65 years of age. MACRAL was found more commonly in all age groups of MABDs, although it was more frequent in the 50-65 (n=119, 29.2%) and over 65 year old (n=189, 46.3%) age groups. Mixed MALRAC was more common in the 50-65 year (n=48, 39.3%) and over 65 year (n=55, 45.1%) age groups. Respiratory alkalosis was observed more frequently in the over 65 year (n=34, 45.9%), 50-65 year (n=20, 27%) and 34-49 year (n=14, 18.9%) age groups. Metabolic acidosis was found more commonly in the over 65 year (n=23, 44.2%), 18-34 year (n=13, 25%), 50-65 year (n=11, 21.2%) and 34-49 year (n=5, 9.6%) age groups. The other types of ABD were more common in the over 65 year and 50-65 year age groups (Figure 2).

Mixed MACRAL was the most frequently observed acid-base disorder of the acid-base disorder types both in male (n=217, 29.5%) and female (n=191, 26%) patients. Again, in male and female patients, mixed MALRAC (9.5%, 7.1%), respiratory alkalosis (4.2%, 5.8%) and metabolic acidosis (3.5%, 3.5%) were observed more commonly both in male and female patients. However, no statistically significant difference was found between the groups (p>0.05).

**ABD and Clinical Features**

Patients with ABD presented most commonly with complaints of dyspnea (44.4%), general poor health (12.9%), nausea/vomiting

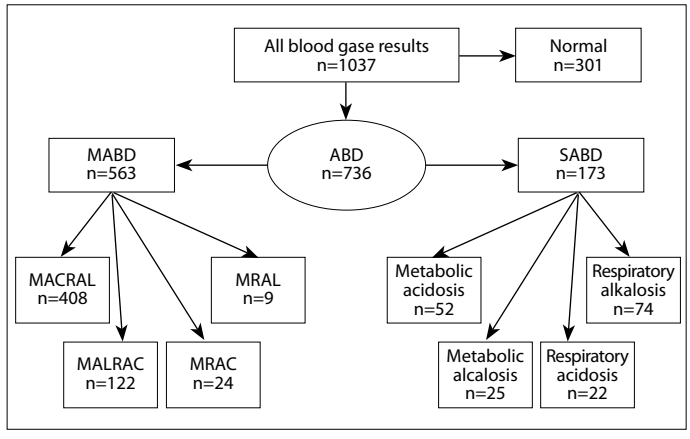


**Figure 1.** Outcomes of the blood gas drawn in the study and types of ABDs

(4.9%), fever (4.3%), altered mental status (3.8%), weakness (3.8%), chest pain (3.8%) and abdominal pain (3.4%). Pneumonia was the most common diagnosis established in patients with ABD (n=120, 16.3%). When SABD (n=48, 27.7%) and MABD (n=72, 12.8%) groups were compared in cases of pneumonia, there was a statistically significant difference ($p<0.0001$). The other common diagnoses included exacerbation of chronic obstructive pulmonary disease (COPD)/asthma (n=107, 14.5%), acute renal failure (ARF) (n=99, 13.4%), acute heart failure (AHF) (n=57, 7.7%), malignancies (n=38, 5.2%), diabetic ketoacidosis (DKA) (n=32, 4.3%), sepsis (n=30, 4.1%) and pulmonary embolism (PE) (n=24, 16.3%).

In the metabolic acidosis cases, dyspnea (25%), general poor health (15.4%) and weakness were the most common complaints, while ARF (23.1%), pneumonia (9.6%), AHF and poisoning (7.7%) were the most common diagnoses. Patients with metabolic alkalosis and respiratory acidosis often presented at the ED with dyspnea and were diagnosed primarily with pneumonia and exacerbation of COPD/asthma. In cases with respiratory alkalosis, dyspnea (51.4%), fever (9.5%), general poor health and altered mental status (8.1%) were the most common symptoms. Of the causes of this type of ABD, pneumonia (37.8%), malignancies (8.1%) and PE (6.8%) constituted a large proportion. In mixed MRAC and mixed MRAL cases, dyspnea and general poor health were the primary complaints, while ARF and sepsis were the primary underlying pathologies. The most common complaints for mixed MACRAL and MALRAC cases were dyspnea, fever, poor general health and nausea/vomiting. Of the conditions leading to mixed MACRAL, ARF (n=73, 17.9%), pneumonia (n=53, 13%), AHF (n=31, 7.6%), DKA (n=27, 6.7%) and exacerbation of COPD/asthma (n=23, 5.6%) were found to be the most common, whereas in patients with mixed MALRAC, exacerbation of COPD/asthma (48.3%), pneumonia (13.1%) and AHF (9%) were the most common causes.

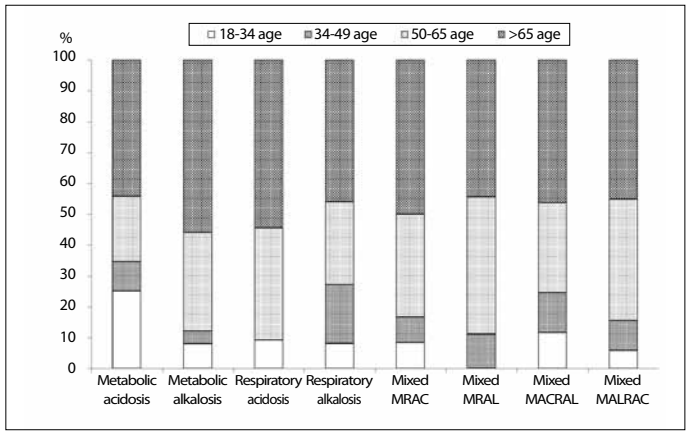


**Figure 2.** Distribution of ABDs according to age

Numerous therapies were administered to patients with ABD. Of these, the most commonly used treatment options were intravenous (IV) hydration, oxygen, inhaler therapy (inhaler steroid and b-agonist) and antibiotics. Furthermore, intubation/ventilation support and cardiopulmonary resuscitation (CPR) were the most commonly performed procedures in MRAC and MACRAL cases. Bi-level positive airway pressure (BIPAP) (n=8) was used only for mixed MALRAC cases. Dialysis was carried out more frequently in patients with metabolic acidosis (n=4) and mixed MACRAL (n=11). In addition, insulin infusion (n=29), anti-ischemic/anticoagulant therapy (n=16), sedation (n=11) and insulin + dextrose therapies were administered in mixed MACRAL cases. Systemic steroid therapy was recommended more frequently in mixed MALRAC cases.

**ABDs and the Outcomes**

Of the patients with acid-base disorders, 379 (51.6%) were discharged, while hospitalization was considered in 318 (43.2%) cases. Of the remaining patients, 22 (2.9%) died in the ED. Seventeen patients (2.3%) left the hospital against medical advice. Of the patients who decided to be hospitalized, 81 (11%) were referred to another health center due to lack of beds in the hospital. Fifty percent of the patients diagnosed with metabolic acidosis and 68% of patients diagnosed with metabolic alkalosis were discharged. Of the respiratory acidosis cases, 50% were discharged and 45.4% were hospitalized. Of the respiratory alkalosis cases, 56.8% were discharged and 41.9% were hospitalized. In cases with mixed MRAC, discharged patients constituted 20.8% of cases, while hospitalized patients constituted 54.2%. Most of the mixed MRAL cases were discharged (55.6%). Of the mixed MACRAL cases, 50.3% were discharged, while hospitalization was planned for 50.3%. In the mixed MALRAC cases, the rate of discharge was 55.7% and the rate of hospitalization was 42.6%. Death was more frequently observed in the mixed MRAC and MACRAL cases. Six deaths occurred in the mixed MRAC cases, while 11 deaths occurred in the mixed MACRAL cases. Most of the patients who rejected treatment had mixed MACRAL (n=12) (Table 1). When the correlation of ABD types with the eventual disposition of the patient (i.e., discharged, hospitalized, referred and lost cases) were examined, there were statistically significant differences in the outcomes between the groups ($p<0.05$) (Figure 3).

Patients with acid-base disorders were admitted to the following clinics: 61 (25.6%) to the pulmonary diseases, 42 (17.6%) to oncology,

**Table 1.** ABD types based on the outcomes of patients who presented to the ED

| Outcomes/ ABD types, n (%)+ | Met. acidosis | Met. alkalosis | Res. acidosis | Res. alkalosis | Mixed MRAC | Mixed MRAL | Mixed MACRAL | Mixed MALRAC | Total |
|---|---|---|---|---|---|---|---|---|---|
| Discharge | 26 (50) | 17 (68) | 11 (50) | 42 (56.8) | 5 (20.8) | 5 (55.6) | 205 (50.3) | 68 (55.7) | 379 (51.5) |
| Hospitalize | 16 (30.8) | 5 (20) | 7 (31.8) | 22 (29.7) | 9 (37.5) | 2 (22.2) | 136 (33.3) | 40 (32.8) | 237 (32.2) |
| Mortality | 1 (1.9) | 0 (0) | 0 (0) | 1 (1,4) | 6 (25) | 1 (11.1) | 11 (2.7) | 2 (1.6) | 22 (3) |
| Dispatch | 6 (11.5) | 2 (8) | 3 (13.6) | 9 (12.2) | 4 (16.7) | 1 (11.1) | 44 (10.8) | 12 (9.8) | 81 (11) |
| Treatment refusal | 3 (5.8) | 1 (4) | 1 (4.5) | 0 (0) | 0 (0) | 0 (0) | 12 (2.9) | 0 (0) | 17 (2.3) |
| Total | 52 (100) | 25 (100) | 22 (100) | 74 (100) | 24 (100) | 9 (100) | 408 (100) | 122 (100) | 736 (100) |

+% values are the rates for each ABD type.

ABD: acid-base disorder; MRAC: mixed metabolic and respiratory acidosis; MRAL: mixed metabolic and respiratory alkalosis; MALRAC: mixed metabolic alkalosis and respiratory acidosis; MACRAL: mixed metabolic acidosis and respiratory alkalosis

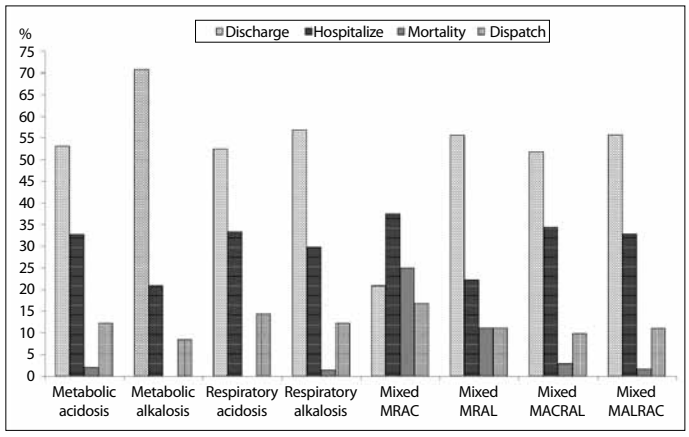


**Figure 3.** Distribution of ABD types according to case outcome

26 (10.9%) to cardiology, 21 (8.8%) to infectious diseases, 20 (8.4%) to metabolic and endocrine diseases, 15 (6.3%) to nephrology and 15 (6.3%) to anesthesia and reanimation intensive care clinics.

When outcomes for patients with SABD and MABD were compared, 96 (55.5%) of the SABD patients were discharged and 70 (40.4%) were hospitalized. Death occurred in only 2 (1.2%) cases. Of the MABD patients, 283 (50.3%) were discharged, while 248 (44%) were hospitalized. Most of the deaths occurred in this type of ABD (n=20, 3.6%).

## Discussion

Although ABDs are quite common in the ED, especially among critically ill patients, 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 ED. Many of the studies that have been conducted on this topic have included critical patients in intensive care units. Indeed, data regarding patients presenting at the ED are limited. In a few studies from China on critically ill patients, the incidence of ABD was found to be high (94.2%-97.3%) (9-11). In Korea, this rate was noted to be 87.2% in one study (12), while another study from Italy reported this rate to be 56% (13). However, the number of patients in the studies from Korea and Italy is lower than that noted in our study (n=187, n=110). In the present study, our sample size included 1,037 patients, and the mean age of patients was 60.7±17.17 years. We found the incidence of ABD to be 71% (n=736). Previous studies conducted with critical patients in intensive care units have reported mean ages of 55.9±18.1 years and 70.5±17.4 years. In studies similar to our own, ABDs were more common in males (8, 9, 12, 13 ). These rates indicate that more attention should be given to the evaluation of blood gas data, the identification of ABD and the approach to patients, especially critically ill patients, in the ED.

Some calculations are helpful in determining the type of acidosis or alkalosis and whether the ABD reflects part of a mixed condition (14, 15). Determining the incidence of such disorders can be difficult because they may be underreported, and some types of ABD among people with critical illnesses are not yet well defined. The importance of identifying these disorders lies in their diagnostic and therapeutic implications. In our study, 23.5% of ABD patients were defined as SABD and 76.5% were characterized as MABD. Of the cases with SABD, patients had higher rates of respiratory alkalosis (10%), while mixed MACRAL (55.4%) was defined as the most common MABD. The most common ABD was MACRAL for all age groups and genders. All types of ABDs were found to occur more commonly in patients over 65 years of age. In previously conducted studies, MABD was observed more frequently, while mixed MACRAL was not noted to be as common (9, 12), which is consistent with the findings of this study. In contrast to this result, another study reported mixed MACRAL as a less commonly observed ABD (16). However, SABD was noted to be more common in other studies. The limited sample size might have been disadvantageous in these studies. Nevertheless, similar to our study, these studies reported respiratory alkalosis as the most common type of SABD (13, 17). In our study, metabolic acidosis and alkalosis constituted the remaining SABD, while MALRAC constituted an important proportion of MABD. Song et al. (9) found metabolic acidosis to be the most common type of ABD in very sick patients, whereas Hodgkin et al. (16) and Webster and Kulkarni (18) found metabolic alkalosis as the most common type of ABD in very sick patients. Hodgkin et al. (16) found that 26% of patients with respiratory alkalosis and 41% of patients with respiratory acidosis had mixed disorders. In general, metabolic acidosis and respiratory alkalosis accounted for the majority of cases in our study. ABD was noted to occur more commonly in patients of advanced age, which is probably due to the increased incidence and severity of disease 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 (19). In addition, because we are a tertiary care referral center, the features of patients presenting at our center may have contributed to outcomes. 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 (3, 18).

A diagnostic approach to ABD begins with suspicion based on the clinical history and physical examination, which is then followed by evaluation of the patient's electrolytes and blood gas values (5, 14, 15). 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 hyperventilation, severe breathing problems, drowsiness, confusion, coma, shock, weakness, nausea, tremors, muscle twitching, and muscle spasms (3, 14, 15, 20). In the present study, patients presented at the ED with numerous symptoms, although the most common cause of presentation in the cases with ABD was dyspnea. In addition, complaints of poor general health, nausea/vomiting, fever, chest pain, altered mental status and abdominal pain were frequently observed. In a study on patients presenting at an ED, respiratory alkalosis and acidosis were the most common types of ABD (21). However, in our study, mixed MACRAL and MALRAC were the most common types of ABD in all patients who presented at our ED, including those who had dyspnea. ABDs for the complaints of weakness, which was the cause of many presentations and was often ignored, were metabolic acidosis and mixed MACRAL. 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.

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) (4, 5, 9, 20, 22). AHF, exacerbation of COPD/asthma, pneumonia and PE account for the majority of emergency consultations for patients with acute dyspnea and ABD (21). In our study, pneumonia was the most common diagnosis in patients with ABD. The other

common diagnoses included an exacerbation of COPD/asthma, ARF, AHF, malignancies, DKA, sepsis and PE. In cases of pneumonia and exacerbation of COPD/asthma, the most common causes of ABD included respiratory acidosis resulting from hypercarbia, metabolic acidosis due to other underlying pathologies, compensatory metabolic alkalosis that develops in response to respiratory acidosis, and MABD (particularly mixed MRAC) (20, 23-26). ABDs, specifically metabolic acidosis and metabolic alkalosis secondary to hypoalbuminemia, are considered common in patients with ARF (14, 27). Metabolic acidosis is the most common ABD observed in diabetes and DKA, although metabolic and respiratory alkalosis are also commonly observed in MABD (particularly mixed MACRAL) (28-30). 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 (31-33). Both the underlying disease and the therapeutic interventions used to treat them can contribute to the development of ABDs in patients with malignancies. Metabolic acidosis is often observed in cancer patients, and vomiting or nasogastric suctioning and loop and thiazide diuretic administration are the most common causes of metabolic alkalosis in these patients. Respiratory alkalosis can also be found in cancer patients resulting from both hypoxemia and direct stimulation of the respiratory center (34). Poisoning with various substances or drugs (including carbon monoxide, cyanide, alcohol, aspirin, and diuretics) can cause ABDs (14, 15). In the present study, among the conditions leading to the mixed MACRAL and MALRAC, the more commonly noted were ARF, pneumonia, AHF, DKA, malignancies and exacerbation of COPD/asthma. Pneumonia, malignancies and PE constituted a greater portion of the causes of respiratory alkalosis. ARF, pneumonia, AHF and poisoning often resulted in metabolic acidosis. Metabolic alkalosis and respiratory acidosis were primarily found in patients diagnosed with pneumonia and exacerbation of COPD/asthma. However, the most common causes of metabolic alkalosis in the literature were vomiting, nasogastric suctioning and the use of diuretics and steroids (16, 18). In our study, vomiting and the use of steroids might cause metabolic alkalosis in cases with pneumonia and the exacerbation of COPD/asthma. Underlying pathologies in the cases of mixed MRAC and mixed MRAL included ARF and sepsis. Mixed MRAL can be found when hypocapnia occurs in the presence of an initially elevated [HCO3-] (35).

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 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 (7.39 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 (21, 36). Several reports confirm that metabolic and respiratory acidosis are associated with mortality (12, 21, 36, 37). In our study, death was most commonly observed in MRAC and MACRAL 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 MACRAL was the most complicated and challenging, often resulting in serious morbidity or mortality. However, there are several studies reporting that hospitalization and death occur more frequently with metabolic alkalosis (16, 18).

**Study Limitations**

There are several limitations to our study. The first limitation is the fact that the decision to perform an ABG on presentation to the ED was made exclusively at the discretion of the ED physician in charge, based on their initial assessment of the patient. Emergency department patients have longer durations of stay in our hospital; however, in our study, the follow up and treatment control values of ABG were not included. Only the first ABG values were used in this analysis. This approach may affect the results obtained in our study, particularly with respect to discharge. Secondly, we did not use a standardized algorithm to decide whether ABGs should be performed. Thus, the group we studied was not a specially selected patient group taken from patients who were admitted to the ED. Again, when we looked at the diagnoses represented in the study, ABG analyses were performed for the most critical patients. The third limitation of this study is that not all patients with day-night admissions were included in the study. However, all the physicians interested in this study attempted to reach as many of the patients as possible. The fourth limitation was the use of last-year assistants who were trained in how to interpret ABGs and whose work was checked by an expert. Nevertheless, differences in interpretation from person to person may have occurred. Finally, some unknown factors may have affected the results of the blood gas analyses. There are many different factors that may contribute to the mortality of critically ill patients, and ABD is only one of these factors. Finally, long-term follow up of the mortality of admitted and discharged patients could not be performed in this study. We were only able to assess short-term mortality in our sample of patients attending the emergency department.

## Conclusion

Acid-base disorders are common in patients presenting at the ED, especially among very sick patients (71%). Thus, ABGs should definitely be evaluated in the management of such patients. Of the ABDs, MABD is the most common. A mixed metabolic acidosis and respiratory 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 65 years of age. In addition, metabolic acidosis might be observed more commonly in younger adults. ABD patients primarily presented at the ED with complaints of dyspnea, poor general health, nausea/vomiting, fever, altered mental status, weakness and chest pain. Pneumonia, exacerbation of COPD/asthma and ARF were the most common causes of ABD in our sample. Discharge and hospitalization were decided primarily for cases with mixed MACRAL and MALRAC. Mortality occurred more frequently in the mixed MRAC and MACRAL cases. This knowledge may provide important clues in the diagnosis, treatment and early prognosis of these patients.

**Ethics Committee Approval:** As our hospital has been accredited by the International Joint Committee, consent forms were obtained from all patients. Informed patient consent is obtained from all attending patients before blood samples are taken. Furthermore,

no blood samples were taken for this study from the patients. For this reason, approval from the ethics committee was not applied for.

**Informed Consent:** Written informed consent was obtained from patients who participated in this study.

**Peer-review:** Externally peer-reviewed.

**Author Contributions:** Design - A.K., E.A.; Supervision - A.K., E.A.; Funding - A.K., E.A.; Materials - N.Ö.; Data Collection and/or Processing - A.K., N.Ö., D.K.M.; Analysis and/or Interpretation - A.K., E.A., N.Ö.; Literature Review - A.K., N.Ö., D.K.M.; Writer - A.K., N.Ö.; Critical Review - F.O., Ş.A.A., O.K.; Other - F.O., Ş.A.A., O.K.

**Conflict of Interest:** No conflict of interest was declared by the authors.

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