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Acid-Base and Electrolytes Profile in Critically Ill Pediatric Patients Admitted to Pediatric Intensive Care Unit (PICU)

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Abstract

Critically ill pediatric patients are known to experience more frequent episodes of acid-base and electrolyte imbalances when compared to adults, which can significantly impact morbidity and mortality with higher mortality rates and longer hospital stays. Data on the profile of acid-base and electrolyte imbalances in critically ill pediatric patients is very limited in Indonesia. This study was conducted to describe the electrolytes and acid-base profile of critically ill pediatric patients admitted to the Pediatric Intensive Care Unit (PICU). This was a cross-sectional study using secondary data from medical records of critically ill pediatric patients aged 1 month to 18 years admitted to the PICU of Dr. Hasan Sadikin General Hospital, Bandung, Indonesia, from January 1 to December 31, 2021. Results indicated that 131 (50.8%) of 258 patients experienced electrolytes and acid-base imbalances. The majority of patients were boys (53.0%) and infants (32.8%). The most common primary diagnosis was respiratory (28.2%), central nervous system (19.8%), and gastrointestinal disorders (15.3%). A total of 366 electrolyte imbalance events and 111 acid-base imbalance events were recorded. The most common electrolyte imbalance events were hyponatremia (75.6%), hypocalcemia (48.9%), and hypokalemia (42.7%), respectively, while the most frequent acid-base imbalance events were respiratory alkalosis (33.6%) and metabolic acidosis (21.4%). Electrolyte and acid-base imbalances are common among critically ill pediatric patients in PICU. Thus, early evaluation and recognition of acid-base and electrolyte imbalances are crucial in order to prevent poor outcomes in these patients.

Keywords: Acid-base, critically ill, electrolyte, pediatric intensive care units

Introduction

Electrolytes play a critical role in maintaining physiological processes and fluid balance within the body. The five major electrolytes routinely measured include sodium, potassium, calcium, chloride, and magnesium. Infants and children are more prone to experiencing episodes of acid-base and electrolyte imbalances compared to adults.[1] Each year, approximately 200 critically ill children are admitted to the Pediatric Intensive Care Unit (PICU) of Dr. Hasan Sadikin General Hospital in Bandung. Acid-base and electrolyte abnormalities are common among children requiring intensive care.[2] Acid-base and electrolyte abnormalities are common in children who need intensive care.[3] A study by Naseem et al. found that 84.15% of children admitted to the PICU experienced electrolyte imbalances.[4] Meanwhile a study at the PICU of dr. Soetomo National Hospital in Surabaya noted that 61.7% of pediatric patients who had just entered the PICU experienced electrolyte imbalances.[5] Furthermore, during follow-up, an estimated 61% of children with Chronic Kidney Disease (CKD) stage four exhibited metabolic acidosis (with levels <22 mmol/L).[6]

Acid-base and electrolyte imbalances can have an impact on morbidity and mortality, both in terms of the level of care needed and the emergence of complications in PICU patients. For example, children with hypernatremia have an 8.9 times higher risk of death than children with normal sodium levels.[1] Children with hyperkalemia were found to have an eight times higher risk of death.[7] In addition, children with hypomagnesemia have a longer mean duration of stay in the PICU and higher mortality.[8] Metabolic acidosis is one of the most common acid-base

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imbalances, and it is associated with increased length of stay and higher mortality rates.[9] Various critical conditions are often related to conditions that will impact various vital organs. In conditions of lack of oxygen (hypoxemia) or malnutrition due to prolonged or severe circulatory failure (hyperfusion), acute kidney failure often occurs, which can often present initially with electrolyte imbalances. Early detection through screening of serum electrolytes may help identify kidney dysfunction in critical patients. While serum electrolyte levels alone may not be definitive in diagnosing AKI, monitoring them in critical conditions, especially for developing countries with limited facilities, such as Indonesia, can aid in the timely recognition of potential kidney failure.

Given the various causes of acid-base and electrolyte imbalances, early recognition and prompt treatment are crucial to restoring balance and preventing poor outcomes in PICU patients. However, data on the profile of acid-base and electrolyte imbalances in critically ill pediatric patients remains limited in Indonesia, particularly in West Java. This study aims to identify the profile of these imbalances in critically ill pediatric patients treated at the PICU of Dr. Hasan Sadikin General Hospital in Bandung, the main referral hospital in West Java, during the year 2021.

Methods

This cross-sectional study was conducted from January to December 2021 in the Pediatric Intensive Care Unit (PICU) of Dr. Hasan Sadikin General Hospital, Bandung. The study utilized secondary data, specifically patients' medical records, as the primary instrument. The subjects included critically ill pediatric patients who experienced acid-base and electrolyte imbalances and received treatment at the PICU during the study period. The inclusion criteria were pediatric patients aged one month to 18 years. Exclusion criteria consisted of incomplete patient information in medical records (e.g., age, sex, type of acid-base and electrolyte imbalance, main diagnosis, length of stay, and mortality).

This study referred to the normal reference values that were used at the PICU Dr. Hasan Sadikin General Hospital, Bandung. Blood samples were drawn on patients' admission and repeated several times during their stay in PICU, and any acid-base and electrolyte imbalances were noted. The initial diagnosis of acid-base and electrolyte imbalance was made if any value was below or above the normal values. If a patient has more than one acid-base and electrolyte imbalance in the results, the highest and lowest values (most severe) were used to determine the diagnosis. Below are the cut-off values:

The sampling method used in this study was consecutive sampling, and the sample size was determined using a sample calculation formula for categorical descriptive data. A total of 147 cases of acid-base and electrolyte imbalances were identified; however, only 131 cases were evaluable from 258 pediatric patients admitted to the PICU between January and December 2021. This study was approved by the Health Research Ethics Committee of Universitas Padjadjaran (931/UN6.KEP/EC/2022). Data analysis was conducted using Microsoft® Excel® 2019, and descriptive statistics were employed to present the results in terms of percentages and frequencies.

Results

During the study period, a total of 147 cases of electrolytes and acid-base imbalance were found among 258 patients admitted to the PICU of Dr. Hasan Sadikin General Hospital Bandung. Therefore, the frequency of critically ill children presenting with electrolytes and acid-base imbalance in the PICU was 57%. From this, 16 patients were excluded because the data in medical records were incomplete; due to incomplete value results, lack of main diagnosis, length of stay, or mortality.

A total of 131 patients (50.8%) with electrolytes and acid-base imbalances were analyzed in this study, with the ages ranging

Table 1 Normal Reference Values in the PICU of Dr. Hasan Sadikin General Hospital

Variable	Normal Values
Na^+ (Sodium)	135–145 mEq/L
K+ (Potassium)	3.5–5.1 mEq/L
Ca^{2+} (Ionized Calcium)	4.5–5.6 mg/dL
Cl^- (Chloride)	98–109 mEq/L
Mg^{2+} (Magnesium)	1.8–2.4 mg/dL
pH	7.35–7.45
PCO_2	35–45 mmHg
HCO_{3-}	22–26 mEq/L
Standardized base excess	(-2)–(+2) mmol/L

Table 2 Characteristics of Study Population (n=131)

Characteristics	n	%
Age groups		
Infants (1–11 months)	43	32.8
Toddler (12–59 months)	29	22.14
Children (6–12 years)	38	29.0
Adolescent (13–18 years)	21	16.0
Gender		
Males	70	53.0
Females	61	47.0
Main diagnosis		
Respiratory disorders	37	28.2
Cardiovascular system disorders	17	13.0
Kidney disorders	2	1.5
Endocrine and metabolism disorders	1	0.8
CNS disorders	26	19.8
Gastrointestinal disorders	20	15.3
Trauma	8	6.1
Malignancy	12	9.2
Others	8	6.1
Length of stay		
≤7 days	83	63.4
>7 days	48	36.6
Mortality		
Died	40	30.5
Survived	91	69.5

Table 3 Incidence of Electrolyte Imbalances (n=131)

Variable	n	%
Electrolyte imbalances*		
Hypernatremia	20	15.3
Hyponatremia	99	75.6
Hyperkalemia	19	14.5
Hypokalemia	56	42.7
Hyperchloremia	42	32.1
Hypochloremia	28	21.4
Hypercalcemia	24	18.3
Hypocalcemia	64	48.9
Hypermagnesemia	4	3.1
Hypomagnesemia	10	7.6
Acid-base imbalances**		
Metabolic acidosis	28	21.4
Respiratory acidosis	23	17.6
Metabolic alkalosis	16	12.2
Respiratory alkalosis	44	33.6

* **Each patient(s) could experience more than one acid-base and electrolyte imbalance

from one month to 17 years old (Table 1). Among those, 70 (53%) patients were males and 61 (47%) were females. The majority of the patients were infants in the age group 1 to 11 months with a total number of 43 (32.8%), followed by children (6–12 years old) in 38 (29%), toddlers (1–5 years old) for 29 (22.1%), and adolescents (12–18 years old) for 21 (16%).

For the admitting diagnosis, the majority i.e 37 (28.2%) patients have respiratory disorders, followed by central nervous system disorders in 26 (15.3%), followed by gastrointestinal disorders (20 (15.3%)), and 8 (6.1%) were categorized in other disorders including congenital and musculoskeletal disorders. Out of these 131 patients, as many as 83 (63.4%) stayed in the PICU for less and equal to 7 days. For the outcomes, it was found that 91 (69.5%) patients survived (transferred to another unit or discharged) and 40 (30.5%) died during hospitalization.

Out of 131 patients, a total of 366 events of electrolyte imbalance and 111 events of simple acid-base imbalance were reported. The most frequently noted acid-base and electrolyte imbalances abnormality was hyponatremia seen in 99 (75.6%) patients and respiratory alkalosis seen in 44 (33.6%) patients (Table 2). The incidence was followed by hypocalcemia in 64 (48.9%) and metabolic acidosis in 28 (21.4%) patients, followed by hypokalemia in 56 (42.7%) and respiratory acidosis in 23 (17.6%), followed by hyperchloremia seen in 42 (32.1%) and metabolic alkalosis in 16 (12.2%) patients. The less common electrolyte imbalances were hypomagnesemia in 10 (7.6%), and hypermagnesemia in 4 (3.1%) patients.

Regarding gender, it was found that electrolyte imbalances were more frequently

Table 4 Distribution of Electrolytes and Acid-Base Imbalances by Gender (n=131)

Types of Imbalances	Gender (n(%))		Total
	Males (n=70)	Females (n=61)	
Electrolyte imbalances*			
Hypernatremia	11 (15.7)	9 (14.8)	20
Hyponatremia	52 (74.3)	47 (77.0)	99
Hyperkalemia	10 (14.3)	9 (14.8)	19
Hypokalemia	24 (34.3)	32 (52.5)	56
Hyperchloremia	23 (32.9)	19 (31.1)	42
Hypochloremia	15 (21.4)	13 (21.3)	28
Hypercalcemia	14 (20.0)	10 (16.4)	24
Hypocalcemia	33 (47.1)	31 (50.8)	64
Hypermagnesemia	2 (2.9)	2 (3.3)	4
Hypomagnesemia	3 (4.3)	7 (11.5)	10
Acid-base imbalances**			
Metabolic acidosis	16 (22.9)	12 (19.7)	28
Respiratory acidosis	10 (14.3)	13 (21.3)	23
Metabolic alkalosis	9 (12.9)	7 (11.5)	16
Respiratory alkalosis	21 (30.0)	23 (37.7)	44

*,**Each patient(s) could experience more than one acid-base and electrolyte imbalance

seen in males (187 (51.1%)) than females (179 (48.9%)) (Table 3). Hyponatremia is the most common electrolyte imbalance seen in males and females, as seen in 52 (74.3%) and 47 (77%) patients, respectively. However, the incidence of hypokalemia was higher in females (32 (52.5%)) than in males (24 (34.3%)). As many as 56 (50.5%) out of 111 cases of acid-base imbalances were found in males with the most common disturbance being respiratory alkalosis (21 (30.0%)). The remaining cases of acid-base imbalances (55 (49.5%)) were found in females, with respiratory alkalosis (23 (37.7%)) presenting as the most common acid-base imbalance seen in females.

Based on the age group, the percentage of electrolyte imbalances was highest in children aged 6 to 12 years (120 (32.8%)). Hyponatremia was the most prevalent electrolyte imbalance in all groups, i.e infants (31 (72.1%)), toddlers (21 (72.4%)), children (32 (84.2%)), and adolescents (15 (71.4%)) (Table 4). In toddlers and children, hypocalcemia was more common (16 (55.2%) and 23 (60.5%), respectively) compared to the incidence in other age groups. Hypermagnesemia was rare, presenting only in infants (1 (2.3%)), children (1 (2.6%)), and adolescents (2(9.5%)). The most common acid-base imbalance found in infants was respiratory acidosis (14 (32.6%)), meanwhile, in toddlers, respiratory alkalosis is the most frequently noted (12 (41.4%)).

As shown in Table 5, in sodium, the prevalence of hypernatremia in deceased patients was higher than in alive children, with a mean of 161.00 ± 14.38 mEq/L. The same was found with potassium, where the prevalence of hyperkalemia in patients who were deceased (11 (27.5%)) was higher than in alive children (9 (9.9%)). However, hyponatremia was the leading electrolyte imbalance among the deceased patients, accounting for 75% of the deceased patients. The remaining mortality profiles of the patients with electrolyte imbalances are presented in Table 5.

A normal acid-base level was found in only 4 (10%) patients among the deceased patients (Table 6). Acid-base imbalance among the deceased patients was almost evenly distributed, as seen with metabolic acidosis, respiratory acidosis, and respiratory alkalosis that were found in 14 (35%) of the deceased patients.

Discussion

This study identified 147 cases (57.0%) of

Table 5 Distribution of Electrolytes and Acid-Base Imbalances by Age Groups (N=131)

Imbalances	Age groups (n(%))				Total
	Infants	Toddler	Children	Adolescent	
Electrolyte imbalances*					
Hypernatremia	3 (7.0)	9 (31.0)	5 (13.2)	3 (14.3)	20
Hyponatremia	31 (72.1)	21 (72.4)	32 (84.2)	15 (71.4)	99
Hyperkalemia	8 (18.6)	3 (10.3)	5 (13.2)	3 (14.3)	19
Hypokalemia	13 (30.2)	14 (48.3)	20 (52.6)	9 (42.9)	56
Hyperchloremia	13 (30.2)	9 (31)	12 (31.6)	8 (38.1)	42
Hypochloremia	9 (20.9)	8 (27.6)	9 (23.7)	2 (9.5)	28
Hypercalcemia	10 (23.3)	4 (13.8)	7 (18.4)	3 (14.3)	24
Hypocalcemia	14 (32.6)	16 (55.2)	23 (60.5)	11 (52.4)	64
Hypermagnesemia	1 (2.3)	0 (0.0)	1 (2.6)	2 (9.5)	4
Hypomagnesemia	1 (2.3)	2 (6.9)	6 (15.8)	1 (4.8)	10
Acid-base imbalances**					
Metabolic acidosis	6 (14.0)	4 (13.8)	11 (28.9)	7 (33.3)	28
Respiratory acidosis	14 (32.6)	5 (17.2)	3 (7.9)	1 (4.8)	23
Metabolic alkalosis	6 (14.0)	4 (13.8)	4 (10.5)	2 (9.5)	16
Respiratory alkalosis	6 (14.0)	12 (41.4)	17 (44.7)	9 (42.9)	44

*, **Each patient(s) could experience more than one acid-base and electrolyte imbalance

acid-base and electrolyte imbalances among 258 critically ill pediatric patients admitted to the PICU of Dr. Hasan Sadikin General Hospital Bandung from January to December 2021. After excluding 16 patients due to incomplete medical records, 131 cases (50.8%) were included in the final analysis. The exclusion of these cases did not significantly impact the overall incidence percentages, which remained relatively stable. Nevertheless, this exclusion may slightly limit the generalizability of the findings, particularly in representing patients with incomplete documentation or shorter durations of hospitalization.

The findings of this study are consistent with those reported by Agarwal and Octavia et al., which identified electrolyte imbalances in 60% and 61.7% of PICU patients, respectively.[3,5] In this study, a total of 366 electrolyte imbalance events were recorded. This relatively high number may be attributed to the inclusion of five electrolytes—sodium, potassium, calcium, chloride, and magnesium—where an imbalance in any of them was counted. In contrast, many previous studies examined fewer electrolytes. For instance, Octavia et al. reported 97 cases of electrolyte disturbances, focusing only on four electrolytes, and their study period was limited to four months, which was significantly shorter than the duration of this study.[5]

The total cases of acid-base imbalances in this study were 111 events. This study focused only on four major simple acid-base disturbances, namely metabolic acidosis, metabolic alkalosis, respiratory acidosis, and respiratory alkalosis. Currently, there are no available recent data regarding the incidence of acid-base imbalance in critically ill pediatric patients. This might be due to the complexity of the interpretation of complex acid-base status, and a large number of calculations cannot be carried out manually.[10]

This study found that infants aged 1 to 11 months were the majority of the patients, accounting for 43 (32.8%) patients. This was

Table 6 Mortality Profile in Patients with Electrolyte Imbalances (n = 131)

Type of Imbalances	Mean ± SD*	Mortality (n (%))	
		Survived (n=91)	Died (n=40)
Sodium			
Normal	137.94 ± 2.95	11 (12.1)	6 (15.0)
Hyponatremia	5.92 ± 5.27	69 (75.8)	30 (75.0)
Hypernatremia	161.00 ± 14.38	9 (9.9)	11 (27.5)
Potassium			
Normal	4.26 ± 0.49	44 (48.4)	10 (25.0)
Hypokalemia	2.79 ± 0.53	35 (38.5)	23 (57.5)
Hyperkalemia	6.41 ± 0.87	9 (9.9)	11 (27.5)
Chloride			
Normal	103.10 ± 3.20	19 (20.9)	12 (30.0)
Hypochloremia	91.33 ± 5.78	16 (17.6)	12 (30.0)
Hyperchloremia	119.62 ± 12.39	25 (27.5)	17 (42.5)
Magnesium			
Normal	2.80 ± 0.35	4 (4.4)	2 (5.0)
Hypomagnesemia	1.60 ± 0.09	8 (8.8)	1 (2.5)
Hypermagnesemia	2.12 ± 0.18	4 (4.4)	1 (2.5)
Calcium			
Normal	4.85 ± 0.26	34 (37.4)	9 (22.5)
Hypocalcemia	3.94 ± 0.62	39 (42.9)	25 (62.5)
Hypercalcemia	6.26 ± 0.72	15 (16.5)	9 (22.5)

*Values are presented in the following units; sodium = mEq/L; potassium = mEq/L; chloride = mEq/L; magnesium = mg/dL; and calcium = mg/dL

similar to the previous studies that noted the majority of the patients experiencing electrolyte imbalance were in the age group of less than 5 years old, including children of less than one year of age. [1,3–5] The reason for this is that physiologically, infants are more susceptible to fluid and electrolyte imbalances. Significant changes occur in TBW during the first year of life, from 75% of body weight at birth to 60% at 1 year.[11] Also, in the first year of life, there is immaturity of the kidney which causes disruption of sodium and water resorption.[12]

Table 7 Mortality Profile in Patients with Acid-Base Imbalances (n=131)

Type of Imbalances	Mortality (n(%))	
	Survived (n=91)	Died (n=40)
Normal	41 (45.1)	4 (10)
Metabolic acidosis	14 (15.4)	14 (35)
Respiratory acidosis	9 (9.9)	14 (35)
Metabolic alkalosis	9 (9.9)	7 (17.5)
Respiratory alkalosis	30 (33)	14 (35)

In the present study, the patients with electrolytes and acid-base imbalances were dominated by males in 70 (53%) compared to females in 61 (47%). Other studies conducted by Naseem et al., Agarwal, and Ali also found that males experienced more frequent episodes of electrolyte imbalances than females.[1,3,4] Ishaque, et al. also found that the incidence of metabolic acidosis was higher in males.[9] However, there is only limited explanation about the reasons for higher incidence among the males that were reported in the literature. One study found that males had a higher risk of developing hyperkalemia than females.[1]

The majority of the patients had respiratory (37 (28.2%)) and neurological (26 (19.8%)) disorders, as noted in previous studies.[3,4] However, this was different from the study conducted in Dr. Soetomo General Hospital Surabaya, in which digestive system disorder is the most common diagnosis.[5] In this study, the gastrointestinal disorder was the third most common (20 (15.3%)) diagnosis, but since the electrolyte abnormalities are well known, some of them might have received treatments or correction in the preceding unit and later shifted towards improvement, thus bypassing the PICU stay.

As many as 40 (30.5%) of patients with acid-base and electrolyte imbalances died during their course of hospitalization in PICU. This is comparable to the study of Agarwal N which states the mortality rate was 30.5%.[3] Compared to the patients with normal electrolyte levels, mortality rates in children having electrolyte imbalances are higher. The majority of the patients having acid-base and electrolyte imbalances stayed for less than 7 days (83 (63.4%)), as noted in other studies.[3,4] The remaining 48 (36.6%) stayed for more than 7 days. The previous studies mentioned that acid-base and electrolyte imbalances increase the length of stay as compared to patients with normal electrolyte levels.[4,7] However, this was not observed in this study.

Among sodium imbalances, hyponatremia was the most widespread, presenting in 99 (75.6%) of the patients. This is higher than earlier reports where it was 67.2% in a Saudi tertiary hospital[13], 36% in an emergency unit of an Egypt hospital[1], and much higher than a study done in Pakistani children which showed hyponatremia presented in 23.52% cases[4]. This may be attributable to the prevalence of underlying etiologies among the studied children. As mentioned before, the most common main diagnosis of these patients is respiratory and CNS disorders, in which both have been known to present with a high incidence of hyponatremia.

In potassium electrolytes, it was found that the results were dominated by hypokalemia in 56 (42.7%) patients, meanwhile, hyperkalemia was present in only 19 (14.5%) patients. Hypokalemia is the third most common electrolyte imbalance in this study and this was comparable to the study done by Naseem et al.[4] which found that hypokalemia was observed in 30.58%, also as the third most common imbalance in that study. A study in Dr. Soetomo General Hospital Surabaya[5] reported that hypokalemia is the second most common electrolyte disorder found in 54.1% of the patients. Other studies found the incidence of hypokalemia at 34.4%[3] and 64%[1] of the patients. Hyperkalemia in other studies has been reported as 18.82%[4] and 16.1%[3], which is in proximity to our observations.

Regarding chloride imbalance, hyperchloremia was more common than hypochloremia, found in 42 patients (32.1%) and 28 patients (21.4%), respectively. This contrasts with the findings of Octavia et al.,[5] who reported hypochloremia as the dominant disorder, occurring in 35.1% of patients. The higher prevalence of hyperchloremia in our study may be associated with the high incidence of metabolic acidosis, a known contributor to elevated chloride levels.

In cases of calcium disturbances, hypocalcemia was the most frequent imbalance found, accounting for 64 (48.9%) of the patients. Many studies found that hypocalcemia was the most common electrolyte imbalance as noted in 57.4%[4], 59.5%[5], and 56.6%[7] of the patients. Hypercalcemia was less common, found in 24 (18.3%) of the patients. However, this was higher than previous studies that mentioned hypercalcemia was only found in 0-8.1% of patients[4,5]. This might be related to the underlying disease e.g. malignancy that is found in 12 (9.2%) patients in this study, which is not observed in the other studies. Malignancies are known to produce hypercalcemia.

In our study, the incidence of magnesium disorders was the least common among the other electrolytes. Imbalance most frequently noted was hypomagnesemia, presenting in 10 (7.6%) of cases. Hypermagnesemia was rare, as observed in only 4 (3.1%) of the patients. This was similar to the study done by Sadeghi-Bojd et al. that found 13.8% of patients had hypomagnesemia compared to 2.3% who had hypermagnesemia.[7] Magnesium imbalances

were mostly asymptomatic and a strong clinical suspicion to check for the insoluble level is needed. Also, they are not routinely measured compared to other electrolytes in the PICU of Dr. Hasan Sadikin General Hospital, thus this might be the reason for the low incidence of magnesium imbalances.

The interpretation of complex acid-base disturbances was cumbersome and an understanding of dynamic processes is needed to accurately interpret the blood gas analysis. Until now, a convenient method with an understandable, clinically instant result is still lacking, especially in our hospital. Therefore, this study focused only on the simple (primary) acid-base disturbances. In this study, respiratory alkalosis was the most common acid-base disturbance found (44 (33.6%)). This was appropriate with the fact that respiratory alkalosis is the most common acid-base abnormality observed in critically ill patients. However, Forsal et al. found that respiratory acidosis was the primary disturbance in 31% of the cohort.[10] The reason for this is probably because respiratory acidosis was more commonly found as a mixed disorder[14,15], and the incidence of it in this study was masked with the primary disturbance.

Based on gender, the frequency of hyponatremia is more common in males (52 (74.3%)). These findings were similar to the previous studies by Prabaharan K and Al-Sofyani K, which found hyponatremia in 66.7% and 61.1% of male patients, respectively[13,16]. The third most common electrolyte imbalance in males was hypokalemia 24 (34.3%). Although, the frequency was higher in females (32 (52.5%)). This was dissimilar with Cummings[17] who found hypokalemia was less likely in females. Hormonal differences in developing females and males regarding to their potassium homeostasis and total body stores may be one of the explanations for this difference. Hyperkalemia observed in the present study was more common in males (10 (14.3%)). This is similar to and also supported the findings of Ali et al. that males had a higher risk of developing hyperkalemia than females. Regarding magnesium, there is no difference in the frequency of hypermagnesemia in males (2 (2.9%)) and females (2 (3.3%)). However, the frequency of hypomagnesemia is higher in females (7 (11.5%)) than in males (3 (4.3%)). This was different with Dandinavar who reported hypomagnesemia in 57.3% of males, but current data shows there was no significant association between hypomagnesemia and gender.[8]

The most common acid-base imbalance seen in both genders was respiratory alkalosis, accounting for 21 (30%) in males and 23 (37.7%) in females. This supports the current knowledge that there has not appeared to be a significant gender distribution to alkalosis. Meanwhile, for respiratory acidosis, the incidence was higher in females (12 (21.3%)). This might be related to the underlying diseases, where severe lung disease will reduce the effectiveness of the lungs in removing CO2, and diseases of chest nerves will impair the ventilation of the lungs. In this study, the majority of the respiratory and CNS disorders were experienced by females.

As stated before, based on age groups, the most common electrolyte imbalance in all ages was hyponatremia, with the highest in infants 31 (72.1%). This finding aligns with previous reports, which also indicated that hyponatremia is predominant in children aged 0–12 months.[13,16] However, current data shows no statistically significant association found between hyponatremia and gender and age.[13] The frequency of hypokalemia was highest in children aged 6–12 years (20 (52.6%)). This was different from the study by Gauns A which reported that hypokalemia was higher in children aged 1 to 5 years old.[18] This might be caused by the different age ranges used in the studies. In the case of acid-base imbalance, respiratory alkalosis was the most commonly noted acid-base disorder in almost all of the age groups. However, in infants, the most commonly noted imbalance was respiratory acidosis. This finding was important. Acidosis in neonates and infants is supposedly less frequent since they have a relatively greater increase in plasma HCO_3^- concentrations and decrease in plasma hydrogen ion concentrations, due to a large amount of hemoglobin and interstitial fluid for their body weight than those of older children.[20] However, there is very limited literature discussing respiratory acidosis in infants or its correlation with age. Further study is needed to investigate the relationship.

Hyponatremia was the most frequently occurring electrolyte imbalance found in 30 (75%) of the deceased patients, similar with previous study that found hyponatremia in deceased children was significantly higher.[7] Out of 40 deceased patients, only 4 (10%) of them had normal acid-base levels. However, a previous study found that currently there is no association between acid-base disorders and in-hospital death.[14]

This study has several limitations. First,

this was a descriptive study that did not help determine the association between the acid-base and electrolyte imbalances with the factors mentioned in this study e.g. age, gender, mortality, or length of stay in PICU. Also, many acid-base and electrolyte imbalances were not included as a diagnosis in the patient's medical records, thus the author needed to interpret the results manually. This process did not escape the risk of human-based errors. However, behind the imperfection previously mentioned, in conclusion, the present study found that electrolyte (n=366) and acid-base imbalances (n=111) are common in critically ill children admitted to the PICU of Dr. Hasan Sadikin General Hospital Bandung from January to December 2021. The most frequent electrolyte imbalance was hyponatremia (75.6%), while respiratory alkalosis (33.6%) was the most common acid-base disturbance. The majority of patients are infants and males, with respiratory disorders as the most frequent primary diagnosis. These factors should be warning signs of acid-base and electrolyte imbalances. It is important to note that several findings differ from the previous studies. The reason is probably related to the differences in socio-demographic and clinical factors between Indonesia and other countries, as well as differences in the period of the study.

It is recommended that acid-base and electrolyte imbalances be consistently recorded as part of the diagnostic information in patient medical records. This study may serve as a valuable reference to support further evaluation and management strategies aimed at preventing adverse outcomes in critically ill pediatric patients with such imbalances. Future research should include statistical analyses to explore the correlation between acid-base and electrolyte disturbances and clinical outcomes in this population.

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