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Outcomes/Predictions

Acid-base disturbances in acute poisoning and their association with survival☆,☆☆

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ABSTRACT

Purpose: The purpose was to investigate the association between acid-base disturbances and mortality in acute poisoning.
Materials and methods: We performed a retrospective cross-sectional exploratory study on all acutely poisoned patients older than 12 years who had been admitted to the main tertiary toxicology hospital in Tehran between March and August 2010.
Results: Of a total of 1167 patients (median age = 25 years, 50.9% male), 98 died (74.5% male). Psychotropic medications were the most common cause of poisoning (36.5%), whereas narcotics and psychodysleptics were the most common cause of death (23.5%). Mixed respiratory alkalosis and metabolic acidosis with normal pH were the most common acid-base status (333, 28.5%). However, patients with primary metabolic acidosis and respiratory compensation had significantly higher mortality (31 cases, 18.8%). Logistic regression analysis identified age (odds ratio [OR], 1.051; 95% confidence interval [CI], 1.031-1.070; $P < .001$), intensive care unit admission (OR, 12.405; 95% CI, 7.178-21.440; $P < .001$), consciousness level (OR, 1.752; 95% CI, 1.301-2.359; $P < .001$), hospitalization period (OR, 1.1361; 95% CI, 1.079-1.195; $P < .001$), severe metabolic acidosis (OR, 6.016; 95% CI, 1.647-21.968; $P = .007$), and primary respiratory alkalosis (OR, 5.579; 95% CI, 1.353-23.001; $P = .017$) as death predictors during hospitalization ($P < .001$).
Conclusion: On-arrival acid-base status predicts survival and can be used in prognostication of the poisoned patients.

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1. Introduction

Analysis of blood gases and acid-base status is an essential tool in assessment of ill patients in the emergency setting. However, the role of acid-base disturbance on survival of acutely poisoned patients has not been thoroughly investigated. Although few studies have evaluated acid-base disturbance in acute poisonings, most of them have focused on this subject in single specific poisonings, and there is little information on the pattern of acid-base disturbances and their prognostic role in acute poisoning as one of the leading causes of injury-related death worldwide [1–3]. Although such disturbances are signs of clinical conditions and may not be directly related to the cause of toxicity, we were curious to know if we could predict the poisoned patients' outcome based on acid-base status.

Despite development of different prognostic scoring systems such as Simplified Acute Physiology Score and Acute Physiologic and Chronic Health Evaluation, these scoring systems may not be suitable for acutely poisoned patients because on-arrival loss of consciousness is quite important in determination of the final score while having little effect on the outcome of poisoning, making such systems less sensitive in prognostication of mortality [4]. To provide a more accurate prognostic picture, recent studies tried to find new prognostic factors associated with survival in acute poisoning [5–8].

Apart from known prognostic factors such as on-arrival shock state, aspiration, loss of consciousness, and need for intubation and mechanical ventilation, we hypothesized that on-arrival acid-base disturbance, per se, might associate with poor prognosis and could help to separate patients at risk. The present study aims to determine the association of on-arrival acid-base disturbances and outcome in patients with acute poisoning who did not have cardiopulmonary arrest in the

☆ Author contributions statement: HHM and HH conceived the study. HHM, NZ, and HH supervised the data collection. NZ, HHM, and HH undertook recruitment of patients and managed the data, including quality control. HHM and AH provided statistical advice on study design and analyzed the data. AH and HHM drafted the manuscript, and all authors contributed substantially to its revision. HHM takes responsibility for the paper as a whole.
☆☆ Conflict of interest: none for all authors.

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emergency department (ED) and to report the mortality rate associated with different acid-base statuses in acute poisoning. Demographic variables were also evaluated for their association with acid-base status as a secondary aim.

2. Materials and methods

2.1. Study design and patient selection

This retrospective cross-sectional exploratory study was designed and conducted in Loghman-Hakim Hospital, a referral center for poisoning in Tehran with annual hospitalization of about 10 000 to 14 000 poisoned patients, accounting for almost 41% to 46% of all patients admitted to the ED of this hospital annually [9–12]. The study was approved by local ethics committee. All consecutive acutely poisoned patients older than 12 years admitted to the adolescents' and adults' ED during a 6-month period (March-August 2010) were included. Patients without blood gas analysis on admission, those with on-arrival or prearrival cardiopulmonary arrest, and those with missing data were excluded (Fig. 1).

2.2. Data collection

Patients' laboratory tests and electronic medical records were reviewed by a trained physician. Data including the *International Classification of Diseases, 10th Revision* (ICD-10) category of poisoning and subgroups, age, sex, agent and type of poisoning, level of conscious, mean arterial pressure, time elapsed between intoxication and blood gas analysis, length of hospitalization, on-arrival acid-base status, and outcome were extracted. *Pure ingestion* was defined as exposure to a sole agent or similar agents in the same group based on ICD-10 categorization. Level of consciousness was defined according to the 4-grade Reed classification system [13]. Outcome was defined as survival (regardless of the presence of complications) vs death.

2.3. Acid-base interpretation

To evaluate the predictive role of acid-base status, the first on-admission peripheral arterial or venous blood gas analysis was used. Blood gas analyses were reviewed and interpreted retrospectively by a nephrologist coauthor. Based on normal pH values on arterial and venous blood gas analyses, patients were categorized as those with normal blood gas (pH, HCO_3, base excess [BE], and PCO_2 in normal ranges), mixed respiratory alkalosis and metabolic acidosis (pH in normal range but $PvCO_2 < 41$ mm Hg or $PaCO_2 < 35$ mm Hg and BE < −2), or mixed respiratory acidosis and metabolic alkalosis (pH in normal range but $PvCO_2 > 50$ mm Hg or $PaCO_2 > 45$ mm Hg and BE > 2). Fig. 2 shows interpretation of blood gas analyses [14]. Any undefined blood gas was resolved by a consensus between the nephrologist and the corresponding author.

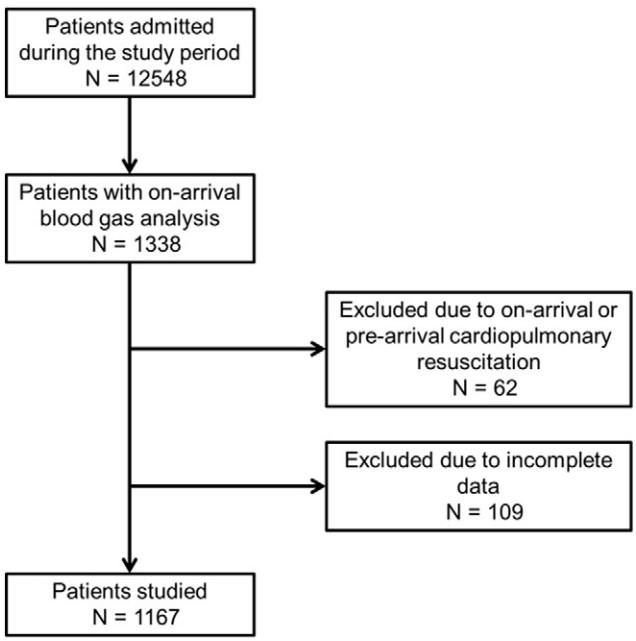

Fig. 1. Flowchart of inclusion and exclusion of patients.

Magnitude of acid-base disturbances was defined based on BE and PCO_2 [15]; in primary respiratory acidosis, any PCO_2 greater than the reference range was categorized as minimal/mild (<50 mm Hg), moderate (50-55 mm Hg), marked (55-62 mm Hg), or severe (>62 mm Hg). In respiratory alkalosis, it was defined as minimal/mild (>30 mm Hg), moderate (25-30 mm Hg), marked (18-25), or severe (<18 mm Hg).

For primary metabolic acidosis, any BE less than the reference range was categorized as minimal/mild (<−6 mEq/L), moderate (−6 to −9 mEq/L), marked (−9 to −13 mEq/L), or severe (> − 13 mEq/L). In metabolic alkalosis, it was defined as minimal/mild (<6 mEq/L), moderate (6-9 mEq/L), marked (9-13 mEq/L), or severe (>13 mEq/L). Because of different severities in each component of mixed acid-base disturbances, they were not entered in severity analysis. Also, for ease of classification, subgroups of acid-base status were merged in this analysis; for example, both primary respiratory acidosis with renal compensation and primary respiratory acidosis with no renal compensation were treated as "primary respiratory acidosis" (Fig. 2 and Table 1).

2.4. Statistical analysis

Results were expressed as mean ± standard deviation for continuous data with normal distribution and mean (interquartile range [IQR]) for nonnormally distributed variables and frequencies and percentages for categorical data. Normality was checked for all dependent variables using Kolmogorov-Smirnov and Shapiro-Wilk tests.

To evaluate the association between death and different acid-base statuses, χ^2 test was used by applying a binominal variable for each acid-base disturbance (yes/no). Mann-Whitney *U* test was used to compare differences between death and ordinal dependent variables (2 samples) when not normally distributed. Cramer *V* was applied to measure the strength of association of a nominal by nominal relationship, if any. Kruskal-Wallis *H* test was applied to compare more than 3 nominal variables when the dependent variable was continuous but not normally distributed. A Kendall tau-b correlation was run to determine the relationship between level of consciousness and acid-base disturbances.

Dunn-Bonferroni post hoc test analysis was used to find the responsible variable when Kruskal-Wallis test was significant. All variables with *P* values less than .2 affecting the survival were incorporated into a multivariate regression model to identify independent predictors of death. Results were reported as odds ratio (OR) and 95% confidence intervals (CIs). Binominal standard logistic model was performed to determine independent variables predicting death in patients. All statistical tests were 2-tailed, and *P* values less than .05 were considered statistically significant. Analysis was performed using the SPSS software version 21.0 (SPSS Inc, Chicago, IL, USA).

3. Results

Fig. 1 shows the actual enrollment number and breakdown of exclusions. Of 1167 enrolled patients, 594 were male, and median age was 25 years old (range, 13-90 years). Two-hundred patients (17.1%) were admitted to the intensive care unit (ICU). Acute poisoning was due to multiple drugs in 500 patients (42.8%). The most common acid-base status was normal pH, mixed metabolic acidosis and respiratory alkalosis (333 cases, Table 1). Ninety-eight patients died (74.5% male; OR, 3.07; 95% CI,

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