Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.53555/wtpzs742

BLOOD GAS AND TOXICOLOGICAL ANALYSIS IN ASPHYXIAL DEATHS: A CROSS-SECTIONAL STUDY

Dr Muhammad Shafay[1*], Dr Roman Ashraf[2], Dr Rabail Altaf[3], Dr Ishrat Bibi[4], Dr Farooq Ahmed Abro[5], Dr Nazia Yasmin[6]

[1*]Assistant Professor, Department of Forensic Medicine and Toxicology, HBS Medical and Dental College, Islamabad, Pakistan
[2]Assistant Professor, Department of Forensic Medicine and Toxicology, Lahore Medical and Dental College, Lahore, Punjab, Pakistan
[3]Assistant Professor, Department of Forensic Medicine and Toxicology, Gambat Medical College @ PAQSJIMS, Gambat, Sindh, Pakistan
[4]Assistant Professor, Department of Forensic Medicine and Toxicology, Liaquat University of Medical and Health Sciences, Jamshoro, Sindh, Pakistan
[5]Associate Professor, Department of Forensic Medicine and Toxicology, Chandka Medical College, Larkana, Sindh, Pakistan
[6]Assistant Professor, Department of Forensic Medicine and Toxicology, HBS Medical and Dental College, Islamabad, Pakistan

*__Corresponding author:__ Dr Muhammad Shafay
***Email**: shafay_jalbani@yahoo.com

ABSTRACT

Background: Asphyxial deaths remain a significant concern in forensic medicine due to their sudden, often preventable nature and complex medico-legal implications. Understanding the demographic profile, causes, and toxicological aspects of such deaths is crucial for effective prevention, investigation, and policy-making.

Objective: To determine the frequency and types of poisons contributing to asphyxial deaths and analyze their demographic, clinical, and postmortem patterns in medico-legal autopsies conducted in the Rawalpindi and Islamabad region.

Methodology: This descriptive cross-sectional study was conducted at the Department of Forensic Medicine and Toxicology, HBS Medical & Dental College, Islamabad, over a period of one year. A total of 52 cases of asphyxial deaths confirmed via autopsy and toxicological analysis were included using non-probability consecutive sampling. Detailed examination of demographics, manner of death, autopsy findings, and toxicology reports was carried out. Data were analyzed using SPSS version 25.

Results: Males constituted 73.1% of cases, with the highest frequency in the 31–45-years age group (36.5%). Urban residents accounted for 59.6% of deaths. The majority (48.1%) were accidental, followed by suicidal (32.7%) and homicidal (19.2%) deaths. External findings included cyanosis (80.8%) and petechial hemorrhages (75%). Toxicological analysis revealed carbon monoxide (32.7%) as the most common toxin, followed by organophosphates (15.4%), methanol (11.5%), and cyanide (9.6%).

Conclusion: Carbon monoxide, organophosphates, and methanol are major toxic agents in asphyxial deaths, particularly among adult urban males. Strengthening occupational safety regulations and public awareness can significantly reduce such preventable fatalities.

Keywords: Asphyxial deaths, carbon monoxide, toxicology, medico-legal autopsy, organophosphates, methanol poisoning, cyanide

INTRODUCTION

Asphyxial deaths, defined as those resulting from inadequate oxygen supply to the body, represent a critical forensic concern due to their multifactorial etiology and diagnostic challenges [1]. These include mechanical causes (hanging, strangulation), chemical causes (carbon monoxide, cyanide poisoning), and environmental causes (drowning, suffocation) [2]. Globally, asphyxial deaths account for a substantial proportion of unnatural fatalities, and accurate postmortem diagnosis often depends on a combination of scene investigation, autopsy findings, and laboratory analysis, particularly blood gas and toxicological profiles [3].

In forensic medicine, blood gas analysis serves as a valuable tool to detect hypoxia, hypercapnia, and metabolic acidosis—hallmarks of asphyxial processes [4]. Simultaneously, toxicological screening helps identify substances like ethanol, narcotics, carbon monoxide, or organophosphates that may induce or mimic asphyxia [5]. This combined analytical approach significantly enhances diagnostic accuracy, especially in cases with minimal external findings [6].

Pakistan faces a significant burden of asphyxial deaths, many of which are misclassified or underreported due to limitations in forensic capacity and postmortem investigations [7]. A study conducted in Punjab from 2020 to 2022 reported a rising trend in hanging and strangulation cases, often linked to domestic violence or suicide [8]. According to the Pakistan Bureau of Statistics (2022), accidental and unnatural deaths, including those due to asphyxia, accounted for approximately 7.8% of total deaths in the country, highlighting a growing public health concern [9]. Moreover, the forensic infrastructure in many regions, including Islamabad, often lacks standardized protocols for blood gas and toxicological testing, leading to gaps in the medico-legal system [10].

The research problem lies in the limited application of modern biochemical methods like arterial blood gas (ABG) and toxicology in determining the cause of asphyxial deaths in Pakistan. In many cases, traditional autopsy findings are relied upon without confirmatory laboratory diagnostics, resulting in diagnostic inaccuracies and possible miscarriages of justice [11]. At HBS Medical & Dental College, Islamabad, this study aims to address this gap by utilizing blood gas and toxicological analysis to assess the physiological changes associated with different types of asphyxial deaths and improve forensic interpretative accuracy [12].

Given the increasing suicide rates, substance misuse, and domestic violence cases in urban Pakistan post-2020—further exacerbated by socioeconomic pressures and the COVID-19 pandemic—this study is both timely and essential [13]. The findings are expected to provide crucial forensic evidence and inform medico-legal protocols for accurate certification and legal processing of asphyxial deaths.

METHODOLOGY

This retrospective cross-sectional study was conducted in the Department of Forensic Medicine and Toxicology, HBS Medical & Dental College, Islamabad, in collaboration with medico-legal data obtained from the Forensic Unit of the District Headquarters (DHQ) Hospital, Rawalpindi. The study spanned from January 2024 to December 2024.

A total of 52 asphyxial death cases were included in the study using purposive sampling. These cases were selected from the archives of medico-legal autopsies and hospital mortality records based on inclusion and exclusion criteria. Inclusion criteria were: (1) confirmed asphyxial deaths based on clinical history, police inquest reports, and autopsy findings; (2) availability of preserved biological samples (blood and viscera); and (3) availability of complete hospital or medico-legal records. Exclusion criteria included decomposed bodies, unidentified corpses with no clinical history, and cases with incomplete toxicological data or missing autopsy records.

The cases were categorized into two groups: (1) Brought-in-dead (BID) cases (n = 22), and (2) Hospital deaths (n = 30)-those admitted to healthcare facilities alive but expired due to suspected asphyxial causes. The hospital deaths were further stratified into early (death within 24 hours of admission) and delayed fatalities (death occurring after 24 hours, up to 45 days). For each case, a comprehensive autopsy was conducted by qualified forensic medicine specialist. The procedure involved a systematic external examination for signs such as cyanosis, petechial hemorrhages, facial congestion, or ligature marks. Internal examination included a detailed inspection of the lungs, trachea, hyoid bone, and neck muscles to detect congestion, edema, or hemorrhage typical of mechanical asphyxia.

Blood samples were drawn from the femoral vein (when available) during autopsy and preserved in fluoride oxalate tubes for blood gas and toxicological analysis. Blood gas parameters-including partial pressures of oxygen (PaO_2), carbon dioxide ($PaCO_2$), blood pH, and bicarbonate (HCO_3^-)-were assessed using a portable blood gas analyzer within two hours of sample collection to minimize postmortem changes. Tests included screening for common asphyxiants such as carbon monoxide (COHb%), cyanide, methanol, and organophosphates, using gas chromatography (GC), spectrophotometry, and enzyme-linked immunosorbent assay (ELISA) techniques, depending on the compound. For suspected methanol toxicity, histological analysis of the optic nerve segment from the optic chiasma was conducted to detect retinal edema or demyelination-a histopathological hallmark of methanol poisoning.

Retrospective clinical data extracted included demographic profile, vital signs on admission (if applicable), administered treatments, duration of hospitalization, and ultimate outcome. All data were entered and coded into a secure SPSS version 25.0 database for analysis. Descriptive statistics such as mean, standard deviation, and frequencies were calculated. Chi-square test was used to compare toxicological and blood gas parameters between BID and hospital death groups. A p-value of ≤ 0.05 was considered statistically significant.

RESULTS

Out of the total 52 asphyxial death cases included in the study, the majority were males (73.1%) and aged between 31–45 years (36.5%), followed by the 18–30 age group (26.9%) as shown in Table 1. Most victims belonged to urban areas (59.6%), indicating a higher burden of asphyxial incidents in city environments

TABLE 1: Demographic Characteristics of Asphyxial Deaths (N = 52)

Variable	**Frequency (n)**	**Percentage (%)**
AGE GROUP (YEARS)		
18–30	14	26.9%
31–45	19	36.5%
46–60	11	21.2%
>60	8	15.4%
GENDER		
Male	38	73.1%
Female	14	26.9%
RESIDENCE		
Urban	31	59.6%
Rural	21	40.4%

As per Table 2, hospital deaths constituted a higher proportion (57.7%) compared to brought-in-dead (BID) cases (42.3%). Among the hospital deaths, 34.6% died after 24 hours of admission (delayed deaths), while 23.1% expired within 24 hours (early deaths). The majority of cases were accidental in nature (48.1%), followed by suicidal (32.7%) and homicidal deaths (19.2%).

TABLE 2: Type And Manner Of Death (N = 52)

Variable	Frequency (n)	Percentage (%)
CASE CATEGORY		
Brought-in-Dead (BID)	22	42.3%
Hospital Death	30	57.7%
Early (≤24 hours)	12	23.1%
Delayed (>24 hours–45 days)	18	34.6%
MANNER OF DEATH		
Accidental	25	48.1%
Suicidal	17	32.7%
Homicidal	10	19.2%

External autopsy findings (Table 3) revealed that cyanosis (80.8%) and petechial hemorrhages (75.0%) were the most frequent signs, reinforcing the hypoxic mechanism of death. Facial congestion was noted in 69.2% of cases, while ligature marks were found in 28.8%, suggesting strangulation in a subset of cases. Neck muscle hemorrhage was observed in 34.6% of victims, consistent with forceful mechanical asphyxia.

TABLE 3: External Autopsy Findings (N = 52)

Finding	Frequency (n)	Percentage (%)
Cyanosis	42	80.8%
Petechial Hemorrhages	39	75.0%
Facial Congestion	36	69.2%
Ligature Marks	15	28.8%
Neck Muscle Hemorrhage	18	34.6%

Blood gas analysis results in Table 4 revealed that low PaO_2 and high $PaCO_2$ were present in 78.8% of the total cases, indicating significant hypoxemia and hypercapnia. Low pH (<7.2) was seen in 69.2% and decreased bicarbonate levels (HCO_3^-) were observed in 61.5% of cases. These derangements were more pronounced in BID cases than in hospital deaths, suggesting more acute and severe asphyxial events in those who died before reaching the hospital.

TABLE 4: Blood Gas Analysis Results by Case Type (N = 52)

Parameter	BID (n = 22)	Hospital Deaths (n = 30)	Total Abnormal (n=52)
Low PaO_2	19 (86.4%)	22 (73.3%)	41 (78.8%)
High $PaCO_2$	17 (77.3%)	24 (80%)	41 (78.8%)
Low pH (<7.2)	15 (68.2%)	21 (70%)	36 (69.2%)
Low HCO_3^-	14 (63.6%)	18 (60%)	32 (61.5%)

Toxicological findings in Table 5 showed that carbon monoxide poisoning was the most common toxidrome (32.7%), with a higher incidence among BID cases (40.9%). Methanol and organophosphate poisonings were detected in 11.5% and 15.4% of cases, respectively. Cyanide was confirmed in 9.6% of deaths. Notably, 30.8% of the cases showed no detectable toxin, indicating either mechanical or anoxic asphyxia unrelated to toxic exposure.

TABLE 5: Toxicological Findings by Case Type (N = 52)

Substance Detected	BID (n = 22)	Hospital Deaths (n = 30)	Total Cases (n=52)
Carbon Monoxide (CO Hb>10%)	9 (40.9%)	8 (26.7%)	17 (32.7%)
Cyanide	2 (9.1%)	3 (10%)	5 (9.6%)
Methanol	4 (18.2%)	2 (6.7%)	6 (11.5%)
Organophosphates	3 (13.6%)	5 (16.7%)	8 (15.4%)
No Toxin Detected	4 (18.2%)	12 (40%)	16 (30.8%)

DISCUSSION

This study offers a detailed examination of asphyxial deaths in Islamabad and Rawalpindi, showing a demographic and pathological pattern similar to national and global trends. The predominance of male victims (73.1%) and the highest incidence in the 31–45 age group (36.5%) reflects findings from a regional study conducted in Hyderabad, Pakistan, where adult males were significantly more affected by asphyxial fatalities [14]. Similar demographic distributions were reported in Peshawar, where the majority of cases also involved middle-aged males from urban backgrounds [15].

Urban settings were responsible for 59.6% of cases in this study, suggesting a link between asphyxial death and urban environmental and occupational hazards. This aligns with international data indicating higher asphyxial mortality in densely populated or industrialized zones [16].Accidental deaths were most frequent (48.1%), followed by suicidal (32.7%) and homicidal (19.2%) cases. These findings echo prior research from Pakistan and other South Asian regions, where accidental and suicidal asphyxial deaths, particularly due to chemical exposure or hanging, are common [17].

Characteristic external signs—such as cyanosis (80.8%), petechial hemorrhages (75.0%), and facial congestion—were noted in the majority of cases. These signs are widely acknowledged in forensic pathology as classic indicators of hypoxic death and have been consistently documented across multiple studies [18].Blood gas analysis provided valuable physiological evidence. Abnormally low PaO_2 and elevated $PaCO_2$ levels were observed in 78.8% of cases, consistent with the pathophysiology of respiratory compromise due to hypoxia [19].

Among toxicological findings, carbon monoxide (CO) was the most frequently detected toxin (32.7%). This supports international epidemiological findings: theGlobal Burden of Disease Study 2021 estimated over 28,900 deaths globally from unintentional CO poisoning in 2021 [20]. In Pakistan, industrial workers and urban residents are particularly vulnerable, with documented elevated carboxyhemoglobin levels among exposed populations [21].Methanolwas found in 11.5% of cases—an alarming figure given methanol's presence in adulterated or counterfeit alcohol. Similar outbreaks have been reported in Iran, where methanol poisoning remains a significant public health issue among youth and low-income populations [22]. Recent global media coverage has highlighted methanol-related deaths in tourist destinations as well, raising international awareness [23].

Organophosphate poisoning accounted for 15.4% of asphyxial deaths in this cohort. Organophosphates, widely used in agriculture, are often consumed in deliberate self-harm. Nationally, they are the most common cause of chemical suicide attempts, with high rates of morbidity and mortality [24]. A study from Karachi found acute kidney injury and cardiac changes as frequent complications of organophosphate poisoning, particularly in young adults [25,26].Interestingly, cyanide was identified in 9.6% of the toxicology-confirmed cases. Cyanide toxicity, although less frequent, can occur via smoke inhalation or industrial exposure. This reinforces the importance of robust industrial safety protocols and fire hazard awareness [27].

CONCLUSION

This study highlights that asphyxial deaths in Islamabad and Rawalpindi are predominantly accidental, affect males in the working-age group, and are more common in urban settings. Most victims exhibit classical autopsy findings of hypoxia and blood gas abnormalities consistent with asphyxia. Carbon monoxide was the leading toxicological cause, especially in BID cases.

REFERENCES

1. Saukko P, Knight B. Knight's Forensic Pathology. 4th ed. CRC Press; 2015.
2. DiMaio VJ, DiMaio D. Forensic Pathology. 2nd ed. CRC Press; 2001.
3. Madea B. Asphyxia deaths: Diagnostic problems. Forensic Sci Med Pathol. 2016;12(4):467-470.
4. Hunsaker DM. Blood gases in forensic pathology. Am J Forensic Med Pathol. 2018;39(3):201–205.
5. Guharaj PV, Chandran MR. Forensic Medicine. 3rd ed. Orient Blackswan; 2011.
6. Palmiere C, Augsburger M. The forensic significance of postmortem blood gas analysis. Forensic Sci Int. 2015;254:165-170.

7. Khan H, Saeed O, Khan MA. Forensic autopsy trends in Pakistan: A neglected discipline. J Ayub Med Coll Abbottabad. 2021;33(2):289–293.
8. Ali R, Shahid A, Jamil M. A forensic analysis of suicide and strangulation cases in Punjab (2020–2022). Pak J Forensic Med. 2023;4(1):23–28.
9. Pakistan Bureau of Statistics. Annual Report of Vital Statistics 2022. [Internet]. Islamabad: PBS; 2022 [cited 2025 May 5]. Available from: https://www.pbs.gov.pk
10. Rehman A, Afridi Z. Challenges in forensic toxicology in Pakistan: A narrative review. Pak J Med Sci. 2022;38(7):1876–1881.
11. Shahid N, Qureshi FA. Diagnostic errors in cause of death determination: Role of forensic science in Pakistan. J Coll Physicians Surg Pak. 2021;31(10):1176-1179.
12. HBS Medical & Dental College. Annual Research Digest 2023. Department of Forensic Medicine. Islamabad: HBS; 2023.
13. Ahmed S, Naeem F, Iqbal M. Suicide and substance use in Pakistan: COVID-19 pandemic implications. Asian J Psychiatr. 2021;59:102679.
14. Akhtar N, Mal S, Anwar A, Rasheed A, Aziz I, Langah IA. Pattern of Asphyxial Deaths in Forensic Autopsies. Pak J Med Health Sci. 2022;16(03):95.
15. Khan FA, Gul F, Khan N, Shah R. Trends of Asphyxial Deaths and Their Association with Demographic Factors: A Retrospective Autopsy-Based Study. J Med Sci. 2022;30(1):55–59.
16. World Health Organization. Global status report on violence prevention. Geneva: WHO; 2022.
17. Saeed A, Javed A, Khalid M. Forensic Aspects of Hanging Deaths in Central Punjab, Pakistan. Pak J Forensic Med. 2021;1(1):10–14.
18. Knight B. Forensic Pathology. 4th ed. London: CRC Press; 2020.
19. Kumar V, Abbas AK, Aster JC. Robbins and Cotran Pathologic Basis of Disease. 10th ed. Philadelphia: Elsevier; 2020.
20. Naghavi M, GBD 2021 Risk Factors Collaborators. Global, regional, and national mortality due to unintentional carbon monoxide poisoning, 2000–2021: results from the Global Burden of Disease Study 2021. Lancet Public Health. 2023;8(3):e210–e218.
21. Ullah S, Khan M, Rehman A, Jan R. Exploring Health Impacts of Occupational Exposure to Carbon Monoxide in the Labour Community of Hattar Industrial Estate. Atmosphere. 2022;13(3):406.
22. Moshiri M, Darchini-Maragheh E, Balali-Mood M. Tertiary referral hospital experience of methanol poisoning in the COVID-19 era: a cross-sectional study in Northwestern Iran. Bull Natl Res Cent. 2023;47:92.
23. Walters J. Teenage Backpacker and 3 Others Die After Drinking Tainted Alcohol in Popular Tourist Town. People. 2024 Nov 21. Available from: https://people.com/backpacker-deaths-tainted-alcohol-methanol-laos-vang-vieng-8749289
24. Sheikh JS, Ubaid R, Alam S, Mohammad P, Munib M, Khan Y. Epidemiological Patterns and Clinical Consequences of Organophosphorus Poisoning. Pak J Med Health Sci. 2023;17(11):96.
25. Arif H, Qamar K, Mahmood N. Frequency of Acute Kidney Injury (AKI) among patients presenting with Organophosphate Poisoning. Pak J Med Sci. 2022;38(3):542–546.
26. Shaikh ZA, Jhatial SA, Shah SMA. Frequency of electro-cardiographic changes in patients of acute organophosphate poisoning at tertiary care hospital Larkana, Pakistan. Nepalese Heart J. 2017;14(2):5–8.
27. Hayes MM. Cyanide poisoning in smoke inhalation: mechanisms and diagnosis. Crit Care Clin. 2020;36(2):339–351.