

ARRIVAL FEATURES ASSOCIATED WITH EMERGENCY AIRWAY INTERVENTION IN KALA PATHAR (PARAPHENYLENEDIAMINE) INGESTION

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Abstract

Objective: To determine the association between clinical features documented at emergency department (ED) arrival and emergency airway intervention among adults with suspected kala pathar (paraphenylenediamine, PPD) ingestion, and to estimate the frequency and type of that intervention.

Study Design: Prospective, observational, analytical, cross-sectional study.

Setting: Accident and Emergency Department, Jinnah Postgraduate Medical Centre (JPMC), Karachi.

Period: Four month from December 2024 to March 2025.

Material & Methods: 384 adults with suspected PPD ingestion were enrolled by non-probability purposive sampling. A structured one-page proforma recorded dysphagia, altered voice, tongue swelling, face/neck swelling, stridor, respiratory rate, room-air SpO₂ and Glasgow Coma Scale (GCS) at first clinician assessment, before the airway decision wherever feasible. The primary outcome was emergency airway intervention (endotracheal intubation or emergency surgical airway) during the initial ED encounter. Associations were tested with the chi-square/Fisher exact test and independent-samples t/Mann-Whitney U test, followed by multivariable logistic regression, using SPSS version 26; two-sided p<0.05 was taken as significant.

Results: Emergency airway intervention was performed in 139/384 patients (36.2%): 85 (61.2%) tracheostomies and 54 (38.8%) endotracheal intubations. All five prespecified arrival signs, respiratory rate, SpO₂ and prior supplemental oxygen were associated with intervention on bivariate analysis (p<0.05). After adjustment for age, time since ingestion and the five arrival signs, visible tongue swelling (adjusted OR 2.75, 95% CI 1.37–5.51, p=0.004) and audible stridor (adjusted OR 2.97, 95% CI 1.61–5.47, p=0.001) remained independently associated with intervention.

Conclusion: Visible tongue swelling and audible stridor recorded at first ED assessment independently identified kala pathar ingestion patients who went on to need emergency airway intervention, supporting their use for rapid bedside triage in this setting.

INTRODUCTION

Paraphenylenediamine (PPD), sold locally in Pakistan as kala pathar, is an aromatic-amine hair-dye ingredient that continues to be ingested, often with suicidal intent, in a recurring pattern of poisoning across the country¹. Its early toxicity is dominated by rapidly progressive angio-oedema of the face, tongue and neck that can compromise the upper airway within hours of ingestion, while rhabdomyolysis and acute kidney injury typically become apparent only later, once laboratory results are available^{2,3}. Because the threat to the airway precedes the biochemical derangement, the treating team's decision to intubate or perform an emergency surgical airway rests almost entirely on the clinical assessment made at the very first encounter^{1,4}.

Published Pakistani series report widely differing rates of airway compromise and intervention. At a district teaching hospital in Sahiwal, 111 patients had a mean age of 23.0 ± 7.2 years; 78.4% had cervicofacial oedema and 47.7% underwent tracheostomy². A smaller prospective Karachi series of eight patients reported that a quarter required emergency tracheostomy and half needed mechanical ventilation, with two deaths¹. More recent Pakistani reports, including a fatal case from a tertiary military hospital and a paediatric case series describing the same poison under its other local name, "black stone," continue to describe rapid, occasionally lethal, airway deterioration after PPD ingestion^{5,6}. Outside PPD specifically, bedside signs such as stridor, respiratory rate and oxygen saturation have been shown to predict the need for airway intervention in other causes of acute upper-airway swelling, including angio-oedema and other obstructive airway presentations seen in the emergency department^{7,8}. Existing PPD reports, however, largely describe complications and outcomes after presentation rather than distinguishing which signs, present on arrival and before treatment, actually accompany the decision to secure the airway^{1,2}.

Because a validated, PPD-specific bedside prediction rule is not available for the local case-mix, this study aimed to determine the association between clinical features recorded at first ED assessment – dysphagia, altered voice, tongue swelling, face/neck swelling, stridor, respiratory rate, oxygen saturation and Glasgow Coma Scale (GCS)⁹ – and emergency airway intervention among adults with suspected kala pathar ingestion presenting to the Accident and Emergency Department of Jinnah Postgraduate Medical Centre (JPMC), Karachi, and to describe the frequency and type of that intervention.

MATERIAL & METHODS

Study Design: Prospective observational analytical cross-sectional study, with outcome ascertainment at the initial ED encounter.

Setting: Accident and Emergency Department, Jinnah Postgraduate Medical Centre (JPMC), Karachi.

Duration: Four months, from December 2024 to March 2025.

Sample Size: The sample size was calculated using the WHO single-population-proportion formula, $n = Z^2 p(1-p)/d^2$, with 95% confidence ($Z=1.96$), absolute precision $d=0.05$, and an expected proportion $p=0.477$ taken from the Sahiwal tracheostomy rate², giving $n = 383.4$, rounded up to 384 patients. This parent estimate concerned tracheostomy alone, whereas the present outcome combines intubation and surgical airway; it therefore served as a pragmatic planning figure rather than a guarantee of power for association testing.

Sampling Technique: Non-probability purposive sampling of all eligible patients encountered during recruitment hours, with a screening log kept for missed and excluded cases.

Inclusion Criteria: Adults aged ≥ 18 years with suspected oral kala pathar/PPD ingestion

presenting to the JPMC ED during the study period, including transfers in whom no definitive airway had been placed before arrival.

Exclusion Criteria: A pre-existing endotracheal tube or surgical airway before JPMC arrival; clearly established ingestion of another substance without PPD; or absence of any reliable PPD exposure history. Patients requiring immediate resuscitation were never excluded merely because consent could not be obtained at once.

Data Collection Procedure: After ethical approval, a resident/trained collector screened ED arrivals and assigned each patient a study ID. Immediately available exposure history and the first recorded clinical examination – dysphagia/inability to swallow saliva, altered/muffled voice, visible tongue swelling, visible face/neck swelling, audible stridor, respiratory rate, room-air SpO₂ and GCS – were entered on a one-page proforma before the airway decision wherever feasible; a sign that could not be assessed before immediate resuscitation was recorded as “not assessed” and never inferred afterwards. The treating ED/anaesthesia/ENT team decided on airway management under usual care, with no treatment threshold imposed by the study protocol. The collector subsequently verified, from the ED record up to disposition, whether endotracheal intubation, cricothyrotomy or tracheostomy had been performed, together with the procedure time. Written informed consent was obtained from the patient, once stabilised, or from an authorised representative, following the ethics-committee-approved emergency/deferred-consent process; refusal did not affect care, and identifiers were kept separate from analysis data.

Data / Statistical Analysis: Data were entered and analysed using IBM SPSS Statistics version 26. Continuous variables were summarised as mean±SD or median (interquartile range), and categorical variables as frequency (%). The primary outcome was emergency airway intervention (yes/no). Each prespecified arrival feature was compared between patients with and without intervention using the chi-square test (Fisher’s exact test where any expected cell count

fell below 5) for categorical variables, and the independent-samples t test or Mann-Whitney U test for continuous variables, together with crude odds ratios (OR) and 95% confidence intervals (CI). Multivariable logistic regression, adjusted for age, time since ingestion and the five prespecified bedside signs, was then used to identify independent predictors, keeping at least ten events per fitted parameter; patients with a “not assessed” value for any sign were excluded listwise from this model, with no imputation performed, consistent with the prespecified analysis plan. Model fit was assessed with the Hosmer-Lemeshow test and Nagelkerke R². A two-sided p<0.05 was considered statistically significant throughout.

Ethical Approval: The study was approved by the Institutional Review Board of Jinnah Postgraduate Medical Centre, Karachi, and was conducted in accordance with the Declaration of Helsinki.

RESULTS

Of 384 patients with suspected kala pathar ingestion enrolled over the study period, the mean age was 27.5±9.7 years (median 24, interquartile range [IQR] 21–31) and 319 (83.1%) were female. The median time from reported ingestion to ED arrival was 3.7 hours (IQR 2.1–5.4); 109 patients (28.4%) were transfers from another facility and 26 (6.8%) had a suspected co-ingestion. Supplemental oxygen had already been started before the first recorded SpO₂ in 126 patients (32.8%).

Emergency airway intervention was performed in 139 patients (36.2%, 95% CI 31.4–41.2%): 85 (61.2%) by tracheostomy and 54 (38.8%) by endotracheal intubation; no patient in this cohort underwent cricothyrotomy. Of the whole cohort, 326 (84.9%) were admitted or transferred onward, 44 (11.5%) were discharged from the ED, and 14 (3.6%) died in the ED.

Values for the five prespecified bedside arrival signs were recorded as “not assessed” in 1.8–3.6% of patients (dysphagia 11/384, altered voice 14/384, tongue swelling 11/384, face/neck swelling 10/384, stridor 7/384); these were treated as missing for the relevant comparison, with no imputation. All five arrival signs – dysphagia, altered voice, tongue swelling, face/neck swelling and stridor – together with

prior supplemental oxygen, were significantly more frequent among patients who underwent

airway intervention than among those who did not (Table-I).

TABLE-I. Categorical arrival/exposure features by emergency airway intervention status (n=384)

Feature	No intervention n (%)	Intervention n (%)	Crude OR (95% CI)	p-value
Sex – Female	208/245 (84.9)	111/139 (79.9)	0.71 (0.41–1.21)	0.206
Transfer from another facility	74/245 (30.2)	35/139 (25.2)	0.78 (0.49–1.25)	0.294
Co-ingestion suspected	14/245 (5.7)	12/139 (8.6)	1.56 (0.70–3.47)	0.274
Oxygen already given before first SpO ₂	65/245 (26.5)	61/139 (43.9)	2.17 (1.40–3.36)	<0.001*
Dysphagia / cannot swallow saliva	112/237 (47.3)	94/136 (69.1)	2.50 (1.60–3.90)	<0.001*
Altered / muffled voice	97/233 (41.6)	81/137 (59.1)	2.03 (1.32–3.11)	0.001*
Visible tongue swelling	103/239 (43.1)	102/134 (76.1)	4.21 (2.62–6.75)	<0.001*
Visible face/neck swelling	151/238 (63.4)	104/136 (76.5)	1.87 (1.16–3.01)	0.009*
Audible stridor	28/241 (11.6)	53/136 (39.0)	4.86 (2.88–8.20)	<0.001*

Chi-square test throughout (all expected cell counts ≥ 5); OR is for the feature present vs absent, outcome = airway intervention. Denominators for the five bedside signs exclude patients coded “not assessed”. Exposure source (3 categories, $p=0.686$) is omitted from the table as it yielded no significant association. * $p<0.05$.

Among continuous variables, respiratory rate and SpO₂ differed significantly between groups,

while age, time since ingestion and GCS did not (Table-II).

TABLE-II. Continuous arrival variables by emergency airway intervention status (n=384)

Variable	No intervention (n=245)	Intervention (n=139)	p-value
Age, years, mean $\pm$ SD	26.9 $\pm$ 9.4	28.4 $\pm$ 10.1	0.165
Time since ingestion, h, mean $\pm$ SD	3.6 $\pm$ 2.0	3.9 $\pm$ 1.9	0.164
Respiratory rate, /min, mean $\pm$ SD	25.2 $\pm$ 3.3	27.1 $\pm$ 4.3	<0.001*
SpO ₂ , %, mean $\pm$ SD	94.8 $\pm$ 2.7	93.8 $\pm$ 3.6	0.006*
GCS, /15, mean $\pm$ SD	14.6 $\pm$ 0.9	14.6 $\pm$ 0.9	0.805

Independent-samples *t* test, Welch-corrected for respiratory rate and SpO₂ where Levene's test indicated unequal variances; Mann-Whitney *U* gave concordant results for all five variables. * $p<0.05$.

On multivariable logistic regression adjusting for age, time since ingestion and the five prespecified bedside signs (334 patients with complete sign data, 124 events; 124/7 $\approx$ 17.7 events per parameter), visible tongue swelling and audible stridor remained independently associated with emergency airway intervention, while dysphagia, altered voice and face/neck swelling were no longer independently

significant once the other signs were accounted for (Table-III). The model showed adequate fit (Hosmer-Lemeshow $\chi^2=4.39$, $df=8$, $p=0.820$; Nagelkerke $R^2=0.215$) and correctly classified 70.7% of patients. Adding respiratory rate, SpO₂ and GCS to the model in a sensitivity analysis did not change these conclusions: tongue swelling (adjusted OR 2.77, 95% CI 1.38–5.58, $p=0.004$) and stridor (adjusted OR

5.12, 95% CI 1.61–16.30, $p=0.006$) remained the only independent predictors, with a similar overall model fit (Nagelkerke $R^2=0.222$).

TABLE-III. Multivariable logistic regression for emergency airway intervention (n=334, 124 events)

Predictor	Adjusted OR (95% CI)	p-value
Age (per year)	1.02 (1.00–1.05)	0.088
Time since ingestion (per hour)	1.10 (0.97–1.26)	0.146
Dysphagia (yes vs no)	1.37 (0.79–2.39)	0.268
Altered voice (yes vs no)	0.99 (0.56–1.74)	0.959
Tongue swelling (yes vs no)	2.75 (1.37–5.51)	0.004*
Face/neck swelling (yes vs no)	1.11 (0.62–1.99)	0.726
Stridor (yes vs no)	2.97 (1.61–5.47)	0.001*

Hosmer-Lemeshow $\chi^2=4.39$, $df=8$, $p=0.820$; Nagelkerke $R^2=0.215$; overall classification accuracy 70.7%. * $p<0.05$.

DISCUSSION

In this cohort of 384 patients with suspected kala pathar ingestion, just over a third (36.2%) required an emergency airway during the initial ED encounter, a rate that sits between the very high tracheostomy proportion reported from Sahiwal² and the small Karachi case series in which two of eight patients died¹, and is broadly consistent with the ongoing occurrence of severe, occasionally fatal, airway compromise reported in recent Pakistani case reports of PPD poisoning^{5,6,10}. That two-thirds of our interventions were tracheostomies rather than endotracheal intubation reflects the rapidity and extent of oropharyngeal and laryngeal oedema that this poison characteristically produces, similar to the airway obstruction described in the original 2020 Karachi case report of kala pathar poisoning¹⁰ and in an Indian prospective series of PPD hair-dye poisoning that likewise emphasised early, aggressive airway management¹¹.

All five prespecified bedside signs were associated with airway intervention on bivariate analysis, but only visible tongue swelling and audible stridor remained independent predictors after adjustment. This pattern is consistent with evidence from other causes of acute upper-airway swelling: a large emergency-department series of angio-oedema found visible tongue and laryngeal swelling and stridor to be among the strongest bedside predictors of intubation⁷, and a retrospective analysis of acute

airway obstructive disease similarly identified stridor as an independent marker of the need for emergency airway intervention⁸. Stridor itself is a late, mechanical sign of critical luminal narrowing, and its association with a nearly five-fold crude odds of intervention in our cohort mirrors reports from otolaryngology practice that arterial oxygenation and the need for emergency tracheostomy both track closely with the presence of stridor¹⁴. Because oedema in PPD poisoning, like angio-oedema from other causes, evolves through soft-tissue swelling that can be histamine- or bradykinin-mediated, signs that reflect mechanical narrowing of the airway lumen (tongue swelling, stridor) may simply track disease severity more directly than signs that are more subjective or intermittent, such as a change in voice²⁰.

Dysphagia, altered voice and face/neck swelling lost statistical significance once tongue swelling and stridor were accounted for in the adjusted model, most likely because these signs cluster together as the airway swelling progresses rather than acting as independent pathways to intervention; a similar attenuation of individually significant bedside signs after multivariable adjustment has been described for other rapidly evolving airway-obstruction syndromes^{7,8}. Age, time since ingestion and GCS were not independently associated with intervention in our cohort, which is unsurprising given that consciousness is typically preserved until very late in PPD poisoning,

unlike the sedation or intoxication that drives airway compromise in other causes of poisoning³. This distinguishes kala pathar poisoning from many other acute poisonings seen in Pakistani emergency departments, where GCS and vital-sign-based early warning scores are the dominant drivers of the decision to secure the airway^{12,16}.

The marked female preponderance in our cohort (83.1%) is consistent with the pattern of kala pathar ingestion as a means of self-harm among young women that has been repeatedly described in Pakistani case series^{1,2} and explored qualitatively in a recent study of self-harm among young women in southern Punjab, which highlighted the easy availability of hair-dye products as a factor in impulsive self-poisoning¹³. This has direct implications for prevention and for ED preparedness, since a poison-control-centre review from Karachi similarly found that intentional poisoning, disproportionately affecting younger women, remains a leading cause of ED presentation in the city¹².

From a health-systems perspective, our finding that two easily elicited bedside signs – tongue swelling and stridor – carry most of the independent predictive information is encouraging for a resource-limited emergency department, since it requires no additional equipment or delay for laboratory results. This is in keeping with broader evidence that simple, vital-sign-based early warning scores can meaningfully predict clinical deterioration in emergency and pre-hospital settings without sophisticated risk calculators¹⁶, and with recent guidance on the management of acute poisoning in low- and middle-income countries, which emphasises rapid bedside assessment over laboratory-dependent algorithms where resources are constrained¹⁷. A comparable emphasis on bedside predictors of mortality, rather than on toxin-specific biomarkers, has also been reported in a low-resource emergency-centre study of acute pesticide poisoning in Uganda¹⁸. Because emergency physicians and trainees managing poisoning cases do not always receive structured training in recognising these features, as suggested by a recent survey of Pakistani medical graduates' knowledge of poisoning management¹⁹, embedding tongue swelling and stridor explicitly into local triage and training protocols for suspected kala pathar

ingestion may help standardise the speed and consistency of the airway decision, alongside the wider principles of difficult-airway preparedness described in recent anaesthesia literature¹⁵.

This study has several limitations. First, as an observational, single-centre study, the associations reported are exploratory and cannot establish a validated prediction rule or a causal effect, as prespecified; external validation in another Pakistani tertiary centre would be needed before any bedside score derived from these findings could be used to guide practice. Second, the WHO sample-size calculation was anchored to a tracheostomy-only estimate from a different cohort, so the study may still be underpowered for less common associations, such as co-ingestion. Third, 1.8–3.6% of arrival signs were recorded as “not assessed” and were excluded rather than imputed, which is methodologically conservative but slightly reduced the sample available for the adjusted model. Finally, because the treating team's airway decision was not standardised by protocol, some threshold variation between individual clinicians is possible, which could not be adjusted for in this dataset.

CONCLUSION

Emergency airway intervention was required in over a third of patients with suspected kala pathar ingestion presenting to this tertiary-care ED, most often by tracheostomy. Visible tongue swelling and audible stridor at first assessment independently identified patients who went on to need that intervention, supporting their use as simple, rapid bedside triage cues in this setting, pending external validation.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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**AUTHORSHIP AND CONTRIBUTION
DECLARATION**

Dr. Umair Ahmad: Conception, data collection.

Dr. Aurangzaib: Data analysis, manuscript drafting.

Dr. Mohsin Nazeer: Literature review, critical revision.

Dr. Waqas Riaz Khan: Supervision, final approval.

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