Evaluation of Pediatric Early Warning System and Drooling Reluctance Oropharynx Others Leukocytosis scores as prognostic tools for pediatric caustic ingestion: a two-center, cross-sectional study

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Abstract

Caustic chemicals are widely distributed in our environment. Exposure to caustic agents is a lifelong problem associated with severe tissue and mucous membrane injuries. In pediatrics, corrosive exposure is the most common cause of nonpharmaceutical exposure presenting to poison control centers. Therefore, this study evaluated the role of the Pediatric Early Warning System (PEWS) and Drooling Reluctance Oropharynx Others Leukocytosis (DROOL) scores as early in-hospital outcome predictors following corrosive ingestion. The current study was a two-center, retrospective, cross-sectional study carried out among pediatric patients diagnosed with acute caustic ingestion during the past 4 years. Most exposure occurred accidentally among boys (59.4%) living in rural areas (51.9%) of preschool age (50% were 2–4 years old). Residence, body temperature, respiratory rate, vomiting, skin and mucosal burns, retrosternal pain, respiratory distress, Oxygen (O₂) saturation, Glasgow Coma Scale score, HCO₃ level, total bilirubin level, anemia, leukocytosis, and presence of free peritoneal fluid were significant predictors of esophageal injuries ($p < 0.05$). DROOL and PEWS scoring were the most significant predictors of esophageal injuries with worthy predictive power, where odds ratio (95% confidence interval (CI)) was 1.76 (0.97–3.17) and 0.47 (0.21–0.99) for PEWS and DROOL, respectively. At a cutoff of < 6.5 , the DROOL score could predict esophageal injuries excellently, with AUC = 0.931; sensitivity, 91.7%; specificity, 72.5%; and overall accuracy, 91.3%. At a cutoff of > 6.5 , PEWS could significantly predict unfavorable outcomes, with AUC = 0.893; sensitivity, 94.4%; specificity, 71.9%; and overall accuracy, 89.3%. However, PEWS better predicted the need for admittance to the intensive care unit (ICU). Pediatric Early Warning System (PEWS) and Drooling Reluctance Oropharynx Others Leukocytosis (DROOL) are potentially useful accurate scorings that could predict the esophageal injuries and ICU admission following corrosive ingestion in pediatrics.

Keywords Corrosive · Pediatric · PEWS · DROOL score · Esophageal injuries · Outcomes · Prediction · ICU

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Introduction

Caustics or corrosive substances are chemicals that can cause damage when coming into contact with tissues. Exposure to caustic agents is a lifelong problem associated with severe tissue and mucous membrane injuries, especially on ingestion (Jones 2002). Exposure is not limited to a specific age, but children are more vulnerable, and exposure is among the leading causes of mortality in those younger than 5 years (Rafeey et al. 2016).

The exposure of children to corrosive substances is a global problem, with an estimated 80% of caustic exposure occurring among children (Park 2014). More than 40,000 cases in the

UK and more than 15.8 cases per 100,000 children in the USA are reported annually (Rafeey et al. 2016). The situation is more severe in developing countries (Urganci et al. 2014). For example, although the precise prevalence of corrosive exposure among Egyptian children is not well known, a study carried out in Egypt has reported that corrosive exposure was the most common cause of nonpharmaceutical exposure in pediatric patients presenting to a prominent medical center (Azab et al. 2016).

Caustic exposure among children occurs accidentally and in the absence of paternal supervision. The diverse risk factors for exposure include improper preserving of household caustics, illiteracy, poverty, large family size, and parental psychological disorders (Urganci et al. 2014). Diverse agents are involved, including potent alkaline substances such as sodium hydroxide and potassium hydroxide and strong acids such as hydrochloric and sulfuric (Park 2014).

On ingestion, patients present with severe pain; drooling; lips and mouth burns; dysphagia; vomiting, which might be blood streaked; and even hematemesis. Respiratory distress and dyspnea are common (Betalli et al. 2008). Esophageal injury is severe and commonly encountered where liquefactive and coagulative necrosis are the pathophysiological mechanisms. Differing by type of ingested chemical, the severity and depth of tissue damage and chronic complications such as esophageal strictures might occur. Death due to nutritional deficiency, infection, and dehydration can follow (Park 2014).

Previous studies have paid attention to the treatment of the resultant complications, with little emphasis on early identification of exposed patients in need of admission to the intensive care unit (ICU) who are at risk for further complications. Because of the high frequency of such toxic exposure among children, this study aims to evaluate the role of the Pediatric Early Warning System (PEWS) and Drooling Reluctance Oropharynx Others Leukocytosis (DROOL) scores as early predictors for pediatric patients needing ICU admission and having subsequent esophageal injuries following corrosive ingestion.

Materials and methods

Study design

This two-center, retrospective, cross-sectional analytical study was done among pediatric patients diagnosed with acute caustic ingestion and presenting to the Tanta Poison Control Center (TPCC), Tanta, Egypt, and to the Saudi German Hospital (SGH), Aseer, Kingdom of Saudi Arabia, during the past 4 years (January 1, 2017, to January 1, 2021).

Sampling and sample size

We used the Epi-Info™ 7.2.3.0 statistical software package (Centers for Disease Control and Prevention, Atlanta, GA, USA) to determine sample size. On the basis of the expected primary outcome of approximately 33% for significant esophageal lesions following corrosive ingestion (Doğan et al. 2006) and the secondary outcome of 18% for patients who needed endotracheal intubation and subsequent ICU admission after corrosive exposure (Riffat and Cheng 2009), at an acceptable margin of error of 5%, and 95% confidence level (CL), the minimum required sample size to equal 340 and 227 children, for primary and secondary outcomes, respectively. Thus, the minimum required sample size is ≥ 340 , and we enrolled 360 patients.

Inclusion criteria

We included the completed medical records of patients' ages 18 years or younger diagnosed with acute caustic ingestion admitted to both centers during the study period. We based the diagnosis of caustic ingestion on parental history of exposure, including the brand name and type of involved caustic, in addition to the clinical examination.

Exclusion criteria

We excluded patients with congenital esophageal disorders and those with an unconfirmed diagnosis, as well as cases of co-ingestions and those discharged on request against medical advice.

Data collection tools

Demographics and exposure history

We recorded the patients' demographic data, including the age, sex, and residence, in addition to the parents' educational level. We assessed the family's socioeconomic status (SES; high, mid, low) using the scale proposed by Fahmy et al. (Fahmy et al. 2015). We thoroughly reported exposure history, including the brand name and type (acidic or alkaline) of chemical, manner of exposure, relative amount ingested, delay time from exposure until approaching emergency services, and any pre-hospital treatment or trails of vomiting.

Presenting complaints

We recorded the presenting complaints, including gastric complaints such as vomiting and its frequency and color; drooling; dysphagia; lip and mouth burns; abdominal pain; and respiratory complaints such as cough, dyspnea, chest tightness, and stridor.

Vital data, clinical examination, and investigations

On admission, vital data were captured, and a thorough clinical examination was done. The Glasgow Coma Scale (GCS) was calculated, with the patients categorized as mild (13–15), moderate (9–12), and severe (3–8) (Kehoe et al. 2015). Skin and mouth were inspected, and, if burned, the degree of the burn was recorded. Findings of the cardiovascular, respiratory, and abdominal examinations were reported.

Results of requested investigations were recorded, including complete blood count findings, random blood sugar, serum electrolytes (Na and K), liver transaminases, serum albumin, total bilirubin, and urea and creatinine levels. Arterial blood gas analysis, including pH, PaCO₂, PaO₂, and HCO₃, were documented. Results of radiologic studies including chest X-ray and ultrasonography have been included (Rafeey et al. 2016).

Scoring and in-hospital outcomes

We requested two independent physicians to blindly evaluate every patients' medical record on admission using the two scoring systems (PEWS and DROOL scores). Both scores were calculated on admission; however, DROOL score had been recalculated 24 hours after admission, and the worst values were considered. Total PEWS score ranges from 0 (the best) to 37 (the worst) and includes 11 parameters: heart rate, systolic blood pressure, capillary refill, pulse, bolus of fluids, respiratory rate and efforts, Oxygen (O₂) saturation and O₂ therapy, temperature, and level of consciousness. PEWS score evaluates the mentioned parameters on a scale (0, 1, 2, 4) where zero represents the normal values and four represents the worst value. According to a reference range, item sub-scores are given for every age group (five age groups, from the first day of life to more than 12 years). Heart rate, systolic blood pressure, pulse, respiratory rate, and effort were given scores (0–4), temperature and O₂ saturation were given scores (0, 1, 2), consciousness level and capillary refill were given scores of 0 or 4, and the bolus fluid was scored one if given and zero if not (Parshuram et al. 2009).

DROOL scoring includes five criteria, and the total score ranges from 0 to 10 where 10 is the best score and 0 is the worst. DROOL scoring considers different issues, including excessive salivary secretions; dysphagia; oropharyngeal burns; leukocytosis; and other symptoms such as fever, hematemesis, and abdominal tenderness. Each item was scored (0, 1, 2) where 2 score is given if the symptom or sign is absent. One score was given for drooling lasts less than 12 h; reluctance lasts for less than 24 h; oropharyngeal hyperemia; Total leucocytic count (TLC) < 20,000; and if one symptom of fever, hematemesis, abdominal tenderness, retrosternal pain, or dyspnea presents. Zero score was given for patients presented with drooling lasts more 12 h;

reluctance lasts more than 24 h; severe oropharyngeal lesions; Total leucocytic count (TLC) $\geq$ 20,000; and if two or more symptoms of fever, hematemesis, abdominal tenderness, retrosternal pain, or dyspnea present (Uygun et al. 2012)

According to the protocols followed in both studied centers, endoscopy is not a part of routine therapeutic regimens. All presented patients were admitted and kept under observation for at least 6 h. Asymptomatic patients with stable vital signs, easily swallowing, and no burns were discharged without endoscopy and requested to attend for follow-up 14 days after discharge. Other symptomatic patients were admitted until stabilization. For these cases, pediatric surgical consultation was requested, and based on the evaluation, stable patients were discharged and requested for follow-up 14 days after, while unstable patients were kept admitted and scheduled for endoscopy 2 weeks after exposure. Endoscopic finding were graded according to Betalli et al. as grade 0 (no lesions), grade I (erythema), grade II (noncircumferential pseudo membrane, ulceration, or necrosis), and grade III (circumferential pseudo membrane, ulceration, or necrosis) (Betalli et al. 2008).

Our study's primary outcome is the incidence of esophageal injuries. Unfavorable outcomes included patients with significant esophageal injuries as revealed by endoscopy (grades I, II, and III) (Betalli et al. 2008) in addition to dead patients. We considered patient outcomes favorable if they recovered entirely without the need for endoscopy or if they underwent endoscopy and had insignificant findings (grade 0). In addition, we considered patient need for ICU admission as a secondary outcome. Criteria for ICU admission include the need for mechanical ventilation, O₂ > 4 L/minute, vaso-pressor therapy, fluid therapy, cardiopulmonary resuscitation, total parenteral nutrition, or renal replacement therapy.

Compliance with ethical standards

The current study began after obtaining ethical approval from the Research Ethical Committees (34457/2/21) of the Faculty of Medicine, TPCC, and an Ethical Clearance Certificate (ECC#2021-04) from the SGH. According to the Declaration of Helsinki, all data were handled anonymously to maintain patients' confidentiality. Informed consent was waived, as the study was conducted retrospectively using medical records.

Statistical analysis

We analyzed the data using SPSS software version 26 (IBM Corporation, Armonk, NY, USA). We presented qualitative data as frequency and percentage and used the Chi-square test for analysis. When a Chi-square test was inappropriate, we used the Monte Carlo exact test. We tested the quantitative variables for normality and presented these as median and

interquartile range and mean and standard deviation, using the Mann-Whitney *U* test for this analysis. We applied the receiver operating characteristic (ROC) curves of the PEWS and DROOL scores as predictors for an unfavorable outcome and need ICU admission. We categorized the AUC as follows: excellent, 0.9–1; good, 0.8–0.9; fair, 0.7–0.8; poor, 0.6–0.7; and fail, 0.5–0.6 (Jessen 1996). In addition, we performed a Spearman correlation between the PEWS and DROOL scores. Finally, we applied univariate and multivariate binary logistic regressions to detect predictors of unfavorable outcomes among the patients. A *p* value of ≤ 0.05 , an alpha margin of error of 5%, a 95% confidence interval (CI), and an 80% power were considered significant.

Results

The total number of cases of pediatric admissions due to toxic and corrosive exposure from 2017 to 2020 in both centers was 492, with a period prevalence of approximately 15% (492 of 3,289). Of these, 132 were excluded as they could not be followed due to incomplete medical records. However, 360 patients met the inclusion criteria and were enrolled in the study. Figure 1 depicts the trend of overall pediatric toxic and corrosive exposure during the time period. Overall, the numbers decreased from 2018 to 2020. The percentage of pediatric admissions due to corrosive exposure to the total pediatric intoxication admissions in TPCC and SGH was 16% in 2017, increasing to 18% in 2018. This percentage dropped to 13% in 2019 and furtherly dropped to 11% in

2020. Among the patients studied, 10% presented with esophageal injuries.

We enrolled 360 patients in the current study: 214 boys (59.4%) and 146 (40.6) girls. Ages ranged from younger than 1 year to 18 years. The highest significant percentage of exposed children was among those ages 2–4 years. The majority of children belonged to families of moderate SES, and 51.9% lived in rural areas. All parental education levels were reported, with a predominance of parents having basic and university education (Table 1).

All patients were exposed accidentally. Table 2 displays the variety of substances to which the children were exposed, including bath cleansers (19.4%). Degreaser-containing products (14.7%) outnumbered other chemicals, while formalin exposure was the least common (1.9%). Bath cleansers and sulfuric acid were the most common substances among patients with unfavorable outcomes.

Most guardians (77.5%) reported that the amount of ingested material was < 100 ml, 16.4% reported ingestion of large amounts, and 6.1% could not recall the ingested amount as shown at Table 2. In patients with unfavorable outcomes, the most frequent substance ingested in little amounts (< 100 ml) was caustic potash (22.2%), while the bath cleansers were the most frequent substances ingested in amounts more than 100 ml (46.2%). The mean time delay to emergency services was 1.98 ± 2.0 h.

Endoscopy was neither indicated nor carried out in 313 children (86.9%), while 47 children (13.1 %) underwent endoscopy. A total of 90% of the children (324 children) were diagnosed with corrosive ingestion without esophageal

Fig. 1 Trend of pediatric admissions due to corrosive exposure in relation to total pediatric admissions due to toxic exposure

Table 1 Comparison between favorable and unfavorable outcome patients in pediatrics diagnosed with corrosive ingestion regarding sociodemographic characteristics

Patient characteristics	Favorable outcome		Unfavorable outcome		Total		Test of significance	<i>p</i> Value
	(N = 324)		(N = 36)		(N = 360)			
	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%		
Sex								
Male	194	59.9	20	55.6	214	59.4	$\chi^2 = 0.251$	0.616
Female	130	40.1	16	44.4	146	40.6		
Age group (years)								
< 12 months	0	0.0	1	2.8	1	0.3	$\chi^2 = 17.316$	MC0.038*
1 to < 2 years	100	30.9	8	22.2	108	30.0		
2 to < 4 years	164	50.6	16	44.4	180	50.0		
4 to < 6 years	35	10.8	7	19.4	42	11.7		
6 to < 10 years	9	2.8	1	2.8	10	2.8		
10 to < 14 years	3	0.9	2	5.6	5	1.4		
14 to 18 years	13	4.0	1	2.8	14	3.9		
Residence								
Rural	161	49.7	26	72.2	187	51.9	$\chi^2 = 6.589$	0.010*
Urban	163	50.3	10	27.8	173	48.1		
Socioeconomic status								
Low	48	14.8	7	19.4	55	15.3	$\chi^2 = 2.322$	0.313
Moderate	218	67.3	26	72.2	244	67.8		
High	58	17.9	3	8.3	61	16.9		
Parent education								
Illiterate	37	11.4	4	11.1	41	11.4	$\chi^2 = 2.775$	MC0.679
Basic education	149	46.0	13	36.1	162	45.0		
University graduate	121	37.4	16	44.4	137	38.0		
Postgraduate	17	5.2	3	8.3	20	5.6		

N number, χ^2 Chi-square test, MC Monte Carlo exact test; *statistically significant ($p < 0.05$)

involvement (11 patients underwent endoscopy and graded zero (3.4%) and 313 (96.6%) did not underwent endoscopy); all were considered of favorable outcome. Ten percent (36 children) were considered of unfavorable outcome and diagnosed with esophageal injury. Of these patients, one child died. Endoscopy revealed that among all studied cases, approximately, 6 % ($n = 21$) presented with grade I injury, 3% ($n = 11$) with grade II injury, and only 1% ($n = 4$) with grade III injury.

We found non-significant differences between patients with favorable and unfavorable outcomes regarding sex, SES, parent education, pH of the ingested substance, and delay time. However, living in a rural area, ingesting amounts of > 100 ml, and exposure to bath cleanser and sulfuric acid are significant findings among the patients with unfavorable outcomes (Tables 1 and 2).

Table 3 shows that patients with unfavorable outcomes had significantly different presentations. Vomiting and hematemesis were the main complaints reported in 97.2% and 61.1% of the patients with unfavorable outcome, respectively. Drooling and dysphagia, as well as, abdominal and retrosternal pain, significantly were reported more often by

the patients with unfavorable outcomes ($p < 0.05$). Most of the patients with favorable outcomes showed significantly absent skin burns (88%), lip burns (60.8%), and tongue and oral mucosal burns (48.1%) as compared to patients with unfavorable outcomes.

We found significant differences among the patients in some vital data. Despite systolic and diastolic blood pressure not showing significant variations between the patients, those with unfavorable outcomes were significantly more feverish, tachypneic, and tachycardic ($p < 0.05$). Moreover, respiratory distress, lung crepitations, and abdominal rigidity were significantly more frequent among patients with unfavorable outcomes (Table 4).

Table 5 highlights the significant radiologic differences between both groups. Among the patients with unfavorable outcomes, free peritoneal fluid was seen in 55.6%, and increased bronchovascular markings were evident in 36.1%, while lung opacities were reported in 13.9%. Lab investigations showed significant differences between the groups, including O₂ saturation, HCO₃ level, total serum bilirubin level, SGOT level, hemoglobin level, and white blood cell (WBC)

Table 2 Comparison between favorable and unfavorable outcome patients in pediatrics diagnosed with corrosive ingestion regarding the history of exposure

Exposure history	Favorable outcome (<i>N</i> = 324)		Unfavorable outcome (<i>N</i> = 36)		Total (<i>N</i> = 360)		Test of significance	<i>p</i> Value
	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%		
Substance:								
Caustic potash	27	8.3	5	3.9	32	8.9	$\chi^2 = 29.277$	MC0.002*
Sodium hypochlorite	36	11.1	0	0.0	36	10.0		
Bath cleanser	59	18.2	11	30.6	70	19.4		
Hydrogen peroxide	14	4.3	3	8.31	7	4.7		
Formalin	7	2.2	0	0.0	7	1.9		
Sulfuric acid	15	4.6	7	19.4	22	6.1		
Degreaser-containing products	52	16.0	1	2.8	53	14.7		
Dishwasher fluid	7	2.2	2	5.6	9	2.5		
Phenol	17	5.2	0	0.0	17	4.7		
Others**	90	27.8	7	19.4	97	26.9		
Type of substance								
Acid	153	47.2	21	58.4	164	45.6	$\chi^2 = 3.695$	0.055
Alkali	95	29.3	5	13.8	100	27.8		
Unknown	76	23.5	10	27.8	96	26.6		
Amount of substance								
Less than 100 ml	261	80.6	18	50.0	279	77.5	$\chi^2 = 17.356$	0.001*
More than 100 ml	46	14.2	13	36.1	59	16.4		
Unknown	17	5.2	5	13.9	22	6.1		
Delay in hours								
Median (IQR)	1.5 (1–2)		2 (1–3)		1.5 (1–2)		Z = -0.708	0.479
Mean ± SD	1.9 ± 2.0		2.3 ± 1.9		1.98 ± 2.0			

N number, χ^2 Chi-square test, *MC* Monte Carlo exact test, *Z* score of Mann-Whitney *U* test, *IQR* interquartile range, *SD* standard deviation; *statistically significant ($p < 0.05$); **others include dye color intensifier, K permanganate, acetyl salicylic acid, acetic acid, stain cleaner, and oxalic acid

count. In the group with unfavorable outcomes, the median O₂ saturation was 95 (92–97) mmHg, the median of hemoglobin was 10.4 (9.6–11.4) gm/dL, and the median WBC count was 13.7×10^3 (11.7–19.9) per microliter (Table 6).

A total of 118 cases (32.8%) were admitted to the ICU. All patients with unfavorable outcomes required ICU admission in addition 82 cases (25.3%) of patients with favorable outcome. ICU admissions among patients with favorable outcome mainly were for giving IV fluid and intensive O₂ therapy especially among dehydrated and asthmatic children. The mean length of hospital stay was significantly higher in the unfavorable outcomes group (74.8 ± 40.6 h) than in the favorable outcomes group (17.8 ± 17.4 h). The complicated patients had significantly lower GCS scores; 13.9% of the unfavorable outcomes group showed moderate GCS scores of 9–12, as compared to 1.2% of the favorable outcomes group (Table 7).

The mean DROOL score was significantly lower in the unfavorable outcomes group (2.8 ± 2.3) than in the favorable outcomes group (7.6 ± 2.4). In contrast, the PEWS score was

significantly higher in unfavorable outcomes group (13.3 ± 5.0) as compared to the favorable outcomes group (4.8 ± 4.6), as shown in Table 7. Similarly, as Fig. 2 depicts, the patients needing admission to the ICU had significantly lower DROOL scores and higher PEWS scores.

The ROC curves of the DROOL and PEWS scores as primary and secondary outcome predictors are shown in Figs. 3 and 4. Both scores significantly predicted unfavorable outcomes and need for ICU admission ($p < 0.001$). Patients with DROOL scores below 6.5 mainly had unfavorable outcomes. At this cutoff, the DROOL score can excellently predict unfavorable outcomes, with 0.931; sensitivity, 91.7%; specificity, 72.5%; and overall accuracy, 91.3%. With a cutoff of more than 6.5, PEWS scores can significantly predict unfavorable outcomes, with AUC = 0.893; sensitivity, 94.4%; specificity, 71.9%; and overall accuracy, 89.3%. Both DROOL score and PEWS score can significantly predict the need for ICU admission. Nevertheless, the PEWS scores show higher AUC, sensitivity, specificity, and accuracy than do the DROOL score

Table 3 Comparison between favorable and unfavorable outcome patients in pediatrics diagnosed with corrosive ingestion regarding the presenting complains

The main presenting complaints	Favorable outcome (<i>N</i> = 324)		Unfavorable outcome (<i>N</i> = 36)		Total (<i>N</i> = 360)		Test of significance	<i>p</i> Value
	N	%	N	%	N	%		
Vomiting								
Yes	240	74.1	35	97.2	275	76.4	$\chi^2 = 9.626$	0.002*
No	84	25.9	1	2.8	85	23.6		
Vomiting attacks								
Median (IQR)	1(1–2)		3(2–4)		1 (1–3)		$Z = -6.154$	< 0.001*
Range	1–6		1–7		1–7			
Hematemesis								
Yes	53	16.4	22	61.1	75	20.8	$\chi^2 = 39.345$	< 0.001*
No	271	83.6	14	38.9	285	79.2		
Drooling								
Yes	136	42.1	30	83.3	166	46.2	$\chi^2 = 22.147$	< 0.001*
No	188	57.9	6	16.7	194	53.8		
Dysphagia								
Yes	148	45.7	32	88.9	180	50.0	$\chi^2 = 24.198$	< 0.001*
No	176	54.3	4	11.1	180	50.0		
Skin burn								
Absent	285	88.0	25	69.4	310	86.1	$\chi^2 = 20.179$	< 0.001*
First degree	34	10.5	6	16.7	40	11.1		
Second degree	5	1.5	5	1.5	10	2.8		
Lip burn								
Absent	197	60.8	6	16.7	203	56.4	$\chi^2 = 60.829$	< 0.001*
Mild	99	30.6	12	33.3	111	30.8		
Moderate	24	7.4	12	33.3	36	10.0		
Severe	4	1.2	6	16.7	10	2.8		
Tongue and oral mucosa burn								
Absent	156	48.1	4	11.1	160	44.4	$\chi^2 = 56.602$	< 0.001*
Mild	124	38.3	10	27.8	134	37.2		
Moderate	40	12.3	17	47.2	57	15.8		
Severe	4	1.3	5	13.9	9	2.5		
Cough								
Yes	163	50.3	17	47.2	180	50.0	$\chi^2 = 0.123$	0.725
No	161	49.7	19	52.8	180	50.0		
Abdominal pain								
Yes	75	23.1	15	41.7	90	25.0	$\chi^2 = 5.926$	0.015*
No	249	76.9	21	58.3	270	75.0		
Retrosternal pain								
Yes	21	6.5	14	38.9	35	9.7	$\chi^2 = 38.769$	< 0.001*
No	303	93.5	22	61.1	325	90.3		

N number, χ^2 Chi-square test, *MC* Monte Carlo exact test, *Z* score of Mann-Whitney *U* test, *IQR* interquartile range, *statistically significant ($p < 0.05$)

(Table 8). These scores showed significant moderate negative correlations to each other ($r = -0.688$), as shown in Fig. 5.

We carried out an initial univariate analysis to ascertain the predictive power of different variables as unfavorable

outcome predictors. We determined that many variables were significant unfavorable outcome predictors ($p < 0.05$), including residence, body temperature, respiratory rate, vomiting, skin and mucosal burns, retrosternal pain, respiratory distress,

Table 4 Comparison between favorable and unfavorable outcome patients in pediatrics diagnosed with corrosive ingestion regarding the vital data and clinical examination

Vital data and clinical examination	Favorable outcome (<i>N</i> = 324)		Unfavorable outcome (<i>N</i> = 36)		Total (<i>N</i> = 360)		Test of significance	<i>p</i> Value
Systolic blood pressure								
Median (IQR)	100 (90–100)		100 (90–120)		100 (90–100)		<i>Z</i> = -1.253	0.210
Mean ± SD	98.14 ± 12.6		102.5 ± 17.3		98.6 ± 13.2			
Diastolic blood pressure								
Median (IQR)	60 (60–70)		60 (60–68.8)		60 (60–70)		<i>Z</i> = -0.827	0.408
Mean ± SD	62.5 ± 9.5		63.2 ± 13.3		62.6 ± 9.9			
	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%		
Fever								
Yes	65	20.1	24	66.7	89	24.7	$\chi^2 = 37.814$	< 0.001*
No	259	79.9	12	33.3	271	75.3		
Tachypnea								
Yes	87	26.9	19	52.8	106	29.4	$\chi^2 = 10.483$	0.001*
No	237	73.1	17	47.2	254	70.6		
Pulse								
Normal	202	62.3	13	36.1	215	59.7	$\chi^2 = 10.718$	^{MC} 0.010*
Bradycardia	5	1.5	0	0.0	5	1.4		
Tachycardia	117	36.1	23	63.9	140	38.9		
Respiratory distress								
Absent	236	72.8	15	41.7	251	69.7	$\chi^2 = 21.200$	< 0.001*
First degree	49	15.1	8	22.2	57	15.8		
Second degree	20	6.2	9	25.0	29	8.1		
Third degree	19	5.9	4	11.1	23	6.4		
Chest air entry								
Equal	270	83.3	31	86.1	301	83.6	$\chi^2 = 0.182$	0.669
Diminished	54	16.7	5	13.9	59	16.4		
Wheezes								
Present	78	24.1	5	13.9	83	23.1	$\chi^2 = 1.895$	0.169
Absent	246	75.9	31	86.1	277	76.9		
Crepitation								
Present	68	21.0	17	47.2	85	23.6	$\chi^2 = 12.364$	< 0.001*
Absent	256	79.0	19	52.8	275	76.4		
Abdominal rigidity								
Present	16	4.9	13	36.1	29	8.1	$\chi^2 = 42.509$	< 0.001*
Absent	308	95.1	23	63.9	331	91.9		

N number, χ^2 Chi-square test, *MC* Monte Carlo exact test, *Z* score of Mann-Whitney *U* test, *IQR* interquartile range, *SD* = standard deviation, *statistically significant (*p* < 0.05)

O₂ saturation, GCS, HCO₃ level, total bilirubin level, anemia, leukocytosis, presence of free peritoneal fluid, and PEWS and DROOL scores. Moreover, multivariate regression revealed that, besides the scores, only retrosternal pain, anemia, and ultrasonography were significant predictors of unfavorable outcomes (*p* < 0.05). DROOL and PEWS scores were the most significant predictors of unfavorable outcomes with the most predictive power, where the odds-ratios were 1.76 (95%

CI 0.97–3.17) and 0.47 (95% CI 0.21–0.99) for PEWS and DROOL scores, respectively (Table 9).

Discussion

Caustic ingestion represents an imperative health problem, despite different guiding and regulatory work to minimize its

Table 5 Comparison between favorable and unfavorable outcome patients in pediatrics diagnosed with corrosive ingestion regarding the radiological studies

Radiological studies	Favorable outcome (<i>N</i> = 324)		Unfavorable outcome (<i>N</i> = 36)		Total (<i>N</i> = 360)		Test of significance	<i>p</i> Value
	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%		
Chest X-ray								
Normal	246	75.9	18	50.0	264	73.3	$\chi^2 = 16.377$	< 0.001*
Increased bronchovascular markings	69	21.3	13	36.1	82	22.8		
Opacities	9	2.8	5	13.9	14	3.9		
Ultrasound								
Normal	318	98.1	16	44.4	334	92.8	$\chi^2 = 139.456$	< 0.001*
Free fluid	6	1.9	20	55.6	26	7.2		

N number, χ^2 Chi-square test, *statistically significant ($p < 0.05$)

prevalence, complications, and hospital burden (Melek et al. 2008). The current study hypothesized that the PEWS and DROOL scores can be utilized as early outcome predictors for corrosive ingestion among pediatric patients.

This study reveals a period prevalence of approximately 15% for pediatric toxic exposure. This percentage is considered high if compared with that in other developing countries. In Iran, 10% of total pediatric admissions between 2005 and 2006 were due to caustic

ingestion (Rafeey et al. 2016). The percentage is much less in the UK, a developed country, where 4.8% of pediatric admissions were due to caustic ingestion (Rigo et al. 2002). However, the actual number of exposed cases is underreported, with a much higher exposure expected. In addition, the numbers reported by other studies were calculated from total pediatrics admissions, including medical illness. Improper chemical handling, selling, and preservations, in addition to weak

Table 6 Comparison between favorable and unfavorable outcome patients in pediatrics diagnosed with corrosive ingestion regarding the laboratory workout

Laboratory workout	Favorable outcome (<i>N</i> = 324)	Unfavorable outcome (<i>N</i> = 36)	Total (<i>n</i> = 360)	Test of significance	<i>p</i> Value
Median (IQR)					
O ₂ saturation (%)	97 (95–98)	95 (92–97)	97 (95–98)	$Z = -4.330$	< 0.001*
pH	7.38 (7.35–7.40)	7.38 (7.35–7.41)	7.3 (7.3–7.4)	$Z = -0.654$	0.513
HCO ₃ level (mEq/L)	23 (22–25)	22 (18–23)	23 (22–25)	$Z = -3.376$	0.001*
PCO ₂ (mm Hg)	37.9 (36–40.7)	35 (32–42.1)	37.9 (36–41)	$Z = -1.215$	0.224
Random blood sugar level (mg/dL)	132.5 (120–147)	129.5 (105–170.8)	132.5 (120–147)	$Z = -0.545$	0.586
Na serum level (mmol/L)	137.9 (136–139)	136.4 (135–140.8)	137 (136–139.9)	$Z = -0.739$	0.460
K serum level (mmol/L)	3.9 (3.8–4.3)	4 (3.7–4.8)	4 (3.8–4.3)	$Z = -0.386$	0.700
Total bilirubin (mg/dL)	0.8 (0.6–1)	1 (0.8–1)	0.8 (0.6–1)	$Z = -2.270$	0.023*
AST (U/L)	25 (21–32)	32.5 (23–37)	25 (22–32)	$Z = -3.643$	< 0.001*
ALT (U/L)	22 (18–30)	19 (17–32)	22 (18–30)	$Z = -0.819$	0.413
Serum albumin level (g/dl)	4 (3.8–4.2)	4 (3.7–4.2)	4 (3.8–4.2)	$Z = -0.856$	0.392
Serum urea level (mg/dl)	28 (24–33)	29 (24.3–37.8)	28 (24–33.8)	$Z = -0.552$	0.581
Serum creatinine level (mg/dl)	0.8 (0.7–0.9)	0.8 (0.5–0.9)	0.8 (0.7–0.9)	$Z = -1.861$	0.063
Hemoglobin (gm/dL)	12 (10.9–13.2)	10.4 (9.6–11.4)	12 (10.5–13)	$Z = -4.184$	< 0.001*
Red blood cell count (million/microliter)	4.2 (3.6–4.9)	4.4 (4–4.9)	4.2 (3.8–4.9)	$Z = -1.297$	0.195
Total leucocyte count TLC (*10 ³ /microliter)	9.4 (7.65–10.6)	13.7 (11.7–19.9)	9.6 (7.8–12.0)	$Z = -6.407$	< 0.001*
Platelets (*10 ⁴ /microliter)	26.75 (23.0–35.0)	27.5 (25.0–34.75)	26.9 (23.0–35.0)	$Z = -0.241$	0.809

N number, *IQR* interquartile range, *Z* score of Mann-Whitney *U* test, *statistically significant ($p < 0.05$)

TLC total leucocyte count, *AST* aspartate aminotransferase, *ALT* alanine aminotransferase

Table 7 Comparison between favorable and unfavorable outcome patients in pediatrics diagnosed with corrosive ingestion regarding the different scoring, need for ICU and total parenteral nutrition, length of hospital stay and discharge type

Variables	Favorable outcome (<i>N</i> = 324)		Unfavorable outcome (<i>N</i> = 36)		Total (<i>N</i> = 360)		Test of significance	<i>p</i> Value
	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%		
GCS								
Mild	320	98.8	31	86.1	351	97.5	$\chi^2 = 21.285$	< 0.001*
Moderate	4	1.2	5	13.9	9	2.5		
PEWS score								
Median (IQR)	3 (1–8)		13 (9.3–17)		4 (1–9)		$Z = -7.769$	< 0.001*
Mean ± SD	4.8 ± 4.6		13.3 ± 5.0		5.67 ± 5.3			
DROOL scoring								
Median (IQR)	8 (6–10)		2 (1–4)		8 (5–10)		$Z = -8.254$	< 0.001*
Mean ± SD	7.6 ± 2.4		2.8 ± 2.3		7.14 ± 2.8			
ICU admission								
Yes	82	25.3	36	100.0	118	32.8	$\chi^2 = 82.034$	< 0.001*
No	242	74.7	0	0.0	242	67.2		
Length of hospital stay (in hours)								
Median (IQR)	12 (6–24)		72 (48–96)		12 (6–24)		$Z = -8.512$	< 0.001*
Mean ± SD	17.8 ± 17.4		74.8 ± 40.6		23.5 ± 26.9			
Discharge type								
Improvement	243	75.0	3	8.3	246	68.3	$\chi^2 = 72.206$	< 0.001*
Follow-up for complications	81	25.0	32	88.9	113	31.4		
Death	0	0.0	1	2.8	1	0.3		

N number, χ^2 Chi-square test, *Z* score of Mann-Whitney *U* test, *IQR* interquartile range, *SD* = standard deviation, *statistically significant ($p < 0.05$)

GCS Glasgow Coma Scale, *PEWS* Pediatric Early Warning Score system, *DROOL* Drooling Reluctance Oropharynx Others Leukocytosis, *ICU* intensive care unit

preventive measures in developing countries, might explain the high prevalence (Uygun 2015).

We report a noticeable decline in the prevalence of caustic exposure over the past 3 years, which agrees with another study carried out in the USA (Rafeey et al. 2016). Decreased caustic exposure during 2020 agrees with an earlier study carried out in Egypt and reported significant decline in the corrosive exposure during COVID-19-associated lockdown compared to the past 4 years. They attributed this decline to the increased availability of parents and guardians at homes and thus more children guidance and supervision. The same study reported less admissions to the poison control center during the pandemic which might be another explanation (Fayed and Sharif 2021). Increased orientation programs and awareness campaigns held by primary healthcare providers are another justification (Gutberlet and Uddin 2017).

We found that 10% of the presented cases developed esophageal injuries, and their outcomes were considered unfavorable; 32.8% were admitted to the ICU. Similarly, 7–15% of children developed gastrointestinal strictures following corrosive ingestion (Uygun et al. 2012). Research reporting ICU

admissions is scarce. However, in one study, 18% of the involved children underwent endotracheal intubation and mechanical ventilation (Arnold and Numanoglu 2017). Another study carried out among adults after corrosive ingestion has mentioned that 15.2% were admitted to the ICU (Faz et al. 2017). The discrepancy in ICU admissions rates between this study and our current study might be attributed to different criteria for the involved patients, including age, residence, and manner of exposure.

The predominance of accidental corrosive ingestion reported in the current study agrees with that of previous studies (Thomas et al. 2009; Abbas et al. 2017). We report more frequent exposure among children ages 2–4 years. Correspondingly, various studies have reported elevated rates of corrosive exposure in preschool-age patients (Melek et al. 2008; Contini et al. 2009; Doherty et al. 2017). Frequent exposure during preschool age can be explained by the hyperactive and self-endangering behaviors of this age group, in addition to the lack of insight to distinguish edible matters from toxic ones (Al-Binali et al. 2009). Another factor might be the lack of or inadequate parental supervision. Janoušek

Fig. 2 PEWS and DROOL scoring in pediatrics diagnosed with corrosive ingestion according to the studied outcomes

et al. has stated that guardian negligence, careless categorizing, and unsafe storage are the main reasons for unintentional child exposure (Janoušek et al. 2006).

The current study shows that more than half of the exposed children were boys, which agrees with other studies that have reveal similar or even higher percentages (57–81%) (Gün

Table 8 Features of receiver operating characteristic ROC curves of PEWS and DROOL scores as outcome predictors in pediatrics diagnosed with corrosive ingestion

Parameter	Cutoff value	Sensitivity	Specificity	PPV	NPV	Accuracy	AUC	p Value
As unfavorable outcome predictor								
PEWS system	6.5	94.4%	71.9%	27.2%	99.1%	89.3%	0.893	< 0.001*
DROOL score	6.5	91.7%	72.5%	27.0%	98.7%	91.3%	0.913	< 0.001*
As need for ICU admission predictor								
PEWS system	5.5	96.6%	90.5%	83.2%	98.2%	96.5%	0.965	< 0.001*
DROOL score	7.5	89.8%	77.3%	65.8%	93.9%	91.9%	0.919	< 0.001*

AUC area under curve, PPV positive predictive value, NPV negative predictive value, *statistically significant ($p < 0.05$)

PEWS Pediatric Early Warning Score system, DROOL Drooling Reluctance Oropharynx Others Leukocytosis

Fig. 3 Receiver operating characteristic ROC curves of PEWS and DROOL scores as predictors of unfavorable outcome in pediatrics diagnosed with corrosive ingestion

et al. 2007; Contini et al. 2009; Uygun 2015; Balderas et al. 2018; Dehghani et al. 2018). The gender differences apply to other toxic exposures and injuries and are not limited to corrosive exposure. Different patterns of activities besides engagement in exploring misbehavior might be a reasonable justification (Morrongiello et al. 2004).

We also report significant exposure among children living in rural areas and significant associated poor outcomes, aligning with the study by Hashimi et al. (Hashimi et al. 2018). Higher prevalence among rural areas might be attributed to the more accessibility of concentrated caustic products for utilizing them in agricultural purposes. Similarly, and in agreement with the current study, children of a lower SES are more vulnerable. Lower cultural levels, poverty, illiteracy, and overcrowding might be responsible (Bautista Casasnovas et al. 1997). Lacking healthcare facilities and delays in

Fig. 4 Receiver operating characteristic ROC curves of PEWS and DROOL scores as predictors of need for ICU in pediatrics diagnosed with corrosive ingestion

reaching emergency services might resonate with the associated poor outcomes among rural residents (Fayed and Sharif 2021). However, other research has reported more incidences of caustic ingestion in urban societies (Riffat and Cheng 2009; Thomas et al. 2009). Therefore, both residents of urban and rural areas can be exposed. In addition, low parental educational level is considered a trigger of caustic ingestion, particularly those unlabeled agents sold through informal markets (Sarioglu-Buke et al. 2006; Gün et al. 2007).

The current study lists bath cleansers as the most encountered toxins among the studied cases, agreeing with the findings of other studies (Doğan et al. 2006; Al-Binali et al. 2009). This could be related to the probable acidic composition of most bath cleansers (Quirce and Barranco 2010). However,

Fig. 5 Correlation between PEWS system and DROOL score in pediatrics diagnosed with corrosive ingestion

non-cleaning materials were the most habitually involved corrosives (Contini et al. 2009; Riffat and Cheng 2009), which might be related to the wide use of products assumed by the public to not be hazardous (Otcu et al. 2003).

Moreover, significant gastrointestinal injuries following sulfuric acid ingestion agree with those reported in similar studies among adults who ingested sulfuric acid as a suicidal agent (Rollin et al. 2015). The widespread

use of sulfuric acid as cleaning agent due to its strong lytic effects increases the chance of accidental exposure (Paugam et al. 2013). Severe esophageal or gastric burns and strictures, in addition to aspiration pneumonia, were the main findings. Noticeable prolonged healing has been associated with such injuries (Poley et al. 2004; Tohda et al. 2008). Furthermore, in agreement with the current study, the pH of the ingested

Table 9 Univariate and multivariate binary logistic regression analysis for different variables and scoring systems as unfavorable outcome predictors in pediatrics diagnosed with corrosive ingestion

Predictors of unfavorable outcome	Univariate		Multivariate	
	<i>p</i> Value	OR (95% CI)	<i>p</i> Value	OR (95% CI)
Residence (rural)	0.013*	2.6 (1.2–5.6)	0.111	11.92 (0.56–25.19)
Temperature (fever)	< 0.001*	2.3 (1.6–3.1)	0.346	0.47 (0.10–2.21)
Respiratory rate	0.011*	1.03 (1.00–1.06)	0.671	1.029 (0.91–1.15)
Vomiting	0.014*	12.3 (1.6–90.8)	0.80	47.6 (0.62–360.57)
Skin burn	0.001*	0.17 (0.01–0.80)	0.282	2.70 (0.44–16.57)
Mucosal burn	0.045*	2.16 (1.01–4.61)	0.666	1.48 (0.24–9.03)
Retrosternal pain	< 0.001*	9.2 (4.1–20.5)	0.022*	67.7 (1.84–249.81)
O ₂ saturation	< 0.001*	0.8 (0.7–0.9)	0.226	1.49 (0.78–2.85)
Respiratory distress	< 0.001*	1.8 (1.4–2.4)	0.590	0.656 (0.142–3.039)
GCS	< 0.001*	0.5 (0.3–0.7)	0.417	2.96 (0.21–40.69)
HCO ₃	< 0.001*	0.8 (0.7–0.9)	0.982	1.004 (0.73–1.38)
Total bilirubin	0.010*	10.6 (1.7–64.7)	0.372	17.8 (0.03–997.84)
Anemia	< 0.001*	11.3 (5.0–25.1)	0.018*	18.8 (1.66–212.52)
Leukocytosis	< 0.001*	15.6 (6.5–37.1)	0.506	2.72 (0.14–52.21)
Ultrasonography findings (free peritoneal fluid)	< 0.001*	0.02 (0.005–0.043)	0.048*	0.046 (0.002–0.97)
PEWS System	< 0.001*	1.31 (1.21–1.41)	< 0.001*	1.76 (0.97–3.17)
DROOL Score	< 0.001*	0.48 (0.39–0.58)	< 0.001*	0.47 (0.21–0.99)

OR odd ratio, CI confidence interval, *statistically significant ($p < 0.05$)

GCS Glasgow Coma Scale, PEWS Pediatric Early Warning Score system, DROOL Drooling Reluctance Oropharynx Others Leukocytosis

chemical (being acidic or alkaline) cannot be considered a reliable outcome predictor (Havanond and Havanond 2007).

Gastrointestinal (GI) complaints, including vomiting, hematemesis, drooling, dysphagia, and tissue burns, were significantly more frequent among patients with unfavorable outcomes. The higher number of vomiting attacks among the unfavorable outcome patients and the significance of vomiting and tissue burns as poor outcome predictors are noteworthy. The role of presenting symptoms as outcome predictors has been reported in another study, which has mentioned that dysphagia and mucosal burns can predict the severity of GI injury (Havanond and Havanond 2007). Similarly, Crain et al. mentioned that the presence of more than two symptoms including vomiting, drooling and stridor may predict the gastric injuries following corrosive exposure (Crain et al. 1984). In contrast, others have refuted the association between the initial gastric symptoms and the presence or severity of gastrointestinal injuries. Some cases with no gastric complaints have progressed to gastrointestinal injuries, although vomiting has been associated with more visceral burns (Betalli et al. 2008). In the current study, the significant frequent presentation with abdominal pain and the observed abdominal rigidity among patients with poor outcomes is supported by Park, who correlates these findings with the extension of the injury (Park 2014).

Due to the importance of GI signs and symptoms in corrosive exposure, and although endoscopy is the mainstay for diagnostic radiological study, the need for non-invasive modalities like ultrasonography is pressing (Elshabrawi and A-Kader 2011). The current study supports the critical role of ultrasonography in patients exposed to caustics. Ultrasonography of 55.6% of the patients with unfavorable outcomes showed free peritoneal fluid. Furthermore, the presence of free peritoneal fluid is a significantly reliable poor outcome predictor. The role of Abdominal ultrasonography as a supplementary diagnostic tool, especially among critically ill patients when endoscopy cannot be carried out, is previously reported (Kartikayan 2014). However, we should consider that free peritoneal fluid is not necessarily due to gastrointestinal perforation. GI inflammation and a wide range of infections are also common causes (Epelman et al. 2007).

The respiratory tract is greatly influenced following corrosive exposure. We reveal significant retrosternal pain, tachypnea, respiratory distress of different grades, and crepitations existing among the unfavorable outcomes group. Lung opacities and increased bronchovascular markings are significant findings among this group. Furthermore, respiratory distress, retrosternal pain, and O₂ saturation are considered significant outcome predictors. Similarly, a systematic review involved 11,345 children focused on respiratory symptoms as a frequent presentation among pediatric patients exposed to corrosives; however, aspiration pneumonia and laryngeal

sores were the most frequent findings (Rafeey et al. 2016). The association between respiratory distress and gastrointestinal injuries also has been determined elsewhere (Doherty et al. 2017).

Moreover, respiratory distress and pneumonia have been considered significant risks of death after corrosive ingestion (Rigo et al. 2002). The irritant effects of the caustic substance, which stimulates choking and gagging, can lead to respiratory failure (Doherty et al. 2017). In addition, children are subjected to aspiration, which predisposes them to more pulmonary deterioration and consequent airway dysfunction. Other principal factors worsening the condition are laryngeal edema and limited bronchial secretion clearance (Chibishev et al. 2012).

This current study highlights the significant elevation of the body temperature and Total leucocytic count (TLC) among patients with unfavorable outcomes. Furthermore, in the univariate analysis, both fever and leukocytosis were significant outcome predictors. Presence of fever and leukocytosis following corrosive ingestion have been reported in the majority of similar studies (Gorman et al. 1992; Jones 2002; Melek et al. 2008; Chibishev et al. 2012; Uygun et al. 2012; Park 2014; Uygun 2015; Dehghani et al. 2018). Similarly, Tosca et al. has mentioned that leukocytosis is a good predictor of unfavorable outcomes (Tosca et al. 2020). Persistent fever and leukocytosis can suggest perforation and extensive tissue damage, followed mainly by inflammatory reactions and secondary infection of the affected tissues (Cibisev et al. 2007). Although leukocytic count can evaluate esophageal injury severity, it has not been considered a valuable indicator for esophageal strictures (Chen et al. 2003). As expected, the current study reports significantly increased heart rate among patients with unfavorable outcomes, which could be explained as a fever (Gorman et al. 1992). Children's fear and stress associated with hospital admission are other added factors (Bryant et al. 2007).

Apart from Total leucocytic count (TLC), some other laboratory investigations have shown significant differences between both groups, including bicarbonate level, total serum bilirubin level, aspartate aminotransferase, and hemoglobin. Except for hemoglobin, all were within the normal reference range in both groups. Partially agreeing with the current study, although low bicarbonate level has been reported to be associated with poor outcome, the degree of metabolic acidosis was related to the severity of the endoscopic esophageal injury (Tosca et al. 2020). Another Turkish study has reported no significant difference in pH nor HCO₃ level between complicated and non-complicated patient groups (Otcu et al. 2003).

Anemia was considered a robust significant outcome predictor, which has been reported in previous studies and attributed to hematemesis or GI bleeding (Abbas et al. 2017). In addition, coagulative necrosis following strong acid exposure, which transforms tissue proteins into acids and hemoglobin into hematin, is another reliable justification (Chibishev et al.

2012). Moreover, Rigo et al. has considered the initial hemoglobin concentration as death predictors in cases of corrosive ingestion (Rigo et al. 2002).

The current study reveals that the mean length of hospital stay was 23.5 ± 26.9 h with a median of 12 h, which is lower than that reported in California (4.13 days, with a median of 2 days) (Johnson and Brigger 2012). Another study carried out in Pakistan reported a much higher duration of the first hospital stay (mean 11.8 ± 11.1 days) (Hashmi et al. 2018). In the current study, the mean length of hospital stay was significantly higher in the unfavorable outcomes group (74.8 ± 40.6 h) than in the favorable outcomes group (17.8 ± 17.4 h) due to the need for TPN and ICU admission.

Despite the importance of the above-mentioned individual factors, we cannot depend on a single variable to evaluate patient condition and expected outcomes. Moreover, research has suggested that endoscopy is not mandatory for evaluating the cases of caustic ingestion, especially asymptomatic ones (Christensen 1995). The presence of a reliable clinical scoring system for prediction of outcomes and the need for ICU admission can help with better patient evaluation and management and avoid the need for invasive maneuvers (e.g., endoscopy).

As per the current study and despite the significant variations in GCS between the patients with different outcomes, GCS is not a significant outcome predictor in a multivariate analysis. This finding can be attributed to the fact that most of the patients (97.6%) were categorized as mild cases. Basically, GCS is designed for evaluating cases of traumatic brain injury (Salottolo et al. 2014). Similarly, another study has revealed that GCS showed no significant difference for ICU admission or mortality in cases of corrosive exposure (Faz et al. 2017).

Our study introduces two accurate, rapid scoring systems that can be used on admission and can successfully predict patients needing ICU admission and those expected to develop esophageal injuries following corrosive ingestion. The DROOL score was significantly lower in the patients with unfavorable outcomes (2.8 ± 2.3). Furthermore, a DROOL score < 6.5 was associated with unfavorable outcomes. Parallel findings have been reported in a Turkish study mentioning that DROOL scores ≤ 4 were associated with gastric stricture (Hashmi et al. 2018). The significance of DROOL score as an esophageal injury predictor following corrosive ingestion has been reported elsewhere (Uygun et al. 2012; Uygun 2015). The current study adds to the significance of this score in predicting the need for ICU admission among these cases.

This study also conveys the significant role of the PEWS score as a predictor of ICU admission. We obtained more accuracy, sensitivity, and specificity as compared to the DROOL score. The ability of PEWS to predict ICU admission mirrors the results of one study that has obtained comparable AUC, sensitivity, and specificity (Gold et al. 2014). In

addition, another study has evaluated the initial use of PEWS in the emergency department, revealing that high PEWS scores suggest a need for ICU admission (Lillitos et al. 2016).

The more significant results can be explained by the different parameters constituting each score. PEWS emphasizes the status of the cardiopulmonary system, O_2 therapy, and the neurological status of the cases, while most DROOL score variables are related to local GI corrosive effects. The ability of PEWS to predict significant respiratory illnesses has been suggested previously (Tosca et al. 2020). Furthermore, PEWS has been found to be the earliest indicator of patient deterioration in other contexts (Akre et al. 2010) and to be correlated with LOS (Shafi et al. 2020). Furthermore, a multicenter study has reported that PEWS score can detect poor outcomes, and increasing scores can predict cardiopulmonary arrest (Parshuram et al. 2009).

To our knowledge, ours is the first study to evaluate the use of PEWS as an outcome predictor among cases of toxic exposure. This well-known, simple, and reliable clinical pediatric score can evaluate the different body systems rather than only esophageal injuries. PEWS can detect early deterioration, and its use in the toxicology field can facilitate earlier patient management, which is associated with better outcomes (Parshuram et al. 2009). PEWS is a promising tool, especially for hospitals with limited resources (Brown et al. 2019). However, because both scores are strongly correlated, combining both PEWS and DROOL scores can yield significant predictions of outcomes.

Conclusion

Most toxic and caustic exposure occurs accidentally among preschool-age boys living in rural areas. Predictors of poor patients' outcomes include ingestion of bath cleansers and sulfuric acid, in addition to presenting symptoms of vomiting, skin and mucosal burns, retrosternal pain, and respiratory distress. Moreover, fever, tachypnea, low O_2 saturation, lower GCS, lower HCO_3 , higher total bilirubin, anemia, leukocytosis, and free peritoneal fluid are significant predictors of poor outcomes. PEWS and DROOL scores are potentially useful in-hospital outcome predictors for pediatric patients exposed to corrosive ingestion. The DROOL score better predicts esophageal injuries, while PEWS more accurately predicts ICU admission. Combination of the two scores may be useful to predict outcomes.

Recommendation

- Utilizing PEWS and DROOL score in pediatric patients with corrosive ingestion can assist admitting physicians in

predicting the severity of injury and illness, and hence improve the level of care and outcomes.

- Conducting prospective studies to validate these scores in in different settings and following other types of toxic exposure is highly recommended.
- Validating the findings of this study will be substantially beneficial to the admitting physician. Prioritizing the patients based on their need for ICU and vulnerability for esophageal injuries is life and sources saving.
- Conducting community orientation campaigns to reduce pediatric exposure to corrosives especially in rural areas.
- Giving more attention for preschool children and restricting their access to household chemicals, thus reducing their exposure to such threatening injuries.

Limitations

Six months of follow-up to assess the long-term esophageal strictures in presented patients is recommended in future studies. However, early prediction of esophageal injuries and patients in need for ICU based on novel scoring systems strengthens the current findings and adds to the knowledge gap.

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Author contribution A. Sharif conceptualized the study, collected the data, interpreted the data, wrote the manuscript draft, proofread it, and approved the final manuscript.

D. El Gameel conceptualized the study, collected the data, interpreted the data, wrote the manuscript draft, proofread it, and approved the final manuscript.

S. Abdo analyzed the data, proofread and approved the final manuscript.

E. Elgebbally collected the data and obtained the ethical approval from SGH and approved the final manuscript.

M. Fayed conceptualized the study, collected the data, interpreted the data, wrote the manuscript draft, proofread it, and approved the final manuscript.

Data availability The dataset used during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate The current study began after obtaining ethical approvals from Research Ethical Committees (34457/2/21) of the Faculty of Medicine, TPCC, and an Ethical Clearance Certificate (ECC#2021-04) from the SGH. According to the Declaration of Helsinki, all data were handled anonymously to maintain patients' confidentiality. Obtaining informed consent was waived by the Research Ethical Committees.

Consent for publication Not applicable as data were retrieved anonymously from the medical records to maintain the confidentiality of the patients.

Competing interests The authors declare no competing interests.

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