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Clinical Outcomes of Phenol Burns Managed with Polyethylene Glycol-Glycerine Dressing: A Retrospective Case Series

Sanjay Kumar Giri, Syama Sundar Behera, Reena Minz, Aparna Kanungo, Vidush Kumar, Surya Yashaswi PVS, Keerthi G, Ambrish Ramasamy, Deepanjali Shetty

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ABSTRACT

Background: Chemical injury by phenol is a rare type of chemical burn that can lead to progressive local tissue damage and systemic toxic effects post-dermal absorption. Clinical studies on polyethylene glycol (PEG) and glycerine for phenol exposures exist due to PEG's solvent properties; however, literature exists in both clinical and limited quantities. The purpose of this case series was to document the clinical presentation and short-term treatment results of those individuals who were treated for phenol burns using a PEG-glycerine dressing and supportive burn care.

Case series: A retrospective review was conducted on six patients who suffered phenol burns. Four of the patients were children and two were adults. The age ranged from 1 to 43 years, with a median age was 4.71 years. Five patients were male. Total body surface area burned averaged 27.83 ± 10.52 % (Range = 15%–42%). Superficial to deep partial thickness burns occurred in five cases; one case involved superficial burns. The mean length of time prior to being presented for treatment was 24.17 ± 23.91 hours. A PEG-glycerine dressing was applied to each patient's burns in addition to standard supportive burn care. Two patients developed infection. None of the patients underwent an operative procedure for debridement, or skin grafting. Systemic toxicity was noted in none of the available medical records. The average length of hospitalization was 12.83 ± 6.11 days. Each of the six patients survived, and all discharged with either healing or stable wounds.

Conclusion: Favorable short term wound progression was seen in patients with phenol burns treated with PEG-glycerine dressing and supportive care in this small retrospective case series. This should however be interpreted with caution due to the limited number of cases within the series; lack of a control/comparator group for comparison purposes; no information regarding the extent, or type of irrigation performed prior to hospital arrival (pre-hospital); and a failure to document the precise time intervals between application of the PEG and any systemic monitoring.

Clinical Significance: Systemic toxic exposure should be considered when managing potential chemical (phenol) burns. A PEG-glycerine dressing can help with local wound care; however, it does not take the place of removing the chemical quickly by washing, flushing where necessary, treating the wound appropriately, and closely monitoring for signs of systemic toxicity.

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Department of Burns and Plastic Surgery, AIIMS Bhubaneswar, Bhubaneswar, Odisha, India.
***Correspondence:** Syama Sundar Behera (drsyamasundar.2010@gmail.com)*
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INTRODUCTION

Although not common, chemical burns represent an important subset of all types of burn injuries. They differ clinically from thermal burns because further tissue damage continues until the chemical is either washed off, diluted, or neutralized. The eventual degree of injury is determined by many factors including the type and concentration of the chemical agents, the amount of each chemical used, how long the chemicals were in contact with the body surface area, the size of the body surface area that was affected, and how soon treatment was received. Organic chemical agents such as phenol are particularly important because they may cause both local skin injury and systemic toxicity after absorption through the skin.[1]

Phenol, also known as carbolic acid, is an aromatic compound used in industrial, disinfectant, household, and medical settings. Cutaneous exposure may initially produce pain, erythema, blanching, blistering, discoloration, and later slough or eschar. However, phenol may also produce local anesthesia, so the severity of injury may be underestimated at first. After absorption, systemic toxicity may manifest as central nervous system depression, seizures, cardiac dysrhythmia, metabolic acidosis, hemolysis, hepatic injury, renal injury, respiratory compromise, and cardiovascular collapse.[2,3]

The risk of systemic toxicity is especially relevant in children because of their higher body surface area to weight ratio. Giri *et al.* reported four pediatric cases of acute carbolic acid poisoning from India and observed severe systemic complications, including depressed sensorium, seizures, hemolysis, acute kidney injury, coagulopathy, arrhythmia, and acute liver failure.[4] Severe adult phenol burns have also been reported from India. Parikh described a 35-year-old patient with 37% total body surface area (TBSA) exposure to 94% phenol who developed metabolic acidosis, acute renal failure requiring hemodialysis, pleural effusion, acute respiratory distress syndrome, and multiorgan dysfunction, but survived with intensive supportive care.[5]

Early decontamination is therefore central to phenol burn management. The solubility of phenol in agents such as PEG (polyethylene glycol) and glycerine has provided a basis for their application. Experimental data support PEG use in various contexts. Similarly, studies comparing PEG to water or isopropyl alcohol have reported that either both methods are equally effective or there was an advantage to using isopropyl alcohol. Therefore, the existing literature establishes biological feasibility for use of PEG but it also does not suggest superior effectiveness when compared to all other alternatives.[6-10]

The present study describes six patients with phenol burns managed with PEG–glycerine dressing and supportive burn care. The purpose of this series is to report clinical experience with a consistent local wound-care strategy in an uncommon chemical injury. It is not intended to prove that PEG–glycerine is superior to water irrigation or other decontamination methods.

CASE SERIES

Study Design

This was a retrospective descriptive case series of patients with phenol burns managed with PEG–glycerine dressing and supportive burn care. Because the study was retrospective and included a small number of patients, only descriptive analysis was performed.

Study Setting

All cases were managed in a hospital burn-care setting. The study was based on available clinical records.

Inclusion Criteria

Patients were included if they had documented phenol or carbolic acid burn injury and received PEG–glycerine dressing as part of local wound management.

Exclusion Criteria

No formal exclusion criteria were predefined because of the retrospective descriptive nature of the series. Records with missing variables were not excluded if the diagnosis of phenol burn and use of PEG–glycerine dressing were documented.

Data Collection

The following variables were extracted from the available records: age, age category, sex, mode of injury, burn site, TBSA, burn depth, time to presentation, PEG–glycerine dressing use, adjunctive treatment, infection, operative intervention, hospital

stay, systemic toxicity or adverse reaction, survival, and wound status at discharge.

Although the documentation on certain variables within the medical records did not provide clear information on these items they were documented as missing for purposes of analysis; prehospital (at scene) decontamination methods were not provided such that it could be determined if there had been a wash or an irrigate prior to arrival at the hospital; similarly, the timing from when an individual suffered their injury until they received the initial PEG-glycerine application was not consistently recorded. Thus, the use of PEG-glycerine in this study is reported as a locally applied wound care intervention that has been documented; as opposed to standard decontamination immediately upon injury in all cases.

Outcome Measures

The primary outcomes of interest in assessing the effects of these treatments included the ability of patients to survive, their wound status upon discharge from the hospital, presence of infections, necessity for surgical interventions (operative), evidence of systemic toxicities/adverse reactions and length of hospitalization. Additionally, secondary observational data were collected on burn depth, total body surface area (TBSA) distribution, duration prior to arrival at a medical facility and whether an additional form of therapy was needed.

Statistical Analysis

All descriptive statistics only were reported. Continuous variables have been described as mean ± SD (standard deviation) and range. Categorical variables are expressed as number and percent. Since there is no comparison group, we did not perform any comparative/inferential statistical analyses.

Ethical Considerations

Institutional ethics committee waiver was obtained for this retrospective descriptive case series. All clinical records utilized for this investigation were anonymized. There was no direct intervention with any patient for the purpose of conducting research. Patient identity was concealed during data collection and manuscript preparation. Written consent for publication was obtained for any clinical photographs used in the manuscript.

RESULTS

Demographic Characteristics

Six patients were included in the series. Four were children and two were adults. Five patients were male and one was female. The ages were 1 year, 1 year, 17 months, 8 years, 29 years, and 43 years. The median age was 4.71 years, with a range of 1 to 43 years. Because the cohort included both young children and adults, the median and range were considered more appropriate than mean age for describing age distribution. All injuries were accidental. Two cases were specifically documented as accidental domestic exposures.

Burn Characteristics

The TBSA involvement ranged from 15% to 42%, with a mean of 27.83 ± 10.52%. Individual TBSA values were 35%, 20%, 25%, 15%, 30%, and 42%. Five patients had superficial-to-deep partial-thickness burns, while one patient had superficial burns. Burn sites were documented in four patients and included the face, torso, back, right upper limb, right lower limb, bilateral lower limbs, right hand, neck, abdomen, right thigh, penis, knee, and forearm. In two adult patients, the exact anatomical site was not clearly documented in the available records.

Treatment Details

PEG–glycerine dressing was used in all six patients. Supportive treatment varied according to clinical condition and included intravenous fluids, antibiotics, antifungal therapy, furosemide infusion, packed red blood cell transfusion, colistin, silver nitrate ointment, oral fluids, compression garments, analgesics, and general supportive care. One child underwent upper gastrointestinal endoscopy because of concern for possible ingestion or mucosal exposure. No patient underwent operative debridement, split-thickness skin grafting, or any other surgical intervention.

Clinical Outcomes

Time to presentation ranged from 4 to 72 hours, with a mean of 24.17 ± 23.91 hours. Hospital stays ranged from 6 to 23 days, with a mean duration of 12.83 ± 6.11 days. Infection was documented in two patients.

One patient had fever spikes and received culture-guided colistin. Another patient had fever spikes, but detailed microbiological data were not available.

No systemic toxicity was documented in the available records. However, serum phenol levels, urine phenol levels, serial electrocardiographic monitoring, and standardized renal, hepatic, and hemolysis monitoring were not uniformly available. Therefore, subclinical or undocumented systemic effects cannot be excluded.

All six patients survived. At discharge, wound status was described as healthy and healing, gradual wound healing with recovery, or stable. Exact time to complete epithelialization, pigmentation changes, scar quality, contracture, and long-term functional outcomes were not documented. Serial clinical photographs demonstrating wound progression from presentation to follow-up are shown in figure 1.

Discussion

Phenol burns are uncommon but potentially serious chemical injuries. Their importance lies not only in local cutaneous damage but also in the possibility of rapid systemic absorption. Phenol can be absorbed through the skin and disrupt protein function at a cellular level and create systemic toxicity from an external burn regardless of how severe the burn appears to be. Seth *et. al.* stated that chemical burns will continue to damage tissues until the chemical has been completely neutralized and also that phenol will have toxic effects on internal organs in addition to the local area damaged by the burn.[1]

The clinical danger of phenol exposure has been repeatedly highlighted in the literature. Horch *et al.* stated that phenol burns and intoxications are serious enough to be life threatening and they also documented that an individual survived a 20.5 % TBSA burn from phenol after receiving multiple treatments of polyethylene glycol (PEG) for removing excess phenol from their blood and other forms of supportive care.[2] Vearrier *et al.* documented pediatric cutaneous phenol toxicity secondary to Creolin use. The symptoms included depressed mental status, ventricular tachycardia, dark green urine, desquamation and transaminitis.[3] These cases demonstrate why it is important to treat phenol burns as a systemic toxin and not just as a localized injury to the skin.

The pediatric component of the present series is notable, as four of the six patients were children. Giri *et al.* reported four pediatric carbolic acid poisoning cases from India and found that extensive skin exposure was associated with serious complications, including seizures, hemolysis, acute kidney injury, arrhythmia, and multiorgan dysfunction.[4] In contrast, no systemic toxicity was documented in our cohort despite a mean TBSA of 27.83% and four patients having 20%, or more TBSA involvement. This should not be interpreted as evidence that PEG–glycerine

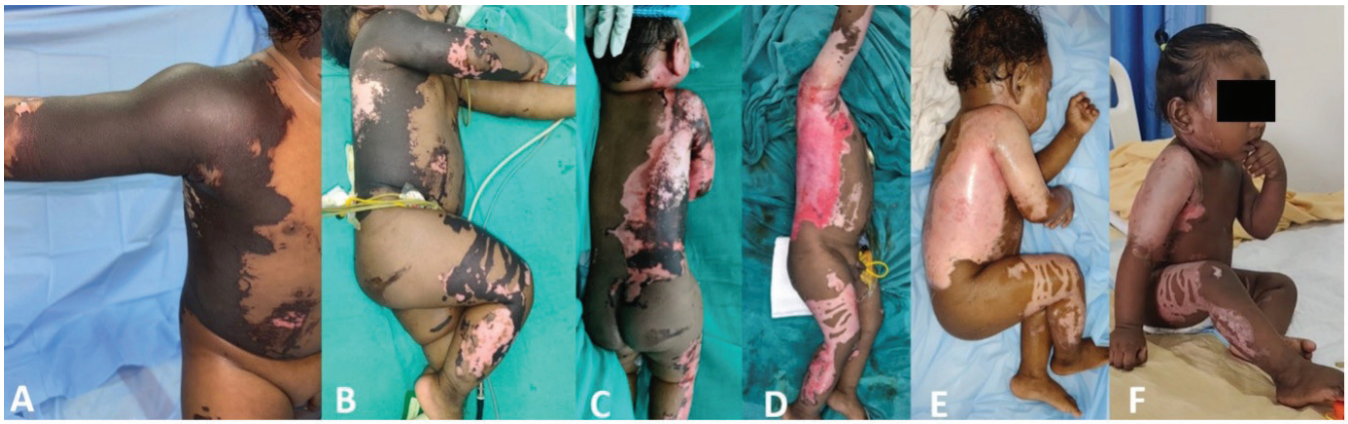

Figure 1: Serial clinical progression of pediatric phenol burns managed with PEG–glycerine dressing and supportive burn care. **(A)** Post-burn day 4, at the time of presentation and admission, showing extensive phenol-related cutaneous discoloration and burn involvement. **(B)** Post-burn day 5, showing early wound appearance after initiation of local wound care. **(C)** Post-burn day 7, showing evolving wound changes during inpatient management with PEG-Glycerine dressings every alternate day. **(D)** Post-burn day 11, showing good epithelialization and recovery. **(E)** Post-burn day 15, at discharge, showing good recovery with complete epithelialization. **(F)** Post-burn day 25 follow-up, showing stable healed wound status. Identifying features have been removed, and written consent for publication was obtained from the parent/guardian.

Table 1: Individual patient characteristics and outcomes.

Patient	Age/Sex	TBSA	Burn depth	Time to presentation	PEG–glycerine dressing	Infection	Surgery	Hospital stay	Outcome
1	1 year/Male	35%	Superficial-to-deep partial thickness	72 h	Yes	Yes	No	17 days	Wounds healthy and healing
2	1 year/Male	20%	Superficial	10 h	Yes	No	No	6 days	Stable at discharge
3	8 years/Male	25%	Superficial-to-deep partial thickness	23 h	Yes	No	No	7 days	Gradual wound healing with recovery
4	17 months/Male	15%	Superficial-to-deep partial thickness	4 h	Yes	No	No	10 days	Gradual wound healing with recovery
5	29 years/Female	30%	Superficial-to-deep partial thickness	24 h	Yes	No	No	14 days	Gradual wound healing with recovery
6	43 years/Male	42%	Superficial-to-deep partial thickness	12 h	Yes	Yes	No	23 days	Gradual wound healing with recovery

prevented systemic toxicity. Differences in phenol concentration, exposure duration, prehospital first aid, timing of hospital presentation, burn depth, and supportive care may have contributed. In addition, systemic monitoring was not standardized in our retrospective records.

Parikh reported a severe adult phenol burn from India involving 37% TBSA exposure to concentrated phenol, complicated by metabolic acidosis, acute renal failure requiring hemodialysis, pleural effusion, acute respiratory distress syndrome, and multiorgan dysfunction.[5] Compared with that report, our two adult patients and four pediatric patients had favorable short-term outcomes, with survival in all cases and no operative intervention. Our case series involved mainly superficial-to-deep partial-thickness burns; therefore, we could not directly compare the burn severity. The literature also does not report uniform data on the specific concentration or duration of phenol exposure in each study.

Table 2: Summary of clinical outcomes.

Parameter	Observation
Total patients	6
Pediatric patients	4/6
Adult patients	2/6
Male patients	5/6
Female patients	1/6
Median age	4.71 years, range 1–43 years
Mean TBSA	27.83 ± 10.52%
Mean time to presentation	24.17 ± 23.91 hours
Mean hospital stay	12.83 ± 6.11 days
Infection	2/6
Surgical intervention/skin grafting	0/6
Documented systemic toxicity	None documented
Survival	6/6
Final wound status	Healing or stable in all patients

PEG-glycerine has been recommended based on its solvating properties for phenol. In an animal model, Brown *et al.* demonstrated that decontamination with PEG resulted in decreased mortality rates, lower levels of systemic toxicity from phenol, and fewer burns than untreated animals exposed to phenol.[6] This supports the theoretical explanation behind the use of PEG. However, the literature varies. Using a swine model and the plasma level of phenol as an indicator of exposure, Pullin *et al.* determined there was no significant difference between washing with water versus swabbing with PEG-300/industrial methylated spirits (IMS) for reducing dermal and systemic toxicity due to phenol. Therefore, Pullin *et al.* recommend water be used as the most convenient first aid measure in the event of acute phenol exposure.[7]

Hunter et al. investigated four different options for removing phenol from acute swine burn wounds via water rinsing (with varying amounts of time) as well as by use of industrial methylated spirits (IMS)/PEG

(Polyethylene Glycol), ethanol, or isopropyl alcohol. The results indicated that IMS/PEG and isopropyl alcohol were the most successful in terms of reducing the degree of histologic injury associated with the phenol exposure. However, they concluded that the length of time for which the swines' wounds were treated with water rinsing was not an important variable in determining the degree of tissue injury.[8] Later on Monteiro-Riviere et al. conducted a study comparing various methods of phenol removal using pig skin as a model and determined that PEG 400 and 70% isopropanol were two of the best at reducing damage to the skin caused by phenols. In addition, they noted that treatments with PEG 400, 70% isopropanol, and 15 minutes of water treatment were all significant at reducing the amount of phenol absorbed into the skin versus untreated skin.[9]

These results indicate that PEG based methods have experimental basis for decontamination; however, this should not represent a sole means of decontamination. Water will remain important due to the rapid availability of water in emergency situations. This can be supported with recent poison center data from Testa et. al. who also indicated while low molecular weight PEG is recommended for dermal exposure to phenols, none of the cases they evaluated utilized it for decontamination. Water, high-molecular-weight PEG, or combinations were used more commonly, and no systemic toxicity was reported in their cohort.[10]

The current series would support this view. PEG-glycerine can be an added treatment to help manage phenol burns locally. However, PEG-glycerine is best managed as part of a larger treatment plan which addresses all other aspects of managing phenol exposure including removing contaminated clothing, protecting healthcare workers from the chemical agent; immediate removal and/or diluting the remaining agent, accurately assessing total body surface area (TBSA) and burn injury depth, controlling the patients' pain, managing fluids appropriately when needed, watching for signs of infection, and being able to detect early signs of systemic toxic effects from the agent. In addition, children have unique considerations due to their different physiological characteristics such as respiratory risks from an open airway, fluid replacement needs based on age and weight, and burn assessment and resuscitation.[11]

Based on the findings of the present case series and the available literature, a practical algorithm for evaluation and management of phenol burns is proposed in figure 2.

The main strength of this study is its description of individual patient experiences with an unusual type of chemical burn (phenol) using the same method to treat those wounds with PEG-glycerine as a topical dressing. The study's subject matter also encompasses treatment of children and adults. Additionally, since the time frame to hospitalization is variable and the pre-hospital first aid given can vary widely, this study demonstrates real world experience.

The limitations are significant. This was a retrospective case series of just six patients. There was no control group receiving only water irrigation; only glycerine; only silver-based dressings; isopropyl alcohol; or another treatment. Additionally, the specifics of the initial irrigation in the field (e.g., timing, volume, temperature) were not available to assess the impact of early first aid. The time elapsed from the patient's injury until PEG-glycerine application varied among subjects. Finally, documentation of systemic toxicity relied on historical data rather than routine clinical toxicology assessment; therefore, we cannot be certain regarding all potential effects. Also, the information on exact healing time, scar outcome, pigmentation, contracture, and long-term function was unavailable. These limitations prevent any causal conclusion that PEG–glycerine was responsible for the favorable outcomes.

Despite these limitations, the series adds valuable clinical experience with an uncommon burn injury mechanism. In addition, the results demonstrate the need for a standard protocol for recording phenol-exposure information (exposure time/dose, location of burn, etc.) along with prehospital treatment procedures, decontamination procedure(s), timing and nature of PEG application, system-wide monitoring parameters, and long-term scar outcomes.

CONCLUSION

In this retrospective case series, six patients who had been treated for phenol burns using a PEG-glycerine

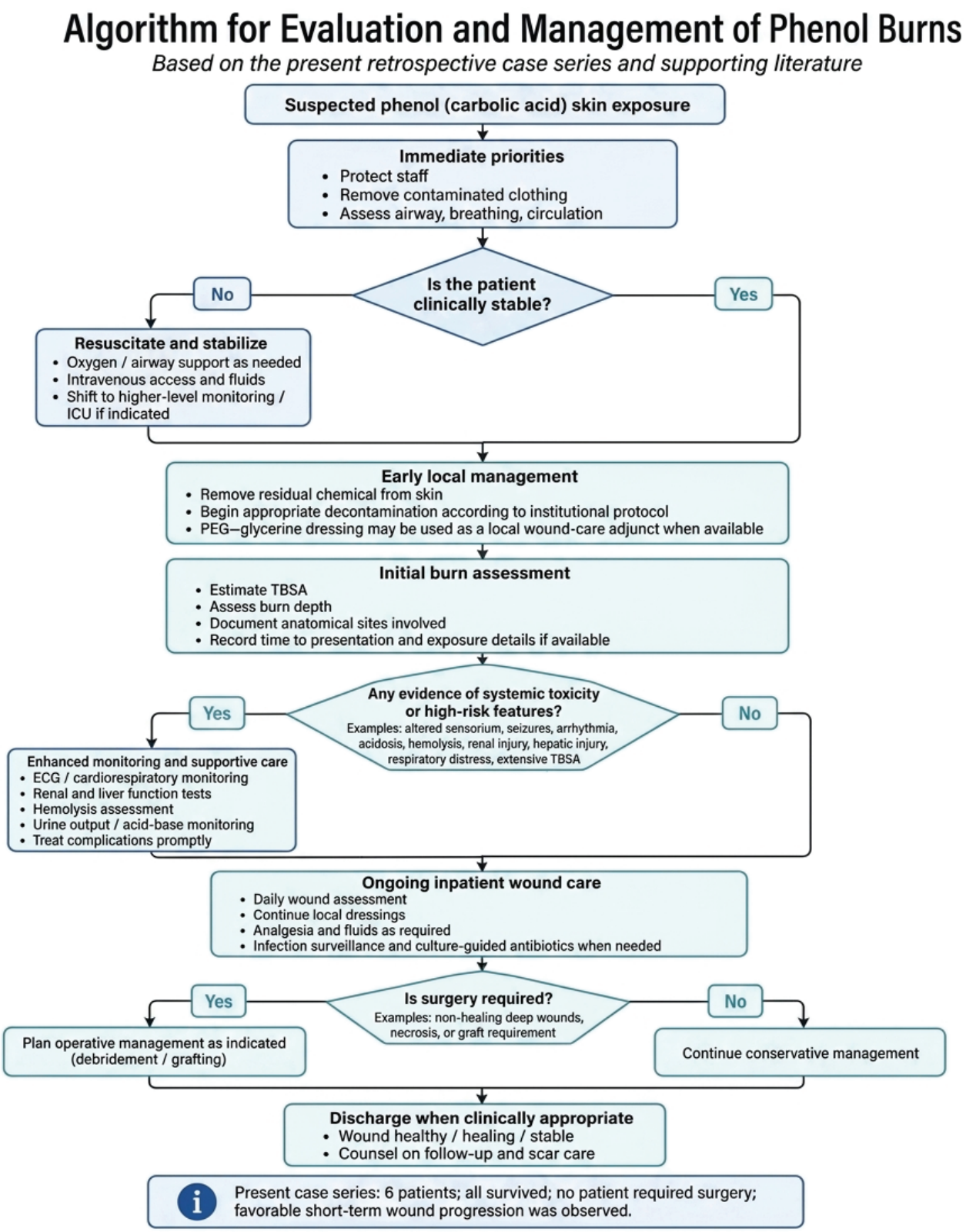

Figure 2: Algorithm for evaluation and management of phenol burns. The proposed algorithm summarizes a practical approach to phenol burns, including staff protection, removal of contaminated clothing, initial stabilization, local decontamination or wound-care measures, TBSA and depth assessment, monitoring for systemic toxicity, ongoing wound care, and selective surgery when indicated. PEG–glycerine dressing may be used as a local wound-care adjunct when available, but should not replace prompt chemical removal, appropriate decontamination, supportive care, and systemic monitoring.

dressing in conjunction with other forms of supportive care for their burn injuries demonstrated positive progression of their wound injury within a relatively short period post-injury. All patients survived without requiring surgical intervention; additionally, all wounds were documented as healthy, healing, or stable upon discharge from the hospital. That said, there are many reasons to interpret the data reported here with caution due to the very limited sample size, absence of comparison groups, possibility that some patients may have received pre-hospital irrigation (status was unknown) and lack of uniformity in the systematic monitoring of the patients' overall medical conditions. Based on these considerations, use of a PEG-glycerine dressing may provide additional utility when treating wounds resulting from phenol burns, however further larger prospective studies are required to define its role more clearly.

Clinical Significance

Burns from Phenol are to be considered as potential systemic toxins. The role of PEG – Glycerine as an adjunct to local wound care has been described due to solubility of phenol in PEG and glycerine. Prompt chemical removal; appropriate irrigation/decontamination of wounds; adequate support with burn care; and observation for neurologic, cardiologic, renal, hepatic, hematologic, and respiratory toxicity remain critical. This series supports further prospective evaluation of PEG-based protocols but does not establish superiority over water irrigation or other decontamination strategies.

Limitations

The principal limitations were the retrospective design, small sample size, absence of a control group, unavailable prehospital irrigation details, inconsistent documentation of exact PEG–glycerine timing, lack of standardized systemic toxicity monitoring, missing healing-time data, and absence of long-term scar and functional outcomes.

Future Recommendations

Future studies should prospectively record phenol concentration, exposure duration, first-aid measures, time to irrigation, time to PEG or glycerine application, PEG molecular weight and formulation, duration and frequency of dressing application, serial renal and hepatic parameters, hemolysis markers, urine color, acid-base status, electrocardiographic changes, infection, healing time, need for surgery, scar quality, pigmentation, contracture, and functional outcome. A simple institutional phenol-burn protocol may help standardize emergency decontamination and subsequent wound care.

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