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Article

Predictors of Mortality in Perforated Peptic Ulcer Surgery in Young Male Patients: A Multicenter Study from Yemen

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Abstract

Background/Objectives: Perforated peptic ulcer (PPU) remains a significant surgical emergency, with substantial morbidity and mortality, particularly in resource-limited settings. This study aimed to determine the 30-day morbidity and mortality rates following surgery for PPU in a predominantly young male population in conflict-affected Yemen and to identify predictors of adverse outcomes in this specific healthcare environment. **Methods:** We conducted a prospective multicenter observational study across four major governmental hospitals in Sana'a, Yemen. All adult patients who underwent surgery for PPU between February 2023 and February 2024 were included in the study. The primary outcomes were 30-day mortality and complications according to the Clavien-Dindo classification. Univariate and multivariate analyses were performed to identify the predictors of adverse outcomes. **Results:** A total of 108 patients (97.2% male) with a mean age of 39.6 years were included. The overall 30-day mortality rate was 11.1% (12/108) and the 30-day morbidity rate was 44.4% (48/108). Complete separation of mortality outcomes was observed, with all 12 deaths occurring in patients presenting with shock and acute kidney injury, identifying an extremely high-risk phenotype requiring validation in larger studies. Multivariate analysis for morbidity identified shock on admission (odds ratio [OR] 9.38, 95% confidence interval [CI] 2.73-32.26), delayed presentation (OR 1.03 per hour, 95% CI 1.01-1.05), and increasing age (OR 1.04 per year, 95% CI 1.00-1.07) as significant independent predictors. **Conclusions:** Surgery for PPU in this young male population from conflict-affected Yemen was associated with substantial morbidity and mortality rates. The observed complete separation of mortality outcomes, while requiring validation in larger and more diverse populations, may inform risk stratification in resource-limited settings. These findings contribute to the understanding of PPU outcomes in conflict-affected environments; however, their generalizability to other populations and healthcare systems requires further investigation.

Keywords: perforated peptic ulcer; mortality; risk factors; Yemen; conflict-affected setting; surgical outcomes; young male patient

1. Introduction

Perforated peptic ulcer (PPU) is one of the most challenging surgical emergencies, with reported morbidity and mortality rates of up to 50% and 30%, respectively [1,2]. This condition requires prompt surgical intervention and is associated with a significant global health care burden. The incidence of PPU varies across different populations, ranging from 3.8 to 14 per 100,000 individuals,

with notably higher rates reported in resource-limited settings, where delayed presentation and limited healthcare infrastructure compound clinical challenges [1,3].

Contemporary literature demonstrates that PPU outcomes are influenced by multiple factors, including patient age, comorbidities, hemodynamic status at presentation, and the timing of surgical intervention [4,5]. Established risk factors include the use of non-steroidal anti-inflammatory drugs (NSAIDs), *Helicobacter pylori* infection, and ulcer size ≥ 1 cm [1,2]. The condition typically presents as an acute abdominal emergency with localized or generalized peritonitis, requiring immediate surgical management through primary closure or gastric resection, depending on various clinical factors [6,7].

Prognostic scoring systems, such as the PULP, Boey, and ASA scores, have been developed to predict outcomes in patients with PPU [8,9]. These systems consider factors such as age, comorbidities, shock upon admission, preoperative metabolic acidosis, acute renal failure, and preoperative delay exceeding 24 h [4,10]. However, most of the existing literature is derived from high-income countries with well-resourced healthcare systems, creating a significant knowledge gap regarding PPU outcomes in conflict-affected, resource-limited settings [11,12].

Yemen, currently experiencing one of the world's most severe humanitarian crises, presents unique challenges to surgical care delivery. Ongoing conflicts have resulted in over 50% of health facilities being non-functional or partially functional, creating significant obstacles for emergency surgical care [13]. This resource scarcity, delayed patient presentation, and disrupted healthcare infrastructure necessitate localized research to understand the specific effects on surgical outcomes and to develop appropriate intervention strategies [14].

Yemen's ongoing humanitarian crisis has created unique demographic and clinical patterns that may differ significantly from the PPU populations described in international literature. The predominantly young male population seeking emergency surgical care, combined with limited healthcare infrastructure and delayed presentation patterns, creates a distinct clinical context that may limit the generalizability of our findings to other settings. Understanding these contextual factors is essential for interpreting outcomes and their potential applicability in other healthcare environments. The extreme demographic skew observed in this setting may reflect sociocultural factors, including gender-based healthcare access patterns, occupational risk factors, and substance use behaviors, such as khat chewing, which is prevalent among Yemeni men.

This study aimed to determine the 30-day morbidity and mortality rates following surgical intervention for PPU in this specific population from conflict-affected Yemen and to identify predictors of adverse outcomes within this unique healthcare environment. The findings should be interpreted within the context of this specific population and setting, with appropriate consideration of their limited generalizability to other demographic groups and healthcare systems

2. Materials and Methods

2.1. Study Design and Setting

We conducted a prospective, multicenter observational study to assess 30-day morbidity and mortality outcomes following surgical intervention for PPU. This study was performed across four major governmental tertiary hospitals in Sana'a, Yemen: Al-Thawra Modern General Hospital, 48 Model Hospital, Al-Kuwait University Hospital, and Al-Gumhori Teaching Hospital. These centers were selected based on their high volume of PPU cases and status as referral hubs, ensuring a representative sample of the target population within the constraints of the conflict-affected health care system.

2.2. Study Context and Population Characteristics

This study was conducted in the context of Yemen's ongoing humanitarian crisis, which has significantly affected healthcare delivery and population demographics seeking emergency care. The study population characteristics reflect several contextual factors that are important for interpreting

the results and their generalizability. The predominance of young male patients may be attributed to the cultural patterns of healthcare-seeking behavior, occupational risk factors, and substance use patterns, including khat chewing, which is prevalent among Yemeni men. Gender-based disparities in healthcare access, potentially exacerbated by ongoing conflicts, may also contribute to the observed demographic patterns.

The exclusive use of open surgical techniques reflects resource constraints rather than surgical preference, as laparoscopic equipment and expertise are not consistently available across the participating centers. This limitation is representative of many resource-limited settings but differs significantly from contemporary surgical practice in high-income countries where laparoscopic approaches are increasingly utilized. The conflict-affected setting also introduces unique factors, including delayed presentation owing to transportation barriers, security concerns, and limited healthcare access, which may not be applicable to other healthcare environments.

2.3. Study Population and Sampling

The study population comprised of all adult patients (aged ≥ 18 years) diagnosed with PPU who underwent surgical treatment at participating hospitals between February 2023 and February 2024. The inclusion criteria were as follows: age ≥ 18 years; confirmed PPU diagnosis based on clinical presentation, imaging, or intraoperative findings; and patients who underwent surgical intervention for PPU. Exclusion criteria included patients younger than 18 years, those with non-perforated peptic ulcers or alternative causes of acute abdomen, those managed non-operatively, those with incomplete medical records, or those lost to 30-day follow-up.

The sample size calculation was based on the estimation of the 30-day mortality rate with sufficient precision. Using an expected mortality rate of 12.5% based on the literature from low- and middle-income countries [2,3], 95% confidence level, and 5% margin of error, the calculated sample size was 97 patients for a finite population of approximately 150 PPU cases annually. To account for potential loss to follow-up and to enhance statistical power, the target was increased to 100-110 patients, achieving a final sample of 108 patients.

2.4. Data Collection and Variables

Data were prospectively collected using a standardized data-collection instrument that captured patient demographics, presurgical clinical parameters, surgical details, and 30-day outcomes. Data collection was performed by trained surgical residents at each participating center using standardized data collection forms, with consultant oversight for the verification of key variables. Regular meetings were held among investigators to discuss challenging cases and maintain consistency in data interpretation, although some inter-observer variability may have occurred because of the multicenter nature of the study and resource constraints.

Key variables included the presence of shock on admission, defined as a systolic blood pressure < 90 mmHg or clinical signs of hypoperfusion. Clinical signs of hypoperfusion were defined as altered mental status, delayed capillary refill (> 2 s), cold extremities, or oliguria (< 0.5 mL/kg/hr). While efforts were made to standardize these assessments across participating centers through investigator meetings, some inter-observer variability may have occurred. Acute kidney injury (AKI) was defined according to the KDIGO criteria [15], delayed presentation was measured as the time from symptom onset to hospital presentation, and NSAID use was defined as use within 30 days prior to presentation.

The primary outcomes were 30-day mortality (death within 30 days post-surgery) and 30-day morbidity (postoperative complications graded according to the Clavien-Dindo classification [16]). Follow-up was conducted for 30 days via hospital visits or telephone interviews. Data were recorded by trained surgical residents and verified by consultants to ensure accuracy.

2.5. Statistical Analysis

Continuous variables were summarized using means and standard deviations or medians and interquartile ranges depending on the distribution. Categorical variables are reported as frequencies and percentages. Univariate analyses using chi-square tests and t-tests were used to explore the associations between predictors and outcomes.

Multivariate logistic regression was performed to identify independent predictors, with special attention paid to the complete separation of the mortality predictors observed in this dataset. Given the observational nature of the study and the potential for unmeasured confounding factors, causal inferences are limited. The complete separation observed for certain variables prevents traditional multivariate modeling for mortality outcomes, as standard logistic regression cannot provide meaningful estimates when perfect separation occurs. Sensitivity analyses were considered but were not feasible because of the small number of events and the complete separation phenomenon.

Statistical significance was defined as $p < 0.05$, and analyses were performed using the SPSS software. The complete separation phenomenon is recognized as a statistical finding that requires careful interpretation and validation in larger datasets before clinical application.

2.6. Ethical Considerations

The study protocol was reviewed and approved by the Ethics Committee of the Faculty of Medicine and Health Sciences, Sana’a University, Sana’a, Yemen. Additional administrative approval was obtained from the ethics committees of all the participating hospitals. This study was conducted in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants or their legal guardians included in the study.

3. Results

3.1. Patient Demographics and Clinical Characteristics

A total of 108 patients were included in this multicenter study, revealing a cohort with distinctive demographic and clinical characteristics that fundamentally shaped the surgical outcomes and must be considered when interpreting the generalizability of the findings (Table 1). The patients demonstrated a mean age of 39.6 ± 17.3 years (range 18-80 years), with a striking male predominance of 105 patients (97.2%) versus 3 females (2.8%), resulting in a male-to-female ratio of 35:1. This extreme gender imbalance represents a significant departure from PPU demographics reported in the international literature and reflects the unique sociocultural context of this conflict-affected setting.

The clinical presentation revealed a population at substantial risk, with NSAID use representing the most prevalent risk factor in 78 patients (72.2%), far exceeding the rates reported in most international studies. This high prevalence of NSAID use may reflect both cultural patterns of medication use and limited access to alternative pain management strategies in conflict-affected settings. Regarding smoking patterns, 45 (41.7%) patients were current smokers, 15 (13.9%) were ex-smokers, and 48 (44.4%) had never smoked.

On admission, 36 patients (33.3%) presented with hemodynamic shock, immediately identifying a high-risk subset that required intensive intervention. The ASA score distribution demonstrated the physiological burden of disease, with 45 patients (41.7%) classified as ASA I, 30 patients (27.8%) as ASA II, 18 patients (16.7%) as ASA III, and 15 patients (13.9%) as ASA IV (Table 1).

Table 1. Patient Demographics and Clinical Characteristics (N=108).

Characteristic	Value	Percentage
Gender		
Male	105	97.2%
Female	3	2.8%

Age (years), mean ± SD	39.6 ± 17.3	--
Comorbidities		
Hypertension	15	13.9%
Ischemic heart disease	9	8.3%
Diabetes	3	2.8%
COPD	3	2.8%
NSAID use, n (%)	78	72.2%
Smoking status		
Never smoked	48	44.4%
Current smokers	45	41.7%
Ex-smokers	15	13.9%
ASA Score		
ASA I	45	41.7%
ASA II	30	27.8%
ASA III	18	16.7%
ASA IV	15	13.9%
Clinical Presentation		
Shock on admission	36	33.3%
Acute Kidney Injury, n (%)	30	27.8%
Time to presentation (hours)	34.9 ± 32.1	--
Laboratory Values		
	Mean ± SD	Range
Hemoglobin (g/dL)	14.0 ± 2.1	9.0 - 18.7
WCC (×10 ³ /μL)	13.8 ± 6.1	2.0 - 27.0
CRP (mg/L)	78.3 ± 76.2	2.0 - 255.0
Creatinine (μmol/L)	109.3 ± 71.6	26.5 - 400.0
Urea (mmol/L)	8.6 ± 7.3	0.5 - 32.4

One SD, standard deviation; NSAID, non-steroidal anti-inflammatory drug; ASA, American Society of Anesthesiologists.

The temporal patterns of presentation revealed significant delays in seeking medical care, with a mean time from symptom onset to hospital presentation of 34.9 ± 32.1 hours (range 3-122 hours). This delay pattern reflects the complex challenges of accessing healthcare in conflict-affected settings where transportation barriers, security concerns, and resource limitations create substantial obstacles for timely intervention. Acute kidney injury at presentation occurred in 30 patients (27.8%), representing a critical marker of systemic physiological compromise (Figure 1).

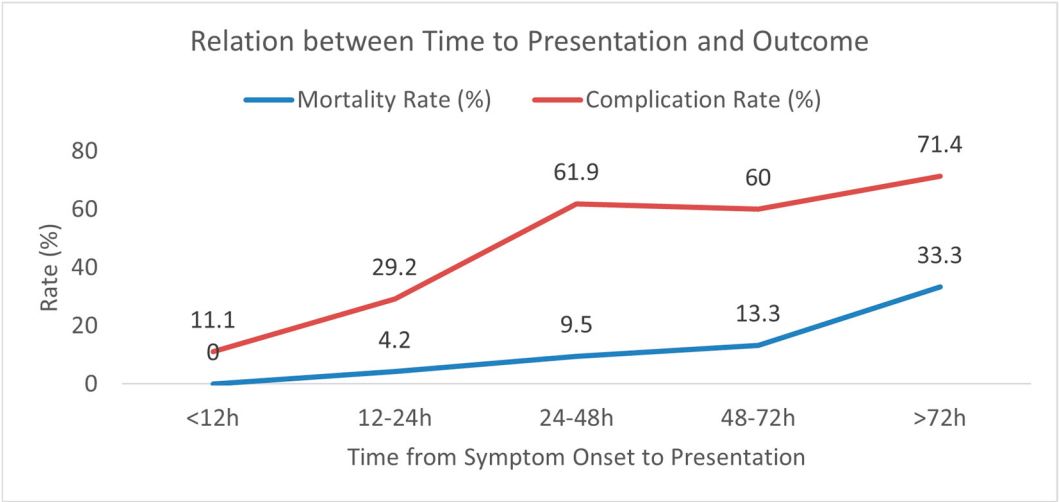


Figure 1. Relationship between Time to Presentation and Outcomes.

3.2. Surgical Characteristics

Surgical management was uniformly approached using open techniques, with all 108 patients (100%) undergoing open surgical repair and no laparoscopic procedures. This exclusive use of open surgery reflects resource constraints and equipment limitations rather than surgical preference and represents an important contextual factor that limits comparison with contemporary surgical outcomes in high-resource settings. The duodenum was the most common site of perforation in 84 patients (77.8%), followed by the antrum in 24 patients (22.2%), with a mean perforation diameter of 1.0 ± 0.6 cm.

The predominant surgical technique was suture repair with omentopexy in 102 patients (94.4%), followed by Graham patch repair in three patients (2.8%), and suture repair without omentopexy in three patients (2.8%). The mean operative time was 91.7 ± 25.4 minutes, reflecting the complexity of cases and surgical approach utilized (Table 2).

Table 2. Surgical Characteristics of the Study Population.

Characteristic	Value	Percentage
Ulcer Location		
Duodenum	84	77.8%
Antrum	24	22.2%
Perforation Diameter (cm)		
Mean $\pm$ SD	1.07 ± 0.58	--
≤ 0.5 cm	27	25.0%
0.6-1.0 cm	42	38.9%
1.1-1.5 cm	18	16.7%
1.6-2.0 cm	21	19.4%
Surgical Technique		
Suture repair with omentopexy	102	94.4%
Graham patch	3	2.8%
Suture repair without omentopexy	3	2.8%
Operating Time (minutes)		
Mean $\pm$ SD	91.5 ± 28.5	--
Time to Surgery (hours)		
Mean $\pm$ SD	8.8 ± 11.8	--

SD = Standard Deviation.

3.3. Primary Outcomes

The primary outcomes revealed substantial morbidity and mortality burdens, with an overall 30-day mortality rate of 11.1% (12/108 patients) and 30-day morbidity rate of 44.4% (48/108 patients). Only three patients (2.8%) required reoperation within 30 days, suggesting that surgical intervention was generally definitive when successful. The mean hospital stay was 7.8 ± 5.6 days (range 1-30 days, median 6.0 days) (Table 3).

According to the Clavien-Dindo classification, 60 patients (55.6%) experienced no complications (grade 0), 18 patients (16.7%) had Grade I complications, 15 patients (13.9%) had Grade II complications, 3 patients (2.8%) had Grade IIIa complications, and 12 patients (11.1%) had Grade V complications (death).

Table 3. Patient Outcomes and Clavien-Dindo Classification (N=108).

Outcome	Value	Percentage
Mortality by Age Group		
<40 years	3/63	4.8%
40-60 years	3/30	10.0%
>60 years	6/15	40.0%

Mortality by ASA Score		
ASA I	3/45	6.7%
ASA II	0/24	0.0%
ASA III	3/21	14.3%
ASA IV	6/18	33.3%
Mortality by Shock Status		
Shock - Yes	12/36	33.3%
Shock - No	0/72	0.0%
30-Day Morbidity	48	44.4%
Types of Complications		
Wound Related	18	16.7%
Chest Related	18	16.7%
GI Leak	9	8.3%
Septic Shock	3	2.8%
Clavien-Dindo Classification		
Grade 0	60	55.6%
Grade I	18	16.7%
Grade II	15	13.9%
Grade IIIa	3	2.8%
Grade V	12	11.1%
30-day Reoperation	3	2.8%
Length of Stay (days)		
Mean ± SD	7.8 ± 5.6	--
Range	1-30	--

SD, standard deviation; NSAID, non-steroidal anti-inflammatory drug; ASA, American Society of Anesthesiologists.

3.4. Risk Factor Analysis

The risk factor analysis revealed that patients who died were significantly older than survivors (60.0 ± 16.9 years vs. 37.1 ± 15.6 years, p<0.001), and higher ASA scores were strongly associated with increased mortality (p<0.001). The mortality rates according to ASA classification demonstrated a clear gradient: ASA I, 6.7%; ASA II, 0%; ASA III, 16.7%; and ASA IV, 40.0%. Patients who died had significantly longer symptom duration before hospital presentation compared to survivors (79.5 ± 46.9 hours vs. 29.3 ± 24.9 hours, p<0.001), emphasizing the critical importance of early intervention (Table 4).

Table 4. Factors Associated with 30-Day Mortality (N=108).

Factor	Died (n=12)	Survived (n=96)	P-value
Age (years)	60.0 ± 16.9	37.1 ± 15.6	<0.001
Shock on admission	12 (100%)	24 (25.0%)	<0.001*
ASA score ≥ III	9 (75.0%)	24 (25.0%)	<0.001
NSAID use	12 (100%)	66 (68.8%)	0.034*
Acute Kidney Injury	12 (100%)	18 (18.8%)	<0.001*
Time to presentation (hours)	79.5 ± 46.9	29.3 ± 24.9	<0.001
Urea (mmol/L)	22.1 ± 8.5	6.9 ± 5.0	<0.001
Perforation diameter (cm)	0.9 ± 0.2	1.0 ± 0.7	0.425

* Data are presented as mean ± SD or n (%). Complete separation was observed.

For complications, the analysis revealed that patients who developed adverse outcomes were significantly older (46.5 ± 17.5 years vs. 34.1 ± 14.7 years, p<0.001). Shock on admission was strongly associated with complications, occurring in 83.3% of shocked patients compared with 25.0% of non-shocked patients (p<0.001). Acute kidney injury was significantly associated with complications, with

80.0% of AKI patients developing complications compared to 30.8% of non-AKI patients (p<0.001) (Table 5).

Table 5. Factors Associated with 30-Day Complications (N=108).

Factor	Complication (n=48)	No Complication (n=60)	p-value
Age (years)	46.5 ± 19.5	34.1 ± 13.2	<0.001
Shock on admission	30 (62.5%)	6 (10.0%)	<0.001
ASA score ≥ III	18 (37.5%)	15 (25.0%)	0.096
NSAID use	36 (75.0%)	42 (70.0%)	0.667
Acute Kidney Injury	24 (50.0%)	6 (10.0%)	<0.001
Time to presentation (hours)	50.7 ± 38.9	22.3 ± 17.6	<0.001
Urea (mmol/L)	11.9 ± 8.6	6.0 ± 4.7	<0.001
Operating time (minutes)	93.8 ± 26.1	90.0 ± 24.9	0.425

3.5. Complete Separation Phenomenon

A notable finding was the complete separation of mortality outcomes based on the specific risk factors. All 12 deaths (100%) occurred in patients who presented with shock on admission, whereas no deaths occurred in 72 patients who were hemodynamically stable (p<0.001). This complete separation extended to acute kidney injury, where all 12 deaths occurred in patients with AKI at presentation (representing a 40.0% mortality rate among AKI patients versus 0% among those without AKI, p<0.001). Additionally, all 12 deaths occurred in patients with a history of NSAID use, whereas no deaths occurred in 30 patients without NSAID exposure (p=0.034).

This complete separation, which is statistically significant in our sample, requires careful interpretation. This finding was based on a relatively small number of events (n=12) and could potentially change with additional cases. The observed pattern identifies a phenotype associated with an extremely high mortality risk in our setting, but the deterministic nature of this association should be viewed with appropriate statistical caution.

The observed complete separation should be interpreted with appropriate statistical caution, given the small sample size. This finding was based on 12 mortality events, and the addition of one or two cases with different characteristics could alter this pattern. Although the clinical message that patients with shock and acute kidney injury represent an extremely high-risk group is valid and clinically useful, the deterministic nature of this association requires confirmation in larger, more diverse populations before being considered a universal clinical rule.

3.6. Multivariate Analysis

Multivariate analysis is fundamentally shaped by the complete separation phenomenon, which creates both statistical challenges and clinical insights. Traditional multivariate logistic regression for mortality prediction is limited by the complete separation of mortality predictors, as standard logistic regression cannot provide meaningful estimates when perfect separation occurs. In a simplified model focusing on variables that did not exhibit complete separation, age emerged as the only variable amenable to conventional modeling, with each additional year of age associated with an 8% increase in mortality risk (OR 1.08, 95% CI 1.04-1.13, p<0.001) (Table 6).

For morbidity prediction, multivariate analysis identified shock on admission as the strongest independent predictor (OR 9.38, 95% CI 2.73-32.26, p<0.001), representing nearly a 10-fold increase in complication risk. Age remained an independent predictor, with each additional year being associated with a 4% increase in complication risk (OR 1.04, 95% CI 1.00-1.07, p=0.033). Delayed presentation was independently associated with increased complication risk, with each additional hour of delay associated with a 3% increase in risk (OR 1.03, 95% CI 1.01-1.05, p=0.004) (Table 6).

Table 6. Multivariate logistic regression analysis for mortality and morbidity.

Predictor of 30-Day Mortality	OR	95% CI	P-value
Age (per year)	1.08	1.04-1.13	<0.001
Shock on admission	*	*	<0.001
Acute Kidney Injury	*	*	<0.001
Predictor of 30-Day Morbidity	OR	95% CI	P-value
Age (per year)	1.04	1.00-1.07	0.033
Shock on admission	9.38	2.73-32.26	<0.001
Acute Kidney Injury	0.85	0.16-4.38	0.843
Urea (per mmol/L)	1.08	0.97-1.21	0.177
Time to presentation (hr)	1.03	1.01-1.05	0.004

OR, Odds Ratio; CI = Confidence Interval; * = Complete separation observed; preventing conventional odds ratio calculation.

4. Discussion

This prospective multicenter study offers rare and critical insight into the outcomes of perforated peptic ulcer (PPU) surgery in the unique context of conflict-affected Yemen. Our findings revealed substantial 30-day mortality (11.1%) and morbidity (44.4%) rates in a strikingly young predominantly male population. The most significant discovery was the complete separation of mortality outcomes, which identified a phenotype of patients—those presenting with shock and acute kidney injury (AKI)—for whom mortality was absolute in our resource-limited setting. These findings, while requiring cautious interpretation, provide a framework for risk stratification and highlight the profound impact of socioeconomic and healthcare system collapses on surgical outcomes.

The complete separation of mortality based on the presence of shock and AKI is the most profound clinical finding [18]. All 12 deaths occurred in patients exhibiting this combination, suggesting the existence of an irreversible physiological tipping point beyond which rescue is nearly impossible with available resources. We hypothesize that this triad, likely initiated by a large NSAID-induced perforation leading to profound septic shock and subsequent AKI, marks the onset of fulminant multi-organ dysfunction syndrome. In the absence of advanced critical care such as continuous renal replacement therapy and sophisticated hemodynamic support, this cascade becomes unmanageable. This reframes the finding not merely as a collection of risk factors but also as a terminal pathophysiological state. While this observation is based on a small number of events and requires validation in larger cohorts, it has immediate clinical utility for prognostication, patient counseling, and resource allocation in similar settings [4,5].

Our cohort’s demographic profile—97.2% male with a mean age of 39.6 years—deviates sharply from the global PPU literature, which typically describes older patients with a more balanced sex distribution [4,9]. This extreme skew is likely explained by the sociocultural factors unique to Yemen. Widespread khat chewing, a prolonged daily social practice that is almost exclusive to men, is associated with dental and gum pain. This appears to drive the remarkably high prevalence of over-the-counter NSAID use (72.2%) as a coping mechanism, providing a direct mechanistic link between sex, cultural practice, and PPU etiology [1,19]. This hypothesis explains both the male predominance and relative rarity of PPU in Yemeni women, who engage in this practice far less. This distinct etiological pathway underscores that our findings are most applicable to young male populations in similar cultural and resource-limited contexts.

Delayed presentation was a powerful independent predictor of morbidity and was significantly longer in patients who died (79.5 h) than in those who survived (29.3 h). This aligns with established evidence that treatment delay is a critical determinant of adverse outcomes in PPU [10,17]. In our setting, this is not simply a patient-level factor but a direct consequence of the multifaceted humanitarian crisis. The collapse of the national health system and infrastructure creates immense barriers to access [13,14]. Financial toxicity, damaged transportation routes, and security concerns

force patients to endure symptoms at home, critically prolonging the duration of untreated peritonitis and fueling the high rates of septic shock and mortality observed [20].

Despite these immense challenges, our overall 30-day mortality rate of 11.1% is comparable to, or even more favorable than, the rates reported from other low- and middle-income countries (10-30%) [11,21] and falls within the range of some high-income country reports (5-15%) [2,6]. This might be partially attributable to the younger age of our cohort, which lacks the high comorbidity burden of typical elderly patients with PPU. Furthermore, the exclusive use of open surgery, while reflecting resource constraints, demonstrates that traditional techniques such as suture repair with omentopexy (94.4%) can yield acceptable outcomes. Our 44.4% morbidity rate, rigorously assessed using the Clavien-Dindo classification, aligns with contemporary international figures [5,17,19], suggesting that while the context is unique, the spectrum of postoperative complications is universal.

This study had several important limitations. Its primary weakness is the limited external validity due to its unique demographic profile; these findings cannot be readily extrapolated to female or elderly patients. Second, the absence of data on *H. pylori* status, a fundamental etiological factor, represents a significant unmeasured confounder. Third, despite standardization efforts, the observational design and potential for measurement bias across multiple centers precludes causal inference. Finally, the “complete separation” finding, while compelling, is based on a small number of fatalities and requires urgent validation [18].

Future research should focus on validating this high-risk phenotype in larger and more diverse populations. Comparative studies between conflict-affected and stable low-resource settings could help to isolate the specific impact of conflict on outcomes. Critically, future prospective studies must incorporate testing for *H. pylori* and explore the sociocultural drivers of NSAID use to inform targeted public health interventions aimed at its prevention.

5. Conclusions

Surgery for perforated peptic ulcers in the young male population of conflict-affected Yemen is associated with substantial morbidity and mortality. Our study identified a clinically powerful, high-risk phenotype, the combination of shock and acute kidney injury, which was universally fatal in our setting, a finding that can immediately inform risk stratification while awaiting larger validation. The unique demographic and etiological patterns, driven by sociocultural factors such as khat chewing and high NSAID use and exacerbated by conflict-driven delays in presentation, define the challenging landscape of surgical care in this environment. These findings underscore the resilience of surgical teams to achieve acceptable outcomes with basic techniques, but also highlight the urgent need for strengthening the health system and public health interventions to mitigate preventable risk factors and improve access to timely care.

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Institutional Review Board Statement: The study was conducted in accordance with the guidelines of the Declaration of Helsinki and was approved by the Ethics Committee of the Faculty of Medicine and Health Sciences, Sana’a University, Sana’a, Yemen. Additional approval was obtained from the ethics committees of all participating hospitals: Al-Thawra Modern General Hospital, 48 Model Hospital, Al-Kuwait University Hospital, and Al-Gumhori Teaching Hospital.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study. Written informed consent was obtained from all participants or their legal guardians before inclusion in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author owing to privacy and ethical restrictions related to patient confidentiality in the conflict-affected setting. Requests for data access should include details of the intended use and appropriate ethical approval.

Conflicts of Interest: The authors declare that they have no conflict of interest.

Abbreviations

The following abbreviations are used in this manuscript:

AKI	Acute Kidney Injury
ASA	American Society of Anaesthesiologists
CI	Confidence Interval
COPD	Chronic Obstructive Pulmonary Disease
CRP	C-Reactive Protein
GI	Gastrointestinal
KDIGO	Kidney Disease: Improving Global Outcomes
NSAID	Nonsteroidal Anti-Inflammatory Drug
OR	Odds Ratio
PPU	Perforated Peptic Ulcer
PULP	Peptic Ulcer Perforation
SD	Standard Deviation
WCC	White Cell Count

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