



CLINICAL OUTCOMES OF STEP-UP VERSUS OPEN NECROSECTOMY IN SEVERE NECROTIZING PANCREATITIS: A RETROSPECTIVE OBSERVATIONAL COHORT STUDY

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ABSTRACT

Background & Aims: The management of infected pancreatic necrosis has evolved from primary open necrosectomy (ON) to a step-up approach (SUA) encompassing percutaneous drainage followed, if needed, by minimally invasive necrosectomy. While randomized trials established SUA's superiority, real-world outcomes in contemporary, non-trial settings require further evaluation. This study compares clinical outcomes of SUA versus ON in a tertiary care center.

Methods: A retrospective observational cohort study was conducted on consecutive patients with confirmed infected necrotizing pancreatitis admitted between January 2020 and September 2024. Patients were categorized into the SUA group (initial percutaneous or endoscopic drainage) or the ON group (primary surgical necrosectomy). Primary outcome was a composite of major complications (new-onset organ failure, bleeding, enteric fistula, or death) within 90 days. Secondary outcomes included individual complications, hospital length of stay (LOS), and need for re-interventions.

Results: Of 112 included patients, 68 underwent SUA and 44 underwent ON. The groups were comparable in baseline severity (APACHE-II, CT severity index). The primary composite outcome occurred in 22 patients (32.4%) in the SUA group versus 28 patients (63.6%) in the ON group ($p=0.001$). New-onset multi-organ failure (20.6% vs. 43.2%, $p=0.01$) and enteric fistulae (4.4% vs. 20.5%, $p=0.008$) were significantly lower in the SUA group. Mortality was 10.3% (SUA) vs. 22.7% (ON) ($p=0.08$). Median hospital LOS was 42 days (SUA) vs. 58 days (ON) ($p=0.02$). Re-intervention rates were not significantly different.

Conclusion: In this real-world observational study, the step-up approach was associated with a significantly lower rate of major complications and a shorter hospital stay compared to primary open necrosectomy. These findings reinforce SUA as the standard of care for managing infected pancreatic necrosis in contemporary clinical practice.

Keywords: Necrotizing Pancreatitis, Step-Up Approach, Open Necrosectomy, Infected Necrosis, Outcomes.

INTRODUCTION

Severe acute pancreatitis (SAP) represents the most formidable spectrum of a common gastroenterological emergency, with pancreatic necrosis developing in approximately 15-20% of cases [1]. The subsequent infection of necrotic tissue, occurring in about one-third of these patients, marks a critical inflection point, escalating mortality rates historically to between 30-40% and

imposing a substantial burden on healthcare systems due to prolonged, complex hospitalizations [2, 3]. The central challenge in managing infected necrotizing pancreatitis (INP) has long been the timely and effective removal of infected devitalized tissue while minimizing iatrogenic injury and systemic inflammatory insult.

The management paradigm has undergone a radical evolution over the past two decades. Primary open surgical necrosectomy (ON), once the unchallenged standard, involved extensive laparotomy and direct manual debridement. Despite its definitive intent, it was associated with profound morbidity, including high rates of enteric fistula (up to 40%), incisional hernia, and new-onset organ failure, with mortality often exceeding 20% [4, 5]. This recognition of "surgical trauma on top of disease" catalyzed the search for less invasive alternatives.

The conceptual breakthrough arrived with the "step-up approach" (SUA), a paradigm centered on the principle of damage control. Pioneered in the landmark PANTER trial (2010), SUA mandates initial percutaneous or endoscopic drainage to control sepsis, followed by minimally invasive necrosectomy (e.g., video-assisted retroperitoneal debridement [VARD] or endoscopic transluminal necrosectomy) only if clinical improvement is inadequate [6]. This strategy demonstrated a dramatic reduction in major complications and death compared to primary ON. Subsequent trials, including the TENSION trial focusing on endoscopic versus surgical step-up, have further refined the algorithm, solidifying SUA's role in international guidelines [7, 8].

However, a critical knowledge gap persists between the controlled environment of randomized clinical trials (RCTs) and the nuanced reality of daily clinical practice. Real-world application involves heterogeneous patient populations, varying levels of endoscopic and surgical expertise, and complex decision-making in dynamic critical care settings. Furthermore, primary ON remains a necessary intervention for patients presenting with catastrophic abdominal compartment syndrome, massive hemorrhage, or bowel ischemia, and for those in whom minimally invasive techniques fail or are not available [9]. Therefore, continuous observational evaluation is essential to validate trial findings, assess generalizability, and identify subgroups that may still benefit from or require open surgery. This retrospective observational cohort study, conducted and analyzed in October 2024, aims to provide a contemporary, real-world comparison of clinical outcomes between the step-up approach and primary open necrosectomy in a high-volume tertiary referral center.

MATERIALS AND METHODS

Study Design and Setting

This study was conducted at a high-volume tertiary referral center specializing in gastrointestinal and hepatobiliary surgery. The institution receives referrals for complex pancreatitis cases from surrounding districts, ensuring a diverse patient population. A total of **112 patients** diagnosed with severe necrotizing pancreatitis who required interventional management during the study period were included. Ethical approval was obtained from the institutional review board, and the study adhered to the principles of the Declaration of Helsinki

Patient Selection

Consecutive adult patients (≥ 18 years) admitted between January 1, 2020, and September 30, 2024, with a diagnosis of severe acute pancreatitis with confirmed infected pancreatic or peripancreatic necrosis were screened.

Inclusion Criteria:

- 1) Adults aged ≥ 18 years.
- 2) Diagnosis per Revised Atlanta Classification [10]
- 3) Confirmed infected necrosis (by positive gram stain/culture from image-guided fine-needle aspiration or presence of gas within necrosis on CT)
- 4) Underwent either SUA or ON as primary intervention strategy.

Exclusion Criteria:

- 1) Pancreatic abscess or infected pseudocyst without necrosis;
- 2) Interval debridement >4 weeks after initial drainage for SUA (to ensure distinct strategies)
- 3) Incomplete medical records.

Intervention Groups

- **Step-Up Approach (SUA) Group:** Management began with image-guided percutaneous catheter drainage (PCD) or endoscopic transluminal drainage. Minimally invasive step-up procedures (video-assisted retroperitoneal debridement [VARD] or endoscopic necrosectomy) were performed if there was inadequate clinical improvement after drainage. Open surgery was reserved for failure of the step-up protocol.
 - **Open Necrosectomy (ON) Group:** Patients underwent primary open surgical necrosectomy via a transperitoneal or retroperitoneal approach as the initial invasive intervention.
- The choice of strategy was at the discretion of the treating multidisciplinary team, based on clinical status, anatomical location of necrosis, and evolving institutional protocols favoring SUA over time.

Outcome Measures

- **Primary Outcome:** Composite of major complications within 90 days of intervention, including new-onset/or worsening organ failure (modified Marshall score ≥ 2), major bleeding requiring intervention, development of enteric or pancreatic fistula, or death from any cause.
- **Secondary Outcomes:** Individual components of the primary outcome, intensive care unit (ICU) length of stay, total hospital length of stay (LOS), number of radiological and surgical interventions, incidence of pancreatic endocrine/exocrine insufficiency at discharge, and hospital readmission within 90 days.

Data Collection

Data extraction was performed by a team of two independent researchers using a pre-piloted, standardized electronic case report form (eCRF) designed in REDCap (Research Electronic Data Capture) to ensure data integrity and consistency^[11]. Discrepancies were resolved by consensus or adjudication by a senior principal investigator. The data collection process was rigorous and encompassed the following domains:

1. **Demographics & Baseline Clinical Data:** Age, sex, body mass index (BMI), etiology of pancreatitis, admission date, and vital signs.
2. **Disease Severity Scores:** Calculated scores at admission and prior to first intervention, including APACHE-II, Sequential Organ Failure Assessment (SOFA), and Bedside Index for Severity in Acute Pancreatitis (BISAP). The CT Severity Index (CTSI) and Modified CTSI scores were calculated from the first contrast-enhanced CT scan confirming necrosis^[12].
3. **Microbiological Data:** Results of all cultures (blood, drainage fluid, necrosectomy specimens), including antibiotic susceptibility profiles.
4. **Intervention Details:** For all patients, we recorded the type, date, and details of every invasive procedure (PCD, endoscopic drainage/necrosectomy, VARD, ON). For surgeries, we documented the surgical approach, estimated blood loss, and intraoperative complications.
5. **Outcome Tracking:** Daily monitoring for organ failure (cardiovascular, renal, respiratory), documented bleeding events, and development of fistulae (confirmed by imaging or drain output). Discharge summaries and 90-day follow-up clinic notes were reviewed to capture post-discharge complications, readmissions, and mortality.
6. **Quality Control:** A 10% random sample of records was audited by an independent clinician to verify data accuracy. Key variable definitions (e.g., "major bleeding," "organ failure") were strictly aligned with established consensus definitions from the Revised Atlanta and Determinant-Based Classifications to minimize subjectivity^[10, 13].

STATISTICAL ANALYSIS

Data were analyzed using SPSS version 29.0. Categorical variables were reported as counts (%) and compared using Chi-square or Fisher's exact test. Continuous variables were expressed as median (interquartile range, IQR) and compared using the Mann-Whitney U test due to non-normal distribution. To adjust for potential confounders in this non-randomized study, a propensity score-matched analysis was performed using logistic regression to estimate the probability of receiving ON based on age, APACHE-II score, CTSI, and timing of intervention. Patients were matched 1:1 using nearest-neighbor matching with a caliper of 0.2 standard deviations. Outcomes were compared in the matched cohort using conditional logistic regression for binary outcomes. A p-value <0.05 was considered statistically significant.

RESULTS

Baseline Characteristics

After screening 145 patients, 112 met the inclusion criteria (68 SUA, 44 ON). The most common reason for exclusion was sterile necrosis. Baseline characteristics before matching are shown in Table 1. The groups were well-matched in age, etiology, and disease severity scores (APACHE-II, CTSI), indicating comparable illness severity at presentation.

Table 1: Baseline Patient Characteristics

Characteristic	Step-Up Approach (n=68)	Open Necrosectomy (n=44)	p-value
Age, years (median, IQR)	52 (44-63)	55 (47-65)	0.32
Male, n (%)	42 (61.8%)	28 (63.6%)	0.84
Etiology: Gallstone, n (%)	38 (55.9%)	27 (61.4%)	0.56
APACHE-II (median, IQR)	12 (8-16)	13 (9-17)	0.41
CTSI (median, IQR)	8 (7-9)	8 (7-10)	0.28
Time to intervention, days	28 (21-35)	24 (18-30)	0.09

Primary and Secondary Outcomes

The results are summarized in Table 2. The primary composite outcome of major complications occurred significantly less often in the SUA group (32.4% vs. 63.6%, p=0.001). This difference was driven predominantly by lower rates of new-onset multi-organ failure (20.6% vs. 43.2%) and enteric fistula (4.4% vs. 20.5%). The mortality difference (10.3% vs. 22.7%) showed a strong trend but did not reach statistical significance (p=0.08).

Patients in the SUA group had a significantly shorter median total hospital LOS (42 vs. 58 days, p=0.02). The number of re-interventions per patient was similar between groups. Propensity score-matched analysis (40 pairs) confirmed these findings, with the SUA group maintaining a significant advantage in the composite outcome (OR: 0.35, 95% CI: 0.14-0.82, p=0.01).

Table 2: Clinical Outcomes

Outcome	Step-Up Approach (n=68)	Open Necrosectomy (n=44)	p-value
Primary Composite Outcome, n (%)	22 (32.4%)	28 (63.6%)	0.001

New-onset MOF, n (%)	14 (20.6%)	19 (43.2%)	0.01
Major Bleeding, n (%)	5 (7.4%)	6 (13.6%)	0.27
Enteric Fistula, n (%)	3 (4.4%)	9 (20.5%)	0.008
Death, n (%)	7 (10.3%)	10 (22.7%)	0.08
Hospital LOS, days (median, IQR)	42 (32-65)	58 (41-84)	0.02
ICU LOS, days (median, IQR)	10 (5-21)	18 (8-30)	0.06
Re-interventions (median, IQR)	3 (2-5)	2 (1-4)	0.15

DISCUSSION

This real-world observational study confirms the sustained superiority of the step-up approach over primary open necrosectomy in the management of infected necrotizing pancreatitis, echoing the seminal findings of the PANTER trial over a decade later [6]. Our data demonstrate that SUA is associated with an almost 50% relative reduction in the rate of major complications and a significantly shorter hospital stay.

The significant reduction in new-onset multi-organ failure with SUA (20.6% vs. 43.2%) is a critical finding. ON, as a major abdominal procedure, incites a profound systemic inflammatory response in already critically ill patients, potentially tipping them into irreversible organ dysfunction [14]. SUA, by starting with less invasive drainage, effectively reduces the septic burden while avoiding the surgical stress of a large laparotomy, thereby protecting marginal organ function.

The dramatic reduction in enteric fistulae (4.4% vs. 20.5%) directly reflects the anatomic advantage of minimally invasive techniques. ON often requires dissection through inflamed tissue planes, risking injury to the transverse colon or small bowel. In contrast, percutaneous and endoscopic routes access the necrosis more directly, largely bypassing healthy viscera [7].

While our study showed a strong trend towards reduced mortality with SUA (10.3% vs. 22.7%), it did not reach statistical significance, likely due to the sample size. However, the significant reduction in "morbidity burden" (composite outcome, organ failure, fistulae, LOS) is itself a paramount goal, as it reduces long-term disability and healthcare costs.

Strengths & Limitations: Strengths include contemporary data, detailed outcome tracking, use of propensity scoring to mitigate selection bias, and adherence to standardized definitions. Key limitations are its retrospective, single-center design and non-randomized allocation, which may introduce confounding by indication (e.g., sicker patients may have been taken directly for ON). Furthermore, the SUA group encompasses heterogeneous techniques (PCD, endoscopy), which were not analyzed separately.

CONCLUSION

This contemporary observational study, analyzed in October 2024, provides robust real-world evidence reinforcing the step-up approach as the cornerstone of management for infected necrotizing pancreatitis. Compared to primary open necrosectomy, SUA was associated with a markedly lower incidence of major complications—specifically, a significant reduction in procedure-induced multi-organ failure and enteric fistulae—and a substantially shorter duration of hospitalization. These findings validate the successful translation of landmark clinical trial evidence into daily practice and underscore the importance of a multidisciplinary, minimally invasive-first philosophy in pancreatic necrosectomy teams.

Despite the clear advantages of SUA, our study also highlights that primary open necrosectomy remains a necessary, life-saving procedure for a distinct subset of patients, as reflected in its continued

use. Therefore, surgical expertise in open techniques must be maintained. Future research should not focus on re-litigating the SUA vs. ON debate, but rather on optimizing the step-up protocol itself. Key unanswered questions include determining the optimal timing for escalation from drainage to necrosectomy, refining patient selection criteria for endoscopic versus percutaneous primary drainage, and evaluating long-term quality of life and cost-effectiveness ^[15]. Furthermore, standardized protocols for managing the "failure of step-up" pathway are needed to better guide timely conversion to open surgery when necessary.

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