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Management and outcomes of penetrating duodenal injuries: a retrospective cohort study from a level I trauma centre

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Background: Duodenal injuries are infrequent occurrences in traumatic abdomen.[1] Most common cause of duodenal trauma are gunshot wounds and stab injuries.[1] The purpose of this study is to determine the surgical outcome of penetrating duodenal injuries focusing on duodenal leakage.
Methods: A retrospective chart review with a descriptive-analytical design analysed medical records of 36 patients meeting inclusion criteria from a 966-patient database with penetrating abdominal trauma, admitted to Groote Schuur Hospital trauma centre, Cape Town, South Africa, over 72 months (2014–2019). Demographic data (age, sex), preoperative assessments, operative interventions, and postoperative complications were recorded, with complications graded using the Clavien-Dindo classification.
Results: Out of 966 patients admitted during the study period with penetrating abdominal trauma, 36 (3.73%) had penetrating duodenal injuries. All 36 patients were male, with a mean age of 27.17 (SD 8.28) years. Thirty-three (91.67%) patients sustained gunshot wounds, and the remaining three (8.33%) had stab wounds. Fifteen (41.67%) patients underwent damage control surgery (DCS). Six (16.67%) patients developed a duodenal leak (DL). Ten (27.78%) patients died, including five DL patients, who died due to sepsis.
Conclusion: Simple duodenal repair appears to be the best management option for penetrating duodenal injuries, except for severe injuries graded AAST IV-V where adjunct surgical techniques may be necessary.
Keywords: penetrating duodenal injury, duodenal leak, penetrating abdominal trauma, damage control surgery, primary repair

Background

Duodenal injuries, though rare, present a significant challenge in trauma surgery. Accounting for less than 5% of all abdominal injuries, duodenal trauma is predominantly caused by penetrating mechanisms such as gunshot wounds (GSWs), which represent approximately 85% of cases.[1-7] The duodenum's retroperitoneal position – adjacent to major vessels, the hepatobiliary system, and pancreas – significantly complicates injury management.[1,3] Delayed recognition exacerbates outcomes, as missed injuries often lead to sepsis, fistulas, or death.[8,9] Despite advancements in trauma care, the surgical approach to duodenal injuries remains highly debated, reflecting the challenges of balancing adequate repair with minimising complications.[9-11] The rarity of these injuries further compounds the issue, as most surgeons encounter limited opportunities to gain sufficient experience in managing such cases.[12]

Various surgical techniques are available for managing duodenal injuries, ranging from simple suture repair to more complex procedures.[2,13] Primary repair is effective for low-grade injuries (AAST-OIS I–III), achieving a duodenal leak (DL) rate of 8–15%.[2,14] However, high-grade injuries (AAST-OIS IV–V) often require adjunctive techniques or more complex procedures which carry higher complication rates (DL rates up to 33%).[11,15]

The choice of surgical intervention depends on factors such as the severity of the injury, associated trauma, and the patient's physiological status.[16] The decision-making process for selecting an appropriate surgical technique for duodenal injuries is a significant challenge for surgeons.[12,17] Evidence from the literature highlights a preference for simple repair techniques in most cases, with more complex procedures being reserved for severe or extensive injuries.[2]

Duodenal injuries are associated with high morbidity (22–47%) and mortality (9–15%), most often due to concomitant vascular injuries or sepsis-related complications. Duodenal leak, occurring in 2–11% of cases, remains a serious complication.[1,6] These statistics highlight the urgent need for improved surgical strategies and a deeper understanding of factors influencing patient outcomes.

While existing literature provides valuable insights into the management of duodenal injuries, several gaps remain. There is limited high-quality evidence comparing the long-term outcomes of different surgical approaches. Additionally, most studies are retrospective in nature and involve small sample sizes, limiting the generalisability of their findings.[2,6] The lack of standardised guidelines further complicates decision-making, emphasising the need for robust prospective studies to guide surgical management.

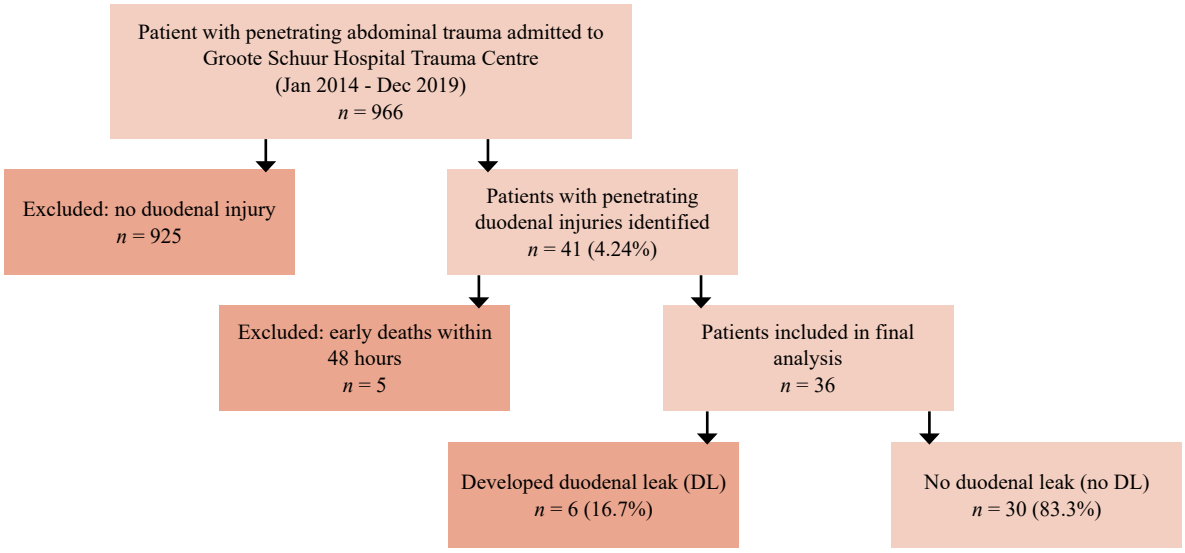

Figure 1: Flowchart illustrating patient selection and outcomes for penetrating duodenal injuries at Groote Schuur Hospital trauma centre (2014–2019)

This study aims to address some of the challenges in managing duodenal injuries, evaluating surgical intervention outcomes, particularly duodenal leakage, and the factors influencing morbidity and mortality. By exploring the current evidence, the study seeks to contribute to the ongoing discourse surrounding optimal management strategies for this complex injury.

Materials and methods

This study was conducted at Groote Schuur Hospital (GSH), which is an academic tertiary hospital located in Cape Town, South Africa.

The study included all adult patients who suffered a penetrating duodenal injury, identified from a database of 966 cases of penetrating abdominal trauma admitted between January 2014 and December 2019 (72 months). No cases of duodenal injury resulting from blunt trauma were reported. The names of patients with duodenal injuries were retrieved and cross-referenced from the existing databases in GSH trauma centre electronic health record and REDCap UCT electronic health record. The descriptive statistics were used to present the data. Patients were stratified based on various criteria such as demographic information, mechanism of injury, transfusion requirements, haemodynamic status, surgical repair techniques, damage control surgery and techniques, admission to intensive care unit (ICU) and length of stay, and associated organ injuries. Injury severity was categorised using the Revised Trauma Score (RTS) and Penetrating Abdominal Trauma Index (PATI). The American Association for the Surgery of Trauma Organ Injury Severity Scale (AAST-ISS) was used to grade duodenal injuries by the attending surgeon intraoperatively. The postoperative complications were extensively documented using the Clavien-Dindo classification (CDG).

The primary objective was to determine the incidence of duodenal leak, defined as: (i) radiologically confirmed duodenocutaneous communication, (ii) intraoperative identification of duodenal repair breakdown with leakage not yet fistulised externally, or (iii) radiologically confirmed intraperitoneal pus collection communicating with the duodenum. While the secondary objectives included determining the rates of morbidity and mortality. Early death was defined as death occurring within 48 hours after admission and late death as that occurring thereafter. Haemodynamically unstable patients are defined as those with an initial systolic blood pressure (SBP) of less than 90 mmHg at the time of presentation. However, responders are those who show a positive response to a 1–2 litre crystalloid infusion. Major abdominal vascular injuries were defined as those involving the portal vein, inferior vena cava (IVC), or aorta.

The study included adult patients older than 18 years who were diagnosed with penetrating traumatic duodenal injuries and presented to the hospital during the study period (2014–2019). Only patients with available medical and surgical records were eligible for inclusion.

Ethical approval was received from the human research ethics committee at the University of Cape Town [REF: 586/2018] and data was recorded with permission in a REDCap database managed by the trauma unit at GSH with prior ethics approval [REF: R024/2014].

Statistical analysis

Data were extracted from the REDCap database into a Microsoft Excel spreadsheet (Excel 2010) and subsequently imported into STATA 18 (StataCorp) and JASP 0.19.3 for data cleaning, coding, and analysis. Descriptive statistics were used to summarise the cohort. Continuous variables (e.g., age) are reported as mean ± standard deviation (SD), and categorical variables (e.g., mechanism of injury) are presented as frequencies and percentages.

Comparisons between patients with and without duodenal leaks were performed using the Mann–Whitney U test for continuous variables and the chi-square (χ^2) test or Fisher's exact test for categorical variables, depending on expected cell counts. Statistical significance was defined as $p < 0.05$. To reduce the risk of type I error due to multiple testing across injury patterns and clinical variables, *p*-values were adjusted using the Benjamini–Hochberg false discovery rate (FDR) procedure.

No generative artificial intelligence (AI) or AI-assisted technologies were employed in the preparation of this manuscript.

Results

The cohort comprised 36 male patients with penetrating traumatic duodenal injuries, representing 3.73% of the 966 patients admitted to our unit with penetrating abdominal trauma during the 72-month study period (2014–2019). Five patients were excluded due to death within the first 48 hours of admission. The mean age of the patients was 27.17 (SD 8.28) years (DL: 29.17±4.22 vs. No DL: 26.77±8.87; p = 0.232).

All injuries in this study resulted exclusively from penetrating trauma, with gunshot wounds (GSW) accounting for 91.66% of cases and stab wounds (SW) for 8.33% (p = 0.418). Primary repair was the most commonly performed surgical intervention, constituting 94.4% (34/36) of cases (DL: 6/34 [17.6%] vs. no DL: 28/34 [82.4%]; p = 0.515). The overall incidence of DL was 16.7% (6/36). All patients who developed DL had undergone primary repair during the initial laparotomy. Among patients without DL 82.35% (30/36), two underwent delayed pancreatoduodenectomy (Whipple procedure) and survived without major complications (Table I).

At presentation, 11 patients (30.6%) were haemodynamically unstable; five (45.5%) stabilised with resuscitation, whereas six (54.5%) required immediate resuscitative surgery without prior investigations. A total of 24 patients required blood transfusion. Transfusion volumes, both during resuscitation and intraoperatively, were higher among patients who developed DL, though these differences did not reach statistical significance. Overall, the mean transfusion volume during resuscitation was 0.70 (SD 1.03) units of packed RBCs, rising to 4.41 (SD 2.43) units intraoperatively (Table I).

A total of 15 patients (41.67%) underwent damage control surgery (DCS), with indications detailed in Table II. These findings provide an overview of the physiological and injury-related factors in patients with and without duodenal leaks, highlighting the complexity of trauma cases within this cohort. Multiple indications for damage control surgery were present in most patients. Among them, four patients developed a duodenal leak (DL: 66.66% vs. no DL: 36.66%; p = 0.174) (Table I). Various damage control procedures were

Table I: Demographics, vital signs, aetiology, management and outcome comparing DL and no DL

Variable	Total	DL	No DL	p-value
	(n =36)	(n = 6)	(n = 30)	
Age (years) (mean±SD)	(27.17±8.28)	(29.17±4.22)	(26.77±8.87)	0.232
Mechanism of Injury				0.418
GSW (n) (%)	33 (91.66)	6 (100.00)	27 (90.00)	
SW (n) (%)	3 (08.33)	0 (0.00)	3 (10.00)	
Primary repair	34 (94.44)	6 (100.00)	28 (93.33)	0.515
Yes (n) (%)	2 (05.55)	0 (0.00)	2 (06.66)	
No (n) (%)				
First recorded mean SBP (mmHg) (mean±SD)	(125.76±24.63)	(125.33±18.48)	(125.93±27.28)	0.694
Blood Transfusion				
Resuscitation (mean±SD)	(0.70±1.03)	(1.00±1.00)	(0.65±1.06)	0.451
Intraoperative (mean±SD)	(4.41±2.43)	(4.80±1.89)	(4.21±2.76)	0.344
DCS				0.174
Yes (n) (%)	15 (41.66)	4 (66.66)	11 (36.66)	
No (n) (%)	21 (58.33)	2 (33.33)	19 (63.33)	
Relaparotomy				
Relook within 30 days				
Yes (n) (%)	21 (58.33)	6 (100.00	15 (50.00)	0.023
No (n) (%)	15 (41.66)	0 (00.00)	15 (50.00)	
2 relooks within 30 days				
Yes (n) (%)	11 (30.55)	5 (83.33)	6 (20.00)	0.002
No (n) (%)	25 (69.44)	1 (16.66)	24 (80.00)	
More than 2 relooks				
Yes (n) (%)	9 (25.00)	4 (66.66)	5 (16.66)	0.010
No (n) (%)	27 (75.00)	2 (33.33)	25 (83.33)	
ICU	24 (66.66)	6 (100.00)	18 (60.00)	
Yes (n) (%)	12 (33.33)	0 (0.00)	12 (40.00)	0.058
No (n) (%)				
ICU LOS (days) (mean±SD)	(8.83±9.53)	(15.83±14.46)	(7.67±8.29)	0.293
Morbidity				0.121
Yes (n) (%)	27 (75.00)	6 (100.00)	21 (70.00)	
No (n) (%)	9 (25.00)	0 (00.00)	9 (30.00)	
Mortality				< 0.001
Yes (n) (%)	10 (27.77	5 (83.33)	5 (16.66)	
No (n) (%)	26 (72.22)	1 (16.66)	25 (83.33)	

SBP – Systolic blood pressure, LOS – Length of stay, DCS – Damage control surgery, ICU – Intensive care unit, GSW – Gunshot wound, SW – Stab wound, SD – Standard deviation

Table II: Damage control surgery indications

Physiological parameter	Total	DL	No DL	*p*-value
Hypothermia (< 35.0°C)	4	1	3	0.930
Acidosis (pH < 7.2 or BD > 8 mmol/L)	4	1	3	0.930
Coagulopathy	4	0	4	0.159
Haemodynamic Instability	7	1	6	0.310
Injury complexes parameter	**Total**	**DL**	**No DL**	***p*-value**
Multiple penetrating torso injury (> 2)	9	2	7	0.634
Combined visceral and major vascular injury	2	0	2	0.360
Injuries across body cavities with competing treatment priorities	8	2	6	0.876

DL – Duodenal leak, BD – Base deficit, °C – Degree Celsius, pH – Potential of hydrogen, mmol/L – Millimoles per litre

Table III: Comparison of RTS and PATI between patients with DL and those with no DL

Score	Total	DL	No DL	*p*-value
RTS (mean±SD)	7.439±0.577	7.792±0.118	7.769±0.607	0.088
PATI (mean±SD)	37.667±19.760	52.333±24.459	34.733±17.739	0.107

DL – Duodenal leak; RTS – Revised trauma score, PATI – Penetrating abdominal trauma index, SD – Standard deviation

Table IV: The Clavien-Dindo Grading classification of surgical complications comparing DL and no DL

Grade	Complication (*n*)	Total	DL	No DL	*p*-value
		(*n* = 27/36)	(*n* = **6**/**6**)	(*n* = 21/**30**)	
I	Superficial SSI (1)	1 (03.70)	**0** (0.00)	**1** (04.76)	
II	Ileus required TPN (2) Deep SSI (3)	**5** (18.51)	**0** (0.00)	**5** (23.80)	
IIIa	Intraabdominal collection* (5)	**5** (18.51)	**0** (0.00)	**5** (23.80)	0.051
IIIb	Intraabdominal collection** (3) Bowel obstruction (1)	4 (14.81)	**0** (0.00)	**4** (19.04)	
IVa	AKI (1)	1 (03.70)	**0** (0.00)	**1** (04.76)	
IVb	Septic shock (1)	**1** (03.70)	**1** (16.66	**0** (0.00)	
V	Mortality (10)	**10** (37.03)	**5** (83.33)	**5** (23.80)	

CDG – Clavien-Dindo Grading classification, DL – Duodenal leak, SSI – Surgical site infection, TPN – Total parenteral nutrition, AKI – Acute kidney injury
* Drained under regional anaesthesia
** Drained under general anaesthesia

performed in these cases. Liver, renal, or splenic packing was conducted in 13 patients (86.67%). Wide drainage of the pancreas was performed in four patients (26.67%). Additionally, six patients (40%) underwent bowel ligation, and one patient required a temporary vascular shunt. All duodenal injuries were managed with primary repair and drainage as part of damage control, except in two patients who were initially treated with drainage alone and later underwent delayed pancreatoduodenectomy.

A total of 24 patients were admitted to the intensive care unit (ICU), with the majority requiring admission due to type 2 respiratory failure or following damage control surgery. All six patients with DL required ICU admission, compared to 18 patients without duodenal leaks (DL: 100% vs. no DL: 60%; $p = 0.058$). The mean ICU length of stay (LOS) was approximately 8.83 (SD 9.53) days (DL: 15.83±14.46 vs. no DL: 7.67±8.29; $p = 0.293$) (Table I).

Among the study cohort, 21 (58.33%) patients required at least one relaparotomy within 30 days (DL: 100% vs. no DL: 50%; $p = 0.023$). Among patients with duodenal leaks, 66.66% required more than two relook laparotomies within 30 days, compared to only 16.66% of those without DL ($p = 0.010$).

All patients with DL were managed with drainage. Significant complications occurred in 100% of DL patients compared with 70% of no DL patients ($p = 0.121$). Furthermore, patients with duodenal leaks exhibited a significantly higher mortality rate (DL: 83.33% vs. no DL: 16.66%; $p < 0.001$) (Table I).

Patients in the DL cohort had higher severity scores on both the revised trauma score (RTS) (DL: 7.792±0.118 vs. no DL: 7.769±0.607; $p = 0.088$) and the penetrating abdominal trauma index (PATI) (DL: 52.333±24.459 vs. no DL: 34.733±17.739; $p = 0.107$) compared to the no DL cohort. These findings are summarised in Table III.

High-grade complications were common among patients with duodenal leaks; one patient developed a Grade IVb complication and the remainder developed Grade V complications, as classified by the Clavien-Dindo system. Among the 21 patients without leaks, five also sustained Grade V complications. All Grade V complications were due to overwhelming sepsis (Table IV).

All patients sustained multi-organ injuries, with concomitant injuries to one or more organs in addition to the duodenal trauma. The colon was the most frequently injured concomitant organ ($n = 21$), followed by the liver and small bowel as common secondary injuries associated with duodenal trauma. Pancreatic ($p = 0.016$) and renal injuries ($p = 0.005$) were significantly associated with duodenal leaks.

Table V: Associated injured organs comparing DL and no DL

Organ	Total	DL	No DL	*p*-value
	(*n* = 36)	(*n* = 6)	(*n* = 30)	
Liver				
Yes (*n*) (%)	16 (44.44)	4 (66.66)	12 (40.00)	0.230
No (*n*) (%)	20 (55.55)	2 (33.33)	18 (60.00)	
Spleen				
Yes (*n*) (%)	3 (08.33)	1 (16.66)	2 (06.66)	0.418
No (*n*) (%)	33 (91.66)	5 (83.33)	28 (93.33)	
Pancreas				
Yes (*n*) (%)	6 (16.66)	3 (50.00)	3 (10.00)	0.016
No (*n*) (%)	30 (83.33)	3 (50.00)	27 (90.00)	
Stomach				
Yes (*n*) (%)	14 (38.88)	4 (66.66)	10 (33.33)	0.126
No (*n*) (%)	22 (61.11)	2 (33.33)	20 (66.66)	
SB				
Yes (*n*) (%)	15 (41.66)	3 (50.00)	12 (40.00)	0.650
No (*n*) (%)	21 (58.33)	3 (50.00	18 (60.00)	
Colon				
Yes (*n*) (%)	21 (58.33)	4 (66.66)	17 (56.66)	0.650
No (*n*) (%)	15 (41.66)	2 (33.33)	13 (43.33)	
IVC				
Yes (*n*) (%)	12 (33.33)	1 (16.66)	11 (36.66)	0.343
No (*n*) (%)	24 (66.66)	5 (83.33)	19 (63.33)	
Kidney				
Yes (*n*) (%)	5 (13.88)	3 (50.00)	2 (06.66)	0.005
No (*n*) (%)	31 (86.11)	3 (50.00)	28 (93.33)	
Diaphragm				
Yes (*n*) (%)	8 (22.22)	3 (50.00)	5 (16.66)	0.073
No (*n*) (%)	28 (77.77)	3 (50.00)	25 (83.33)	
GB				
Yes (*n*) (%)	7 (19.44	1 (16.66)	6 (20.00)	0.851
No (*n*) (%)	29 (80.55)	5 (83.33)	24 (80.00)	
Other vessels				
Yes (*n*) (%)	4 (11.11	0 (0.00)	4 (13.33)	0.343
No (*n*) (%)	32 (88.88)	6 (100.00)	26 (86.66)	
Mesentery				
Yes (*n*) (%)	1 (02.77)	0 (0.00)	1 (03.33)	0.650
No (*n*) (%)	35 (97.22	6 (100.00)	29 (96.66)	

DL – Duodenal leak, SB – Small bowel, IVC – Inferior vena cava, GB – Gall bladder

IVC injuries showed no significant association ($p = 0.343$). (Table V)

After adjusting for multiple comparisons, none of the concomitant injuries retained statistical significance. Unadjusted analyses suggested associations for pancreatic and kidney injuries, but these associations did not remain significant after correction (Figure 2 and Figure 3).

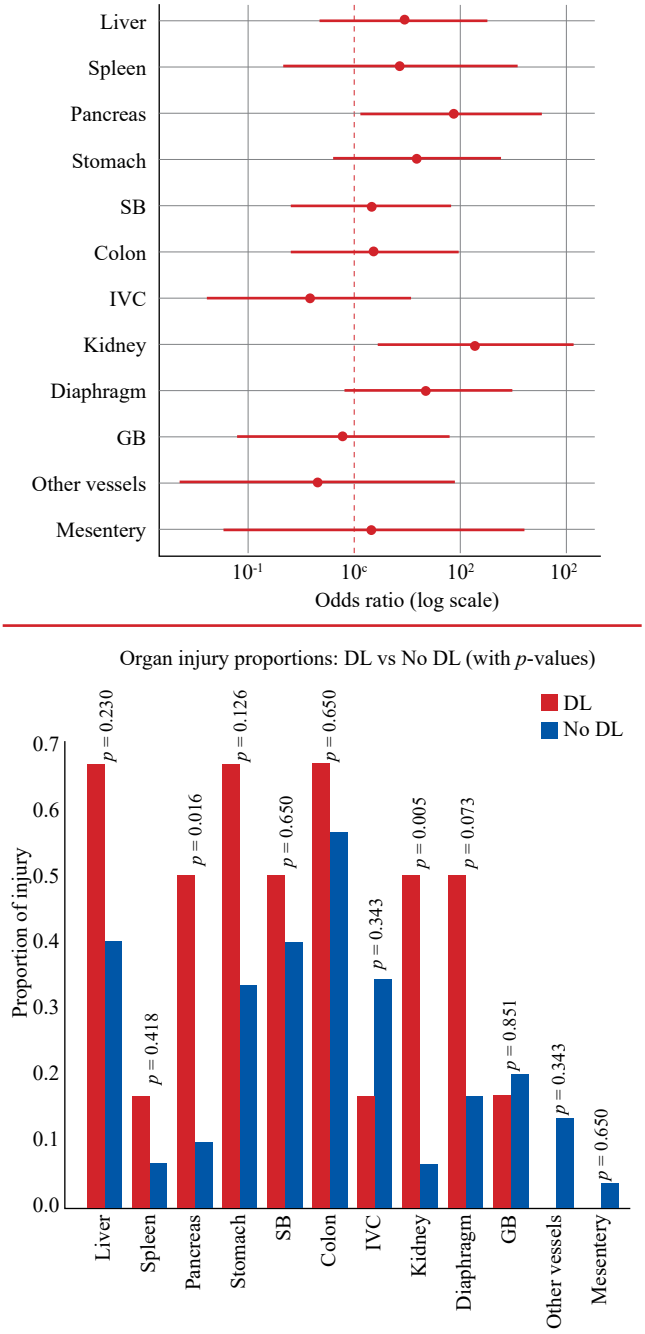

Figure 2: Grouped bar chart showing the percentage of specific concomitant organ injuries in patients with DL versus with No DL, alongside a forest plot displaying odds ratios with 95% confidence intervals for the association between each organ injury and the risk of DL

DL – Duodenal leak, SB – Small bowel, IVC – Inferior vena cava, GB – Gall bladder

Table VI: American Association for the Surgery of Trauma (AAST) classification of duodenal injury comparing DL and No DL

Grade	Total	DL	No DL	*p*-value
	(*n* = 36)	(*n* = 6)	(*n* = 30)	
AAST	3 (1–5)	3 (3–5)	2 (1–5)	
I	2	0	2	
II	14	0	14	0.078
III	15	5	10	
IV	3	0	3	
V	2	1	1	

DL – Duodenal leak, AAST – American Association for the Surgery of Trauma classification

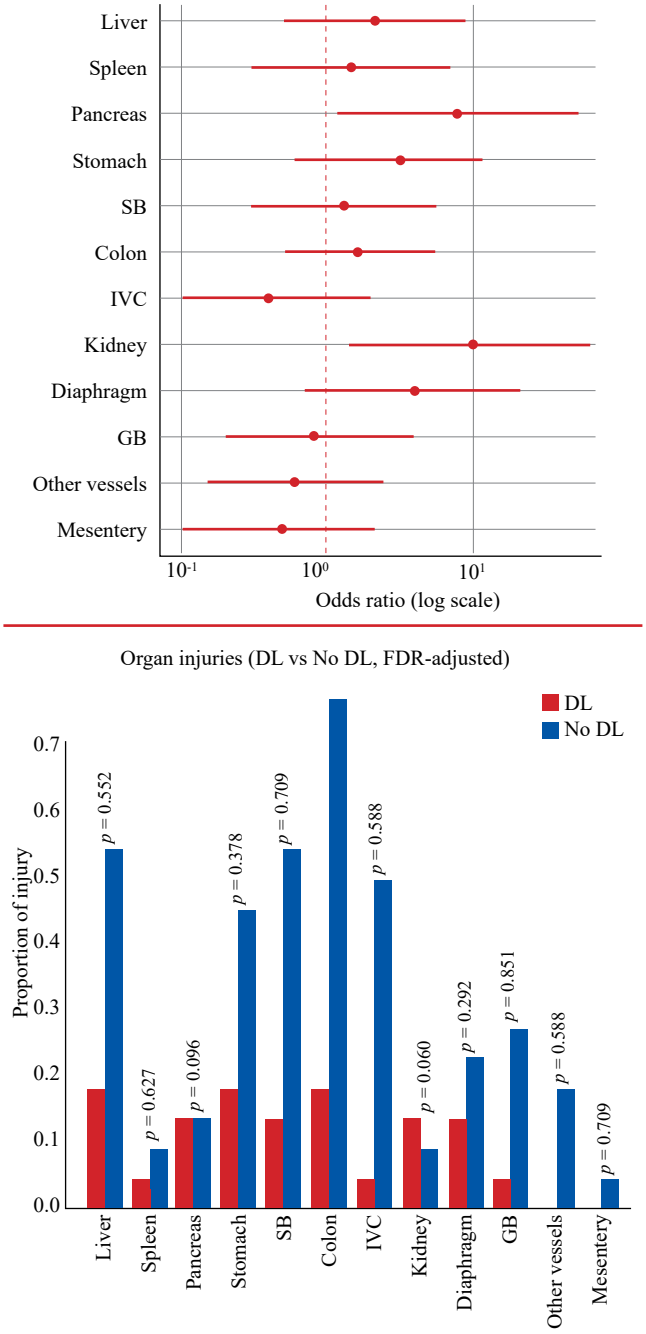

Figure 3: Adjusted odds ratios (with 95% confidence intervals and FDR-adjusted p-values) for the association between individual organ injuries and risk of duodenal leak, presented as a forest plot and grouped bar chart
DL – Duodenal leak, SB – Small bowel, IVC – Inferior vena cava, GB – Gall bladder; FDR – False discovery rate

Duodenal injury severity was assessed intraoperatively by the attending surgeon; 20 patients by the consultant (DL: 50.00% vs. no DL: 56.66%; $p = 0.044$), 7 patients by the fellow (DL: 33.33% vs. no DL: 16.66%; $p = 0.631$), and 9 patients by the registrar (DL: 16.66% vs. no DL: 26.66%; $p = 0.668$). Duodenal injury tends to be more severe in duodenal leak (DL) group. Among the 20 patients with high-grade injuries (AAST Grades 3–5), six had DL, while the remaining 14 did not ($p = 0.078$). The distribution of duodenal organ injury severity is detailed in Table VI.

Discussion

Penetrating mechanisms predominate in traumatic duodenal injury, most commonly gunshot wounds; reported series typically show that 70–80% of duodenal injuries are penetrating and the overall incidence among abdominal trauma ranges ~3–5% (0.2–0.6% of all trauma admissions).[1,9,18-21] In our cohort, 91.7% of duodenal injuries were due to gunshot wounds, reflecting this pattern and local epidemiology.

Several factors have been identified in the literature as contributing to the risk of duodenal leak. A study analysing risk factors for duodenal leak after repair identified factors such as age, shock and perforation diameter as significant predictors.[22,23] In the current cohort, while only some data on these variables are provided, the association between DL and increased mortality underscores the importance of vigilant perioperative management. According to current estimates, the male-to-female ratio of duodenal injuries is 5:1, and most affected patients are between the ages of 16 and 30, constituting 70% of cases, reflecting demographic patterns of violence and trauma exposure.[14,18,24] Our study was consistent, with all patients being male and a mean age of 27.2 years.

Associated intra-abdominal injuries are the rule rather than the exception because of the duodenum's retroperitoneal location and proximity to other viscera.[2,3] Several studies have reported associated injury rates of up to 100%.[4,25] As an instance, a study conducted retrospectively by Phillips et al. revealed that 68% of patients with traumatic penetrating duodenal injuries had associated organ injuries, with the liver and colon being the two most frequently injured organs, each accounting for 45%.[6,25] In our sample, every patient sustained at least one additional abdominal injury, most commonly involving the colon (58.33%), liver (44.44%), and small bowel (41.66%). This high burden of concomitant injuries likely contributed to the elevated overall morbidity observed. Vascular injuries, particularly to the IVC, are present in 30–40% of cases and correlate with mortality rates exceeding 30%.[6,26] But in our study, the major abdominal vascular injuries in the duodenal leak cohort did not reach significance. IVC injury was present in 12 (33.33%) patients, and of these, only 1 (8.33%) developed duodenal leak.

Pancreatic injury emerged in the literature as a consistent predictor of adverse duodenal outcomes. Multiple reviews and retrospective series have shown that concurrent pancreatic trauma increases the risk of duodenal repair failure and leak.[6,25] In our cohort 50% of patients with pancreatic injury developed DL, supporting the published association and underscoring the need for heightened vigilance when pancreatic injury is present. Schroeppel et al. observed that pancreatic injury was also predominant in the DL group. However, the patients in the DL group in their study were managed with various procedures, not limited to primary repair. Furthermore, they reported a higher rate of major vascular injuries in the DL group compared to the no DL group, which contrasts with the findings of our study.[2]

Common causes of complications included inadequate repair techniques and failure to address underlying shock, which further compounded patient morbidity.[13,23,27] In patients who are unstable with concomitant vital organ injuries, and have haemorrhagic shock, hypothermia and acidosis, DCS may be necessary.[3] In our study, most the patients for DCS had more than one indication. The

use of DCS has demonstrated improved patient survival and reduced complications in the surgical treatment of high graded duodenal injuries.[4,9,26] In our study, DCS was performed on 15 patients (41.7%). Among these, four patients developed DL, while the remaining 11 patients did not (p = 0.174). DCS, although beneficial in certain high-grade injuries, did not consistently prevent leaks, highlighting the need for tailored surgical strategies based on individual injury profiles.[28]

The analysis of ICU admission and LOS among patients with penetrating duodenal injuries highlights key trends regarding the severity of complications and resource utilisation. The wide standard deviations observed in ICU LOS suggest heterogeneity in patient responses and possible confounding factors such as comorbid conditions, surgical complexity, and postoperative complications. Similar challenges have been reported in studies with small cohorts evaluating outcomes in penetrating duodenal trauma.[23] Future research with larger, multicentre datasets is necessary to validate these findings and refine predictive models for ICU resource allocation in patients at high risk for duodenal leaks.

To further illustrate the intricate dynamics between surgical interventions and patient outcomes, the study conducted by Choron et al. provides a crucial perspective on the role of complex repair techniques in managing duodenal leaks. This research highlights that although complex repairs may demonstrate decreased leak rates, they often do not significantly differ in addressing the location of the duodenal injury or managing associated pancreatic and ampullary injuries when compared to primary repair methods. In fact, the benefit of complex repair seems most pronounced in cases with severe, grade IV injuries, suggesting that surgical decision-making should heavily rely on injury severity as a guiding principle.[15] Additionally, the disparity in outcomes among various surgical techniques emphasises the necessity for ongoing research and optimisation of repair strategies, particularly in settings where primary repair is prevalent due to resource constraints. As such, there is an imperative for healthcare systems, especially in low-resource environments, to adapt surgical protocols that are informed by detailed injury assessments, ensuring that patient safety and recovery are prioritised.

The need for relaparotomy within 30 days was significantly higher in patients with DL (p = 0.023), indicating the complexity and severity of these cases. The significant burden of relaparotomy in DL cases reflects the necessity for vigilant postoperative monitoring and prompt surgical intervention. This aligns with reports suggesting relaparotomy rates above 60% in DL patients.[15]

The constant curvature of the duodenum from D1 through D4, along with its close proximity to the pancreas on its concave side, presents technical difficulties in repairing high grade duodenal injuries, which can result in severe complications for patients.[29] In order to facilitate healing and prevent the development of complications, adjunctive procedures such as pyloric exclusion, tube duodenostomy, or feeding jejunostomy were required in addition to simple suture repair, or more complex interventions such as pancreatoduodenectomy.[3] This is necessary to ensure continued gut nutrition in the event of repair failure. The occurrence of a DL can lead to severe complications such as sepsis, fluid and electrolyte imbalances, and nutritional issues.[7,16,29] In our study, all patients who developed a DL had undergone primary repair alone, whereas 2 of 30 patients without a leak required a definitive pancreatoduodenectomy, and the remainder were treated with primary repair. This finding suggests that while primary repair is feasible and remains the most commonly employed approach, its limitations become evident in complex injuries where repair tension, tissue viability, or associated pancreatic involvement may predispose to failure. The absence of DLs among those undergoing pancreatoduodenectomy, albeit in a very small subset, highlights the potential value of more radical procedures in select high-risk cases.

However, these injuries can result in a significant level of morbidity, ranging from 39% to 65%, and a high mortality rate up to 47%.[1,6] This may be influenced by various factors, including diagnostic challenges, management difficulties, and a high prevalence of concurrent intra-abdominal injuries.[26-28] Contemporary series report a duodenal leak rate of 6.2% (range 0–33%).[2,14] In our study, morbidity reached 75%, more than the universal average as well as mortality rate which reached 27.78% in our study. Notably, the development of a DL was associated with a significant increase in mortality ($p < 0.001$). This finding aligns with existing literature indicating that DLs are associated with increased morbidity and mortality.[14]

Despite the study's limitations, the findings suggest a nuanced understanding of the implications of various surgical repair techniques on patient outcomes in penetrating traumatic duodenal injuries. Notably, the data reveal that patients undergoing complex repairs experience a lower incidence of leaks, which underscores the necessity of tailoring surgical interventions to the specific nature and severity of the injury. This adaptation is particularly critical in resource-limited settings, such as South Africa, where primary repair remains the predominant approach due to logistical constraints and clinical protocols favouring more straightforward procedures.[14] In addition to exploring advanced reparative strategies, emphasis should also be placed on improving diagnostic accuracy through enhanced imaging techniques, thereby allowing for better preoperative planning and risk stratification. Future investigations should integrate these insights into larger, multicentre prospective studies to determine the most efficacious treatment protocols and ultimately reduce the morbidity and mortality associated with these formidable injuries.

Study limitations

The retrospective nature of the study imposes certain limitations, primarily due to its reliance on existing records, which may not consistently capture all relevant clinical variables or details of surgical techniques. This can lead to incomplete data, affecting the accuracy of the findings, such as the precise incidence of DLs. Additionally, the limited sample size restricts the validity of the results, as the study was conducted over a fixed period at a single institution, potentially impacting the statistical power of the analysis. Furthermore, variations in the descriptions and classifications of injury grades and complications pose challenges in standardising the assessment of injury severity and outcome, which is crucial for evaluating the correlation between injury grade and DLs. These limitations highlight the necessity for future research to employ larger, multicentre cohorts and standardised grading systems to enhance the robustness of the findings.

Conclusion

In conclusion, for penetrating duodenal injuries, simple suture repair appears to be a safe approach, except for severe injuries graded AAST IV-V where adjunct surgical techniques may be necessary. The DL rate of 17.65% in patients who had a primary repair is in keeping with the range reported in contemporary studies (0–33%).[2,3]

Conflict of interest

The authors declare no conflict of interest.

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Ethical approval

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