



“Triple-Tube-Ostomy” Technique for Management of Duodenal Injuries: A Systematic Review and Meta-Analysis



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Abstract

Background: Isolated duodenal injury following blunt or penetrating trauma remains an extremely rare and one of the most challenging hitches confronting trauma surgeons. Triple-tube-ostomy (TTO) technique involving gastrostomy, reverse duodenostomy, and feeding jejunostomy tubes insertion has shown promising results during conservative management of duodenal injuries.

Objective: We aim through this paper to report a successfully managed case of isolated incomplete transverse duodenal injury managed by TTO technique in a 14-year-old boy who presented with severe abdominal pain, one day after sustaining blunt abdominal trauma due to fall from height. In addition, we aimed to systematically review the literature for the usage and outcomes of the TTO surgical procedure, and evaluate its efficiency and effectiveness in the management of duodenal injuries.

Data Sources: OVID/Medline, PubMed, and Scopus databases were lastly searched on December 8th, 2016 to identify all published research studies on duodenal injuries treated by this surgical technique.

Study Selection: Studies reporting cases of duodenal injuries that were managed by TTO were warranting inclusion.

Data Extraction and Synthesis: Both CARE and PRISMA guidelines were followed for conduction and reporting of this study. Throughout the whole review process, two reviewers worked independently and in duplicate to screen titles, assess full texts for eligibility, and abstract data.

Results: Six articles were included in this review. Sixty five cases were reported to have undergone TTO in world literature. Majority of the cases were performed after surgical repair of giant duodenal ulcers, only 2 cases were reported due to perforations following trauma. While majority of cases had uneventful recovery, complications such as wound infections and dehiscence were reported. Mean length of hospital stay was found to be 20.5 days. Mortality occurred in 3 cases.

Conclusions and Relevance: The positive outcomes of our reported case and the structured evaluation of the published studies suggest effectiveness of usage of “triple-tube-ostomy” surgical procedure for management of duodenal injuries. However, further studies are needed to assess the usage of this technique in management of duodenal injuries in comparison to other classical surgical techniques.

Keywords: blunt trauma, abdomen, isolated transverse duodenal transaction, transpyloric “triple-tube-ostomy” decompression, case report, systematic review

Introduction

In contrast to the liver and spleen, injuries to the duodenum are much less frequent, reported as 0.2% of blunt trauma injuries [1,2], and comprising 0.2–3.7% of all trauma-related laparotomies [3]. What makes isolated duodenal injuries scarce is the fact that duodenal trauma is usually associated with one to four other abdominal organ injuries [2,4].

Furthermore, due to its anatomical position, the “protected” retroperitoneal location of the duodenum limits the chance of

injury but makes early diagnosis and treatment a difficult task [5,6]. Add to this diagnostic dilemma is the frequency of associated intra-abdominal and/or multisystem injuries such as concomitant injuries that affect the liver in about 17%, pancreases, colon and small bowels each in about 11% [7,8], which can mask subtle physical and radiographic diagnostic signs found in isolated blunt injuries to the duodenum [9]. Hence, diagnosis is challenging, particularly in the setting of acute blunt trauma, since symptoms and signs resulting from these injuries may not be obvious.

Additionally, there are currently no modalities that allow the clinician to diagnose duodeno-pancreatic trauma accurately.

Conventional surgical management options of duodenal injuries vary according to the duodenal organ injury scale (DIS), which relies upon an injury classification system from the American Association for the Surgery of Trauma (AAST) [10], from conservative non-operative management to surgical intervention. Surgical intervention ranges from simple debridement and primary closure (duodenorrhaphy) of injured duodenum to much more complex procedures, such as resection and primary anastomosis of the damaged portion, pyloric exclusion [11], duodenal decompression [3,12,13], or pancreaticoduodenectomy [14].

Triple-tube-ostomy (TTO) have been done in several cases, but not yet recommended following duodenal injury repair. TTO entails gastrostomy, reverse duodenostomy, and feeding jejunostomy tubes insertion. Gastrostomy and reverse duodenostomy serve to decrease tension at the repair site and help drain both gastric and duodenal secretions allowing time for anastomosis to heal, thus preventing complications. Other than intraabdominal abscesses and pancreatitis, duodenal fistulas/leak are the most life threatening postoperative complications which may occur in about 7% of cases [7,8].

Hereby, we present a case of a 14-year old boy who was diagnosed to have isolated incomplete transverse duodenal injury due to blunt abdominal trauma, treated with duodenorrhaphy and complicated by a postoperative leak managed by the promising “triple-tube-ostomy” technique for decompression in a transpyloric approach. We also present a systematic review of the relevant literature conducted to describe all prior case reports and studies where this surgical technique was used in managing patients with duodenal injuries, and to determine whether it is efficient to be used in such cases.

Case Presentation

A 14-year-old Lebanese boy, previously healthy, presented to the emergency department of Rafik Hariri University Hospital, one of the tertiary care centers in Beirut, with diffuse abdominal pain and distension, 48 hours after sustaining a blunt abdominal trauma due to fall from height of about 4 meters. Patient reported that the pain had been increasing in intensity over the last 48 hours, stabbing in nature, radiating to the back, not relieved by any medication or position and associated with obstipation and anorexia. High-grade fever was also reported, without chills. No nausea, vomiting or any other associated symptoms were reported.

At presentation, patient was hemodynamically stable with blood pressure of 110/90mmHg, pulse rate of 96 beats per minute, respiratory rate of 18 breaths per minute, body temperature of 36.8°C and O₂ saturation of 99%. On physical examination, abdomen was rigid with diffuse rebound tenderness and normal bowel sounds. No pulsating masses were noted in the abdomen. Otherwise, the rest of physical examination was normal. Total leukocyte count on presentation was 13,000cells/ μ L (83% neutrophil count), otherwise normal laboratory blood tests (hemoglobin, hematocrit, electrolytes, creatinine, blood urea nitrogen, liver enzymes, amylase, lipase, and C-reactive protein). Plain abdominal and chest radiographs were normal. Computed Tomography (CT) of the abdomen and pelvis was done with IV contrast showing gas and fluid in the right retroperitoneal space with free fluids in the perihepatic, perisplenic and pelvic areas. In addition, hairline hypodensity was seen at the level of the body of duodenum. Patient was thus admitted for emergency laparotomy and suspected duodenal injury repair. Exploratory laparotomy was performed for primary repair of third portion transverse duodenal rupture - duodenorrhaphy, with insertion of Hemovac drain in the periduodenal region. Patient was successfully discharged after recovery on the 3rd postoperateday (POD) after tolerating PO intake.

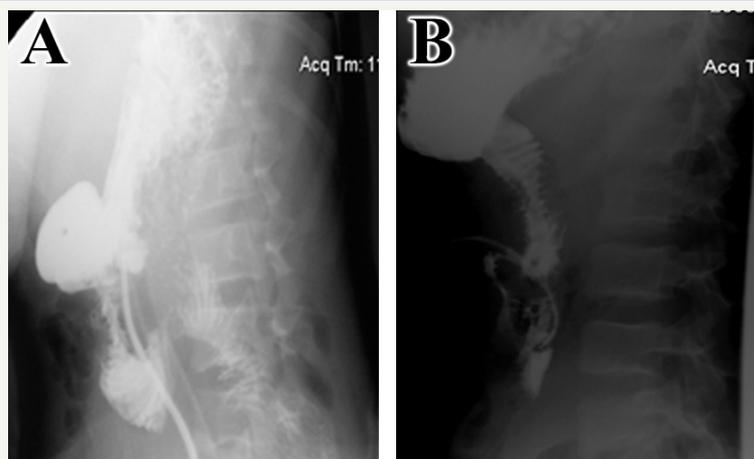


Figure 1: (A) Upper GI series radiography with gastrografin swallow showing significant leak of the contrast material from the lower 2nd portion of the duodenal loop at its junction with the 3rd portion. Two fistulous tracts are demonstrated from this area. The 3rd and 4th portions of the duodenal loop could not be filled. (B) Upper GI series radiography with gastrografin swallow repeated 4 weeks following “triple-tube-ostomy” decompression surgical procedure. Contrast material was injected through gastrostomy tube with no evidence of leak or any fistula from the duodenum. The duodenal loops and upper small bowels show no abnormalities.

The patient returned to the emergency department with sharp abdominal pain on 7th POD. Vital signs showed an elevated body temperature of 38.3°C, tachypnea with 22 breaths per minute, tachycardia with heart rate of 102 beats per minute and hypotension with a blood pressure of 90/60 mmHg. Patient's laboratory results were normal except for an elevated white blood cell count of 18,000 cells/ μ L with 90% neutrophilic count and 11% band cells. Since a leak was suspected, upper gastrointestinal (GI) series was done using gastrografin and showed significant leak of the contrast material from the lower second portion of the duodenal loop at its junction with the third portion (Figure 1A). Patient was

urgently re-operated with "triple-tube-ostomy" decompression procedure involving reverse tube duodenostomy, tube gastrostomy, and feeding jejunostomy. Feeding through jejunostomy started on 3rd POD. Following the second operation, patient showed clinical improvement with normal laboratory values. Gastrografin upper GI series was repeated 4 weeks later showing no evidence of leak or any fistula from the duodenum (Figure 1B). Patient was discharged home on 28th POD following the removal of all -ostomy tubes. Currently, the patient returned to his usual state of health prior to the injury, and had an uneventful recovery. Figure 2 represents the case time line.

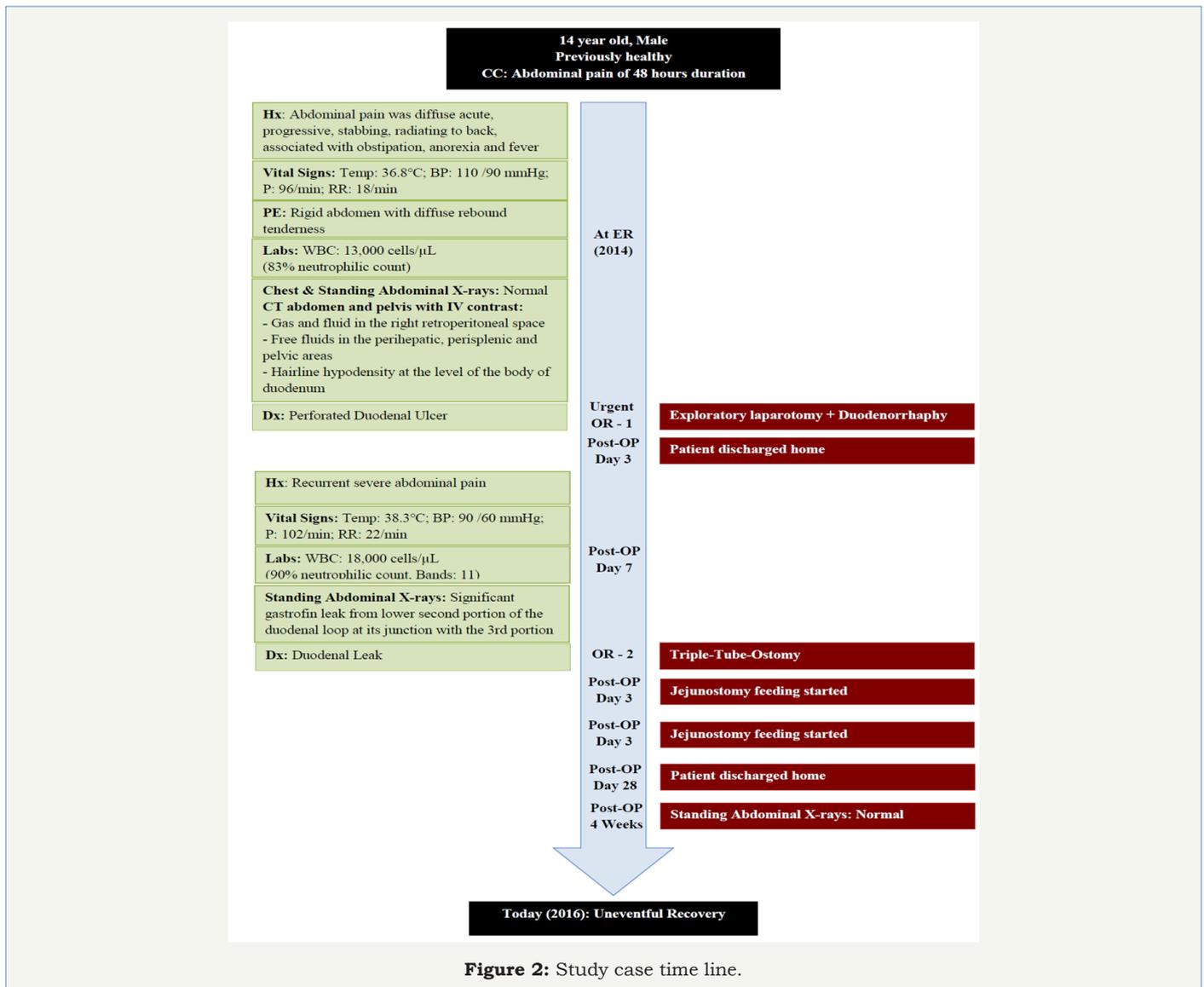


Figure 2: Study case time line.

Methods

Data sources and searches

This paper was reported in compliance with CAsEReports (CARE) and Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines for reporting case reports and systematic reviews (Supplements 1 & 2). Systematic review of the relevant English literature was conducted encompassing studies

documenting the use of "triple-tube-ostomy" technique to manage duodenal injuries of any cause. A comprehensive search strategy was developed by searching 3 databases, PubMed, OVID/Medline and Scopus, for relevant articles since inception up to December 8th, 2016. MeSH terms, keywords and combinations related to the topic were used to search the databases comprehensively: "duodenum", "duodenostomy", "jejunostomy", "gastrostomy", and "triple-tube-ostomy". Complete search strategy is provided in Supplement 3.



CARE Checklist – 2016: Information for writing a case report

Topic	Item	Checklist item description	Line/Page
Title	1	The words “case report” should be in the title along with the area of focus	Page 1
Key Words	2	Four to seven key words—include “case report” as one of the key words	Page 1
Abstract	3a	Background: What does this case report add to the medical literature?	Page 3
	3b	Case summary: chief complaint, diagnoses, interventions, and outcomes	Page 3
	3c	Conclusion: What is the main “take-away” lesson from this case?	Page 3,4
Introduction	4	The current standard of care and contributions of this case—with references (1-2 paragraphs)	Page 5,6
Timeline	5	Information from this case report organized into a timeline (table or figure)	Page 7 (Fig.2)
Patient Information	6a	De-identified demographic and other patient or client specific information	Page 6
	6b	Chief complaint—what prompted this visit?	Page 6
	6c	Relevant history including past interventions and outcomes	Page 6
Physical Exam	7	Relevant physical examination findings	Page 6
Diagnostic Assessment	8a	Evaluations such as surveys, laboratory testing, imaging, etc.	Page 6,7
	8b	Diagnostic reasoning including other diagnoses considered and challenges	Page 6,7
	8c	Consider tables or figures linking assessment, diagnoses and interventions	Page 7 (Fig.1)
	8d	Prognostic characteristics where applicable	Page 7
Interventions	9a	Types such as life-style recommendations, treatments, medications, surgery	Page 7
	9b	Intervention administration such as dosage, frequency and duration	Not Applicable
	9c	Note changes in intervention with explanation	Page 7
	9d	Other concurrent interventions	Page 7
Follow-up and Outcomes	10a	Clinician assessment (and patient or client assessed outcomes when appropriate)	Page 7
	10b	Important follow-up diagnostic evaluations	Page 7
	10c	Assessment of intervention adherence and tolerability, including adverse events	Page 7
Discussion	11a	Strengths and limitations in your approach to this case	Page 11,12
	11b	Specify how this case report informs practice or Clinical Practice Guidelines (CPG)	Page 12,13
	11c	How does this case report suggest a testable hypothesis?	Page 12,13
	11d	Conclusions and rationale	Page 13
Patient Perspective	12	When appropriate include the assessment of the patient or client on this episode of care	Not Applicable
Informed Consent	13	Informed consent from the person who is the subject of this case report is required by most journals	Page 14
Additional Information	14	Acknowledgement section; Competing Interests; IRB approval when required	Page 14



PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	3,4
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	5
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	5,6
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	8
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	8
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	8
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	8 + Supplement 3
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	8,9 + Supplementary Table 1
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	8,9
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	8,9 + Table 1
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	8,9 + Supplementary Table 1
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	9
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I ²) for each meta-analysis.	9
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	NA
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	NA
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	9
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	9,10 + Table 1
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	9, 10 + Supplementary Table 1
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	9,10 + Table 1
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	NA
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	NA
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	NA
DISCUSSION			

Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	10, 11, 12
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	12, 13
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	12, 13
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	14

Ovid MEDLINE Search Strategy

Database: **Ovid MEDLINE(R)** In-Process & Other Non-Indexed Citations and Ovid MEDLINE(R) <1946 to Present>

Search Strategy:

-
- 1 exp jejunostomy/ (2553) [MeSH Term]
 - 2 exp gastrostomy/ (7451) [MeSH Term]
 - 3 exp duodenostomy/ (513) [MeSH Term]
 - 4 1 and 2 and 3 (18)
 - 5 (((duoden* adj3 (injur* or perforat* or neoplasm* or disease* or ulcer* or obstruct* or surger* or repair* or triple or ostom*))) or jejunostomy* and gastrost* and duodenost*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] (50) [Keywords and combinations]
 - 6 4 or 5 (50)

PubMed Search Strategy

Search	Query	Items found
#6	Search #5 OR #1	99
#5	Search #2 AND #3 AND #4	18
#4	Search duodenostomy [mesh]	495
#3	Search gastrostomy [mesh]	7130
#2	Search jejunostomy [mesh]	2429
#1	Search duodenal injur*[tw] OR duodenal neoplasm*[tw] OR duodenal disease*[tw] OR duodenal ulcer*[tw] OR duodenal obstruct*[tw] OR duodenal surger*[tw] OR duodenal repair*[tw] OR duodenum injur*[tw] OR duodenum neoplasm*[tw] OR duodenum disease*[tw] OR duodenum ulcer*[tw] OR duodenum obstruct*[tw] OR duodenum surger*[tw] OR duodenum repair*[tw] OR triple OR ostomy OR triple-ostomy[tw] OR jejunostom* AND gastrost* AND duodenost*	99

Inclusion Criteria

Articles were considered eligible if they described the usage of “triple-tube-ostomy” technique in the management of duodenal injuries. Abstracts, case reports and other studies not including duodenal injuries or demonstrating usage of this decompression procedure in injuries other than the duodenum were excluded. Papers discussing the usage of duodenal decompression alone were also excluded.

Study review

Two reviewers independently and in duplicate screened study titles and abstracts for relevance, after which full-texts were

retrieved and evaluated for eligibility of the inclusion criteria. In case of disagreement, a third reviewer was consulted.

Data extraction and synthesis

For studies that fulfilled the inclusion criteria, reviewers abstracted the data into a specifically designed and piloted data extraction form for the purpose of this review. Data abstracted included the manuscript title, first author (s), year of publication, study design, study time period, site of the study, sample size, patient characteristics (age, sex, cause of injury, complications and mortality. Supplementary Table 1 presents the data of all the articles abstracted.

Title	Author	Time Period	Setting	Patients	Sample Size	Procedure	Follow up	Note		
Gastric Disconnection in the Management of Perforated Giant Duodenal Ulcer	Clifford A. Cranford, Jr., MD, Richard Olson, MD, and Edward L. Bradley III, MD	1984 - 1985	Grady Memorial Hospital, Atlanta, Georgia	perforated duodenal ulcers	11 patients, 5 treated medically, 6 laparatomies,	2 patients --> Vagotomy, antrectomy, and Billroth II reconstruction - sepsis and death after dehiscence of their intestinal suture lines 4 patients Gastric disconnection (truncal vagotomy, antrectomy, gastrostomy, lateral duodenostomy, and feeding jejunostomy)	Patients returned for elective gastrojejunostomy 3 to 4 weeks after discharge. Uneventful antecolic gastrojejunostomy was performed in each patient. At last follow-up 12 to 29 months postoperatively, no further gastrointestinal difficulties had arisen in any of the patients who underwent gastric disconnection.			
Triple-ostomy: management of perforations to the second part of the duodenum in patients unfit for definitive surgery	PJJ Herrod, D Kamali, SCB Pillai	2011	Department of General Surgery, Lincoln County Hospital, Lincoln, UK	peptic ulcer perforation	57-year-old man	tipe tube ostomy	On the 39th postoperative day, both the gastrostomy and duodenostomy were clamped and an oral water soluble contrast study demonstrated no leaks. Over the next two weeks the patient's tube duodenostomy, gastrostomy, subhepatic drain and jejunostomy were removed after ensuring that he had established a normal oral diet and had an adequate calorie intake.	Stone HH, Fabian TC. Management of duodenal wounds. J Trauma 1979; 19: 334-339.		

Triple-Tube-Ostomy: A Novel Technique for the Surgical Treatment of Iatrogenic Duodenal Perforation	Triple-Tube-Ostomy: A Novel Technique for the Surgical Treatment of Iatrogenic Duodenal Perforation	November 2009 and March 2011	iatrogenic duodenal perforation	3 patients		<p>Case 1:</p> <ul style="list-style-type: none"> - age: 75 - sex: female - moi: endoscopic mucosal resection (EMR) iatrogenic - 3rd part duodenum - 33 days length of hospital stay <p>Case 2: 64 years, male, 3rd duodenum, 28 days in hospital stay</p> <p>Case 3: 58 years, female, 2nd duodenum, 23 days length of hospital stay duodenostomy was clamped on day 23, and the C-tube was clamped on day 25. The patient was discharged on day 33, and no complications were observed.</p>	Enteral nutrition was started 2 days after the operation, and the patient resumed a scheduled diet on day 18. The retrograde	decrease any tension at the repair site.	The third principle, involving a feeding enterotomy, enables early enteral nutrition that may well have a positive effect on immune function and nourishment status.	
Traumatic perforation of a duodenal diverticulum	Fowler, Jessica S, MD; Cheatham, Michael L, MD; Sandler, Bryan, MD; Padron, Alberto, MD		diverticulum of 2nd portion duodenal perforation due to trauma	45 year old female			letter to editor	exclude no tripleotomy procedure		
Ten-Year Experience of Managing Giant Duodenal Ulcer Perforations with Triple Tube Ostomy at Tertiary Hospital of North India	Wasif Mohammad Ali 1 & MM. Ansari 1 & Syed Amjad Ali Rizvi 1 & A. Z Rabb 1 Tariq mansoor 1 & Syed Hassan Harris 1 & Mohd Sadiq Akhtar 1	May 2005 to May 2015.	J.N Medical College Hospital, AMU	giant duodenal ulcers	24 males and 10 female patients 40-60 years			Twenty-eight patients were discharged on 21st postoperative day and four patients were discharged on 42nd postoperative day. Two patients died within 3rd postoperative day due to septicemia.	uniformly have high leak rate (>10%) and high mortality rate (10-65%)	
Isolated perforation of a duodenal diverticulum following blunt abdominal trauma	Matthew J Metcalfe, Tanwir G Rashid, and Richard le R Bird			duodenal diverticula perforation following trauma	58-year-old man					exclude no tripleotomy procedure

Duodenal perforation following blunt abdominal trauma	Hemanga K Bhattacharjee, Mahesh C Misra, Subodh Kumar, and Virinder K Bansal	2011	Department of Surgical Disciplines, All India Institute of Medical Sciences, New Delhi, India	duodenal perforation following blunt abdominal trauma	<p>Patient 1:</p> <ul style="list-style-type: none"> - Age: 14 years old - Sex: male - MOI: fall from a bullock car (blunt abdominal trauma) - Duodenal injury: two perforations, one on the anterior and the other on the posterior wall of the duodenum - Initial management: duodenorrhaphy of the anterior perforation (posterior perforation was missed initially) - Follow-up: Patient returned on 6th POD with high-grade fever, altered mental status, abdominal distension and bilious discharge from the laparotomy wound <p>Patient 2:</p> <ul style="list-style-type: none"> - Age: 21 years old - Sex: male - MOI: fall from a scooter - Initial management: duodenal injury missed during the initial assessment in the emergency department - Follow-up: patient returned 24 hours after discharge with abdominal pain and vomiting 	through the proximal jejunum, and a feeding jejunostomy and polypropylene mesh laparostomy were performed. He was discharged home on POD 42				
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<p>login details: http://www.lupinepublishers.us/mailler_info/ username: admin@lupinepublishers.us password: test</p>	Pawanindra Lal, Anubhav Vindal		Department of Surgery, Maulana Azad Medical College (University of Delhi), and Associated Lok Nayak Hospital, New Delhi, India	giant duodenal ulcers	<p>20 patients underwent surgery using the triple ostomy technique described in the article. During the same period, 20 patients with Giant Duodenal Ulcer perforation, who were managed in the conventional manner, were evaluated:</p> <p>16 males and 4 females in study group 1 aged <30yo, 16 aged 30-50 and 3 aged >50 years</p> <p>12 has 2-3cm duodenal perforation, 8 has >3cm</p>		<p>Hospital stay:</p> <ul style="list-style-type: none"> - 12 stayed <15 days - 6 stayed 15-20 days - 1 stayed 21-25 days - The success rate was 100% in the study group compared with 30% in the control patients - Based on the ease of the technique and the high success of the procedure in our experience in this select group, we recommend this procedure for the management of GDU perforation as a safe, reliable, and easy technique to learn. 	Controlled tube duodenostomy		
Zamie et al.	Article could not be retrieved									

Data analysis

The abstracted data were organized into descriptive table where basic statistical tests were performed. Categorical variables were represented by numbers and percentages, continuous variables were presented by means and standard deviations.

Ethical approval

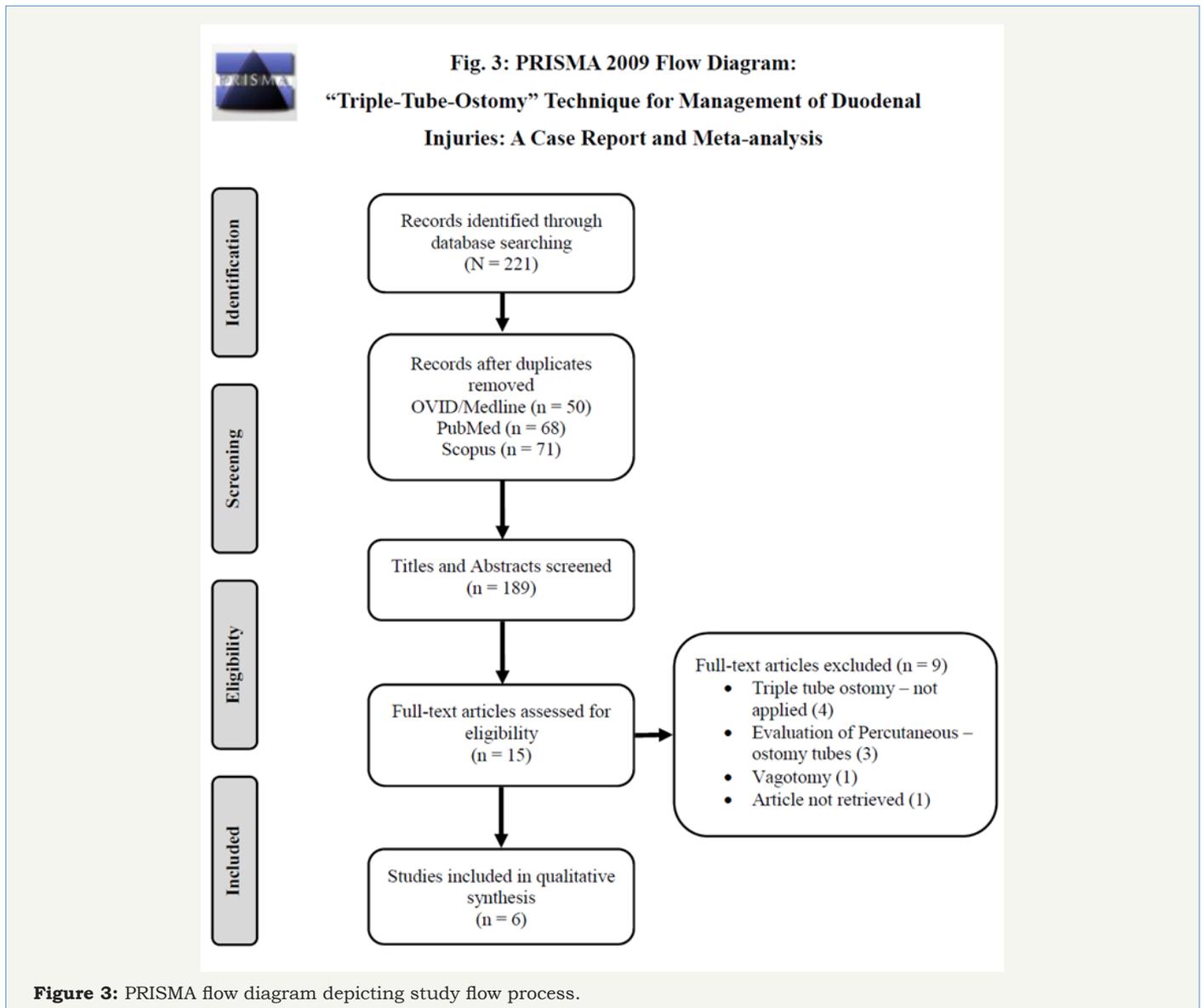
A written informed consent was obtained from the patient's father for publication of this case report and accompanying images. No IRB approval was required for the purpose of the systematic review.

Results

Results of the search

In total, 221 articles were identified using the primary literature search. Thirty-two duplicate articles were removed using the EndNote referencing software to remain with 189 articles (71 from Scopus, 68 from PubMed and 50 from OVID) being eligible for title and abstract screening. During this stage, 174 articles

were excluded. As a result, 15 articles were found eligible and selected for full-text screening. At the end of the full-text screening stage, 6 articles were relevant and reported in this review. Figure 3 presents the study screening flow processes and reasons for full text exclusions. Among the 6 studies selected [3,13,15-18], 2 prospective, 1 retrospective and 3 case studies were published between 1988 and 2016.



Study Setting, time periods and participants

Three studies were conducted in India [3,13,18], one study in United Kingdom [17], one in Georgia [15] and one study in Japan [16]. TTO was reported to be used in 4 studies following giant duodenal ulcers [13,15,17,18], 1 following iatrogenic duodenal perforation after ERCP [16] and 1 case of duodenal perforation following blunt abdominal trauma [3]. The oldest reported usage of TTO was in 1985, in Georgia [15].

In total, 64 cases of TTO's were reported in literature in addition to our case, of which, 48 males and 17 females underwent this procedure. Age groups ranged between 14–77 years, with a mean of 51.1 ± 14.6 years. Table 1 shows all study characteristics and abstracted data.

Length of hospital stay

The mean length of stay in patients that underwent TTO was 20.5 ± 14.9 days. Thirty one (49.2%) cases had a hospital stay less

than 15 days, 11 (17.4%) cases had a hospital stay between 15 -20 days and another 11 (17.4%) patients between 20 -30 days. Two cases (3.2%) had a hospital stay between 25 and 30 days, while 8 (12.6%) cases had a hospital stay more than 30 days. Longest hospital stay was reported to be 88 days postop.

Complications and mortality

Few complications were reported after TTO. Wound infection, dehiscence and burst abdomen were reported only in studies performed in India in nearly all cases reported, and so was mortality [13,18]. Three cases were only reported dead, in which the causes were attributed to septicemia in 2 cases [13] and respiratory failure due to fulminant pulmonary TB in another case [18]. Additional complications included intra-abdominal sepsis in 4 cases; pneumonitis in 8 [18], pneumonia, upper gastro-intestinal bleed [17] and 1 episode of fever [3], each in one case.

Discussion

Duodenal injury following blunt abdominal trauma is an uncommon event that is usually associated with other abdominal organ injuries, such as hepatic (38%) or pancreatic (28%) [19], making isolated injury to the duodenum alone extremely rare. It represents around 2-20% of patients with blunt abdominal injury [20], and 0.2% of all blunt trauma injuries [1,2]. Here, we have described a case of isolated transverse duodenal injury treated initially by duodenorrhaphy then re-operated with "triple-tube-ostomy" (TTO) decompression surgical technique due to leak. We have also evaluated, through systematic review of relevant English literature and meta-analysis of case studies published in this context, the extent of use of this technique to treat duodenal injuries of any cause.

Duodenal injuries are primarily caused by penetrating wounds (78%), such as gunshots and stab wounds [7], rather than blunt traumas (22%) [8]. Blunt injuries to the duodenum and pancreas are mainly caused by motor vehicle collisions (around 75 - 85%) [8,21], due to crushing of these organs between the vertebral column and steering wheel or seatbelt [7]. Other mechanisms of blunt duodenal and pancreatic injuries include falls and assaults [8,22,23]. In addition, giant duodenal ulcers complicated by perforation have been also reported to be causes of duodenal injury as well [13,15,17,18]. In our current systematic review and meta-analysis, majority of cases (59 out of 65), where TTO was used in the management of duodenal injuries, comprise surgical repair of giant duodenal ulcers perforation [13,15,17,18], whereas this technique was used in 3 other patients with iatrogenic duodenal perforation after ERCP 16 and 3 cases of duodenal perforation following blunt abdominal trauma, including our case [3].

As for morbidity and mortality rates associated with duodenal injury, studies have revealed a 14-20% mortality rate in penetrating injuries and 18-19% in blunt injuries [7,8]. Fifty percent of deaths reported are early, due to bleeding and hemorrhagic shock, while the other 50% are late, caused by complications including fistula formation, sepsis, and multiple organs failure [7,8]. Consequently,

no single surgical procedure has yet been recommended to be used for duodenal injury repair, which carries minimal rates of postoperative complications. Surgical intervention in such cases usually ranges from simple debridement of the injured duodenum and primary closure (duodenorrhaphy) of the wound, to other complex procedures, including resection and primary anastomosis of the damaged portion, duodenal decompression using TTO [3,12,113], pyloric exclusion [11], or pancreaticoduodenectomy [14].

Systematic review of world literature unveils 65 cases where TTO decompression was used to treat duodenal injuries of any cause, most of which represent surgical repair of giant duodenal ulcers complicated by perforations. While majority of cases had uneventful recovery, complications such as wound infections and dehiscence were reported. Mean length of hospital stay was found to be 20.5 days. Although it is relatively long, reaching 88 days post op in one case, but due to the severity of sepsis and the general condition of the operative cases, hospital stay should be disregarded for the uneventful recovery that most patients were having. On the other hand, mortality occurred in 3 cases, in which the causes were attributed to septicemia in 2 cases [13] and respiratory failure due to fulminant pulmonary TB in another case [18], and not due to the procedure per say. Noteworthy mentioning that higher rates of complications, including wound infection, dehiscence and burst abdomen, were reported only in studies performed in India in nearly all cases reported, and so was mortality [13,18]. This may be contributed to the higher sample size (34 cases) reported, pathogenicity, antibiotic resistance, and other factors which may be specific to the Indian population studied.

In our case, the patient was effectively managed by simple repair duodenorrhaphy followed by duodenal decompression using TTO technique. TTO comprises the insertion of a tube gastrostomy to decompress the stomach and to drain gastric secretions preventing them from reaching the duodenum, a reverse tube duodenostomy passed through the proximal jejunum reaching the second part of duodenum to decompress it and to drain bile, and an antegrade tube jejunostomy for enteral feeding since early feeding for supplementation of adequate caloric intake was found detrimental for early recovery [3]. This surgical procedure was originally described by Stone and Fabian in 1979 where only duodenal decompression was performed through reverse tube duodenostomy [24]. Time of initiation of insertion of gastrostomy tube and feeding jejunostomy as an addition to reverse tube duodenostomy could not be ascertained, but the earlier report of its use dates back to 1988 by Cranford et al. [15]. Cranford et al. [15] also performed vagotomy in order to decrease the gastric secretions to allow time for proper healing of the anastomosis site, a step that was not performed in later studies [15]. Advantages of TTO include but not limited to being rapid and requiring basic surgical experience. It is also cost-effective with least morbidity rates for managing those severely injured sick patients with favorable outcomes [3].

Limitations

Although this is the first paper to evaluate the effectiveness of usage of the TTO technique in preventing leak post duodenal injury repair, few limitations reside: firstly, the small sample size that was evaluated; second, the high rates of complications that were reported only in India especially wound infection; third and last, the fact that results of this study could not be compared to a matching group, thus opening the ground for future research to be done in this area.

Implications for Clinical Practice and Future Research

In conclusion, triple tube ostomy surgical technique is an effective option in assisting the management of duodenal injuries following trauma or duodenal ulcers perforations. Based on the pattern of few complications and very low mortality rates reported in literature, along with short length of hospital stay following this surgery, we advise the coupling of TTO technique to any definitive treatment in duodenal injury repair to prevent reoperation later due to complications, mainly leaks. In our opinion, TTO should be the first choice for managing high risk patients, until their condition stabilizes and are able to undergo definitive treatment. Besides, we recommend conducting further studies to assess the outcomes of this technique in management of duodenal injuries in comparison to other classical surgical techniques.

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Authors' Contribution

MAK, HB and HAA worked on study conception and design. FI is the attending surgeon who operated the case. HAA developed the search strategy. HAA and HB screened titles for relevance and abstracted the data from the eligible full-text articles. MAK was responsible for reporting the clinical course of the case. HB, HAA analyzed the data and drafted the manuscript. MAK, HB, HAA and FI critically revised and edited the manuscript. All authors have read and approved the final draft.

Consent

Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available upon request for review by the Editor-in-Chief of this journal.

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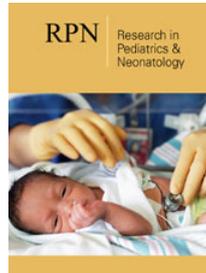
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