Traumatic Injuries to the Duodenum:

A Report of 98 Patients

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Data of 98 patients who had sustained traumatic injuries to the duodenum during a recent 7-year period is reviewed. The overall mortality was 23.5%; that of the blunt injury group was 35%, that of the penetrating injury group was 20%. However, after the establishment of a trauma unit, the mortality for duodenal injuries fell from 32% to 12%. Death from duodenal wounds may be reduced by earlier hospitalization, earlier diagnosis and consequently earlier surgical repair. Vigorous treatment of shock is essential. A specialized trauma unit with personnel experienced in the management of shock and trauma problems provides a better environment to carry out the preoperative and postoperative care of the acutely injured patient. Adequate surgical treatment of the blunt injury and missile injury of the duodenum should consist of the following procedures: 1) repair of the duodenal wall utilizing conventional techniques; 2) internal decompression of the repair by afferent jejunostomy; 3) efferent jejunostomy for postoperative feeding; 4) temporary gastrostomy; and 5) external drainage of the repair. In certain selected instances, the simple stab wound of the duodenum may be treated by conventional repair without decompression, but a loop of jujunum should be sutured over the repair to prevent delayed disruption. The majority of patients with injuries to the duodenum have associated organs injured which also require considered surgical judgment and action.

SUCCESSFUL surgical repair of a duodenal rupture was first reported in 1896,[13] but it was not until 1905 that the first detailed case report of a survival appeared. Since this time, the number of patients with duodenal injuries increased markedly[4,6] largely because of increased numbers of automobile accidents.[1,3] and the increased violence on our streets.[17] Thus, physicians treating civilian trauma are being confronted with increasing numbers of duode-

nal injuries.[4,21,24] But reappraisal of all aspects of duodenal injuries is necessary, if the tragically high morbidity and mortality is to be lowered.

Surgical management of duodenal injuries as presented in the literature is controversial, if not somewhat contradictory.[3,16,21] The experience of most surgeons in this disorder is still limited by its relative infrequency. The surgical literature on duodenal injuries mostly consists of isolated case reports or collective reviews of small series and few authors have had sufficient experience with this injury to develop comprehensive analyses of the problem.[4,6,16,23] Furthermore, many reported series include patients treated by highly variable surgical techniques during the early part of the twentieth century when principles of pre- and postoperative care were poorly developed.

The present study presents data of 98 surgically treated traumatic injuries of the duodenum in order to redefine the concepts of resuscitation, diagnosis, and treatment.

Clinical Data

Type of Injury

From January 1962 through December 1968, 98 patients (or 0.03% of all those hospitalized) were operated for traumatic injuries of the duodenum. There were 75 penetrating injuries, of which 51 resulted from small caliber gun shot wounds and 24 from stab wounds as well as 23 nonpenetrating abdominal injuries. The latter included 12 blunt injuries from automobile accidents, five patients

who were beaten, four patients who fell from various heights and two patients who were kicked and stomped upon. The overall mortality was 23.5% (Table 1).

Sex and Age

The series included 86 males and 12 females who ranged in age from six to 52 years (average 29 years) (Table 2). The majority were between 20 and 40 years (Table 3). The average age of the patients who died was 33 years.

Admission Findings

Twenty-four of this series were admitted in shock; of these, four incurred blunt injury, 14 gunshot wounds and six were stabbed. Thirteen (54%) of these were refractory to the usual preoperative resuscitative measures and required emergency surgery as part of their resuscitation; 12 subsequently died. No male patient complained of testicular pain and none had soft tissue emphysema. Thirteen of 19 adult patients with blunt abdominal injury were intoxicated at the time of their injury. Most of these did not seek medical care immediately following their accident, but waited until they were sober; then, they were unable to remember, or failed to give an accurate account of an accident. Lack of an accurate history often misled the examining physician into incorrect diagnoses. Consequently, many patients had prolonged delays in the preoperative period which may have contributed to increased morbidity and mortality.

X-Ray Findings

Seven of 17 patients with ruptures of the duodenum from non-penetrating trauma had x-ray findings compatible with intraperitoneal organ injury; 3 of these had free intraperitoneal gas. In 12 patients with penetrating trauma, free gas or retroperitoneal gas was demonstrated on scout films of the abdomen.

A correct preoperative diagnosis of intramural hematoma of the duodenum was made in four patients that

TABLE 2. *Sex and Average Age of Patients With Duodenal Injuries*

Type of Injury	Sex Male	Female	Average Age (Years)
Stab Wounds	23	1	32
Gunshot Wounds	44	7	27
Blunt Injuries	19	4	31
Mean			29

had incurred blunt abdominal trauma; the diagnosis was based upon radiographic findings of the preoperative upper gastrointestinal contrast study.[10,14]

Preoperative Management

Patients with nonpenetrating abdominal trauma present much greater diagnostic challenges than do penetrating injuries. The clinical manifestations of blunt abdominal trauma may be unimpressive early in the postinjury period; evidence of this lesion usually becomes apparent to the surgeon only when pathophysiologic derangements take place. Because they produce a paucity of signs and symptoms, retroperitoneal duodenal injuries tax the diagnostic capabilities of the most astute surgeon; early recognition and operative treatment of duodenal injuries is the exception rather than the rule. Rather than relying solely on physical findings to establish a diagnosis, the surgeon should make use of various diagnostic aids, such as abdominal films, gastrointestinal contrast studies, abdominal paracentesis and serum anylase measurements.

The majority of gunshot wound patients were operated as soon as their respiratory and circulatory function was stabilized by appropriate measurements. Seven gunshot patients, despite massive infusions of blood and colloid, remained in extreme shock prior to surgery. These patients were taken to surgery in shock to arrest massive intraabdominal hemorrhage; the emergency surgery was considered an integral part of therapy.[18,19]

Operative Findings

There were 49 injuries to the second portion of the duodenum, which was the most frequently injured part. The first portion was injured 5 times, the third portion

TABLE 1. *Type of Injury and Mortality of 98 Duodenal Injuries*

Type of Injury	Number of Patients	Deaths	Mortality
Penetrating Injuries	75	15	20%
Stab Wounds	24	2	
Gunshot Wounds	51	13	
Blunt Injuries	23	8	35%
Falls	4	2	
Blows	5	1	
Kicked	2	0	
Automobile Accidents			
Pedestrians	3	2	
Drivers	9	3	
Total	98	23	23.5

TABLE 3. *Mortality of All Patients With Duodenal Injuries in Relation to Age*

Age in Years	Number of Patients Total	Deaths
Under 9	2	1
10–19	19	2
20–29	33	4
30–39	24	7
40–49	18	8
50–59	2	1
Total	98	23

16 times and the fourth portion 13 times. Fifteen patients had more than one portion injured. The combined injuries were often the result of multiple injuries.

Six patients who incurred blunt injuries had complete transection of the injured duodenum; seven others had over 50% of their duodenal wall circumference transected; and two patients had less than 50% of their duodenal wall circumference injured. Eight additional blunt injury patients had intramural hematomas of the duodenum; two of these had coexisting perforations.

All but two of the gunshot wounds penetrated the duodenal wall in two places; i.e., they were through-and-through injuries. Many of the gunshot wounds produced large duodenal wall defects; however, the duodenum was never completely transected by a missile. Of 24 stab wounds, 17 were through-and-through injuries.

Surgical Treatment

All penetrating wounds of the duodenal wall were treated by debridement of the site of perforation and closure of the defect with either two or three layers of inverting sutures. The inner layers were closed with chromic catgut and the outer layer with silk. All sutures were placed with care to prevent compromise of the duodenal lumen; the majority of the wounds were closed in a transverse diameter.

Eight of 15 duodenal wall perforations or partial disruptions secondary to nonpenetrating trauma were debrided and closed. Five patients with complete transections of the duodenum had debridement of the wound edges and end-to-end anastomoses. One patient had the second, third and fourth portion of the duodenum resected and the gastrointestinal tract continuity reestablished by gastrojejunostomy; the pancreatic and biliary drainage was restored with a roux-en-Y loop. Another patient with blunt abdominal injury underwent partial gastric resection with gastrojejunostomy for duodenal bulb injury. The eight patients with intramural hematomas were treated by drainage of the hematoma into the lumen and bypass of the duodenum by gastrojejunostomy or various other procedures.

Various ancillary procedures were used as adjuncts to the primary duodenal repair. These producers can be divided into two categories: 1) repair of the duodenum with or without external drainage and 2) repair of the duodenum, decompression of the repair, and external drainage. Decompression of the repair was accomplished by either diverting the gastric secretions through a gastrojejunostomy or gastrostomy and jejunostomy with passage of a soft rubber catheter through the proximal jejunum to the region of repair: this will be referred to as an "afferent" jejunostomy tube. Other surgical adjuncts used in both categories include feeding jejunostomy (or "efferent" jejunostomy), gastrojejunostomy and omental

or jejunal patch, as a reinforcement of the duodenal repair.

There were 53 patients in the first category (repair with or without external drainage) who had 30% mortality (Table 4). Six surviving and eight nonsurviving patients in this group had complications, which included either duodenal fistula or gastrointestinal tract bleeding. Of the five patients with stab wounds in this group, none had injured more than one wall of the duodenum, none had external drainage and only two had injury to other organs.

The second therapeutic category included 39 patients who had some form of decompression of the duodenal repair. There were 12 blunt injuries, seven stab wounds and 20 gunshot wounds in this category. Only six (15%) of the patients in this group died; all of these deaths were among the 25 patients treated by primary repair of the duodenum, gastrojejunostomy and external drainage of the repair. Five living and one dying patient among the 25 treated by gastrojejunostomy developed either a duodenal fistula or gastrointestinal tract bleeding. Fourteen patients (4 stab wounds and 10 gunshot wounds) in this therapeutic category were treated by internal decompression of the repair. This was accomplished by passing a soft rubber catheter through the proximal jejunum to the region of repair and applying gentle suction postoperatively. These patients also had an efferent jejunostomy, gastrostomy and external drainage. All 14 of these patients survived and none developed duodenal complications or gastrointestinal bleeding.

External drainage of the area of duodenal repair was accomplished with multiple Penrose drains through

TABLE 4. *Surgical Management of 92 Patients With Traumatic Perforations of the Duodenum*

Surgical Procedure	Number of Patients	Deaths	Complications Living Patients	Complications Dying Patients
Repair Group	53	16	6	8
Repair only	5	0	1	0
Repair and Drainage	31	11	2	6
Repair, Drainage and Gastrostomy	9	3	2	1
Repair, Drainage, Patch with Jejunum or Omentum	8	2	1	1
Repair and Decompression Group	39	6	5	1
Repair Duodenum, Drainage, Afferent and Efferent Jejunostomy and Gastrostomy	14	0	*j*	0
Repair, Drainage and Gastrojejunostomy	14	2	4	0
Repair, Drainage Gastrojejunostomy and Gastrostomy	11	4	1	1

lateral stab wounds in 52 patients; 29 other patients had a combination of multiple Penrose drains, and sump or Chaffin-Pratt drainage. The pancreas, liver and gall bladder, when injured, were also drained and repaired.

Associated Injuries

Associated injury to adjacent organs commonly accompanied duodenal injury. Data of 206 associated abdominal injuries in 88 patients are summarized in Table 5. The pancreas was the most frequent associated organ injured; this was followed by liver, stomach, small bowel, vena cava, genito-urinary system, extra-hepatic biliary system, major arteries, etc. Extra-abdominal injuries also accompanied duodenal trauma, especially in the patient with multiple blunt injury and multiple gunshot wounds. Three of the blunt injury patients had concomitant chest injuries including multiple fractured ribs, hemothorax and pneumothorax.

Delay in Treatment

The majority of our patients were transported from the scene of the accident to other hospital emergency rooms, doctors' offices or other first aid areas. Often after considerable delay, the patient was transferred for definitive surgical care. Many of the transferred patients arrived in shock, frequently with either inadequate or no attempts at resuscitation. This prior, but often inadequate, medical therapy was reflected in the increased mortality (Table 6). Thus, 62 patients receiving prior medical therapy had a mortality rate of 27%. In contrast, the mortality for 36 patients brought directly to the institution was 17%.

Prior medical therapy often contributed to delays in the surgery. We have noted a direct relationship between mortality and the time interval from injury to surgery. Those patients who survived were found to have been

TABLE 6. *The Relationship of Previous Medical Treatment to Mortality*

Type of Injury	No Previous Treatment		Previous Treatment	
	Number	Died	Number	Died
Stab Wounds	12	2	12	0
Gunshot Wounds	19	3	32	10
Blunt Injuries	5	1	18	7
Total	36	6 (18%)	62	17 (27%)

operated upon three times as early as those patients who subsequently died. However, even in surviving patients, the time interval from injury to surgery was unduly long and should have been reduced.

Effect of Specialized Facilities for Treatment of Trauma Victims

Initially, injured patients were admitted to the general surgical services, but about midway through this study a trauma and shock unit was established to provide specialized care for trauma patients. Forty-one patients with duodenal injuries were cared for on this unit; 5 or 12% died. By contrast, during the 4 years preceding the establishment of the trauma unit 18 of 57 patients with duodenal injuries (32%) died. Only 3 deaths occurred in the group of 26 gun shot wound patients treated on the trauma unit, in contrast to 10 deaths among 25 patients treated for missile injuries before the trauma unit. The patients treated in the trauma unit sustained more severe injuries; the majority of the 23 surviving gun shot wound patients from the trauma unit group had multiple associated organ injuries, including 10 vena cava and 11 hepatic injuries. Moreover, patients treated on the trauma unit had an average of 2.8 associated organs injured, compared to only 1.7 associated organ injuries among the missile injury patients treated before the trauma unit was initiated.

Complications and Mortality

There were 85 postoperative complications in 43 surviving patients and 43 complications in 19 patients who died (Table 9). Infection was the commonest complication; it accounted for 34% of nonfatal complications and for 28% of the complications in fatal cases. Pulmonary

TABLE 5. *Associated Intra-Abdominal Injuries in 88 Patients*

Type of Injury No. of Cases	Gunshot 51	Stab 20	Blunt 17	Total 88
Organ Injured				
Pancreas	18	10	9	37
Liver	23	6	3	32
Colon	18	4	2	24
Stomach	18	2		20
Small Bowel	15	3	1	19
Vena Cava	14	4	1	19
Genito-urinary	10	3	1	14
Extra-hepatic	10	2	1	13
Major arterial	10	3		13
Retroperitoneum	1	2	2	5
Spleen	2	1	1	4
Diaphragm	1	2	1	4
Aorta	2			2
Total	142	42	22	206

TABLE 7. *Relationship of Time Interval From Injury to Surgery*

Type of Injury	All Patients		Living Patients		Dying Patients	
	Cases	Hours	Cases	Hours	Cases	Hours
Stab Wounds	24	6.2	22	6.5	2	4
Gunshot Wounds	51	7.3	38	5.3	13	18.3
Blunt Injuries	23	115.4	15	86.6	8	169.2
Total	98	35.1	75	21.8	23	71.7

TABLE 8. *Relationship of the Trauma Unit to Mortality From Duodenal Injuries*

Type of Injury	Before Trauma Unit			In Trauma Unit		
	Number	Deaths	Percentage	Number	Deaths	Percentage
Stab Wounds	14	1	7%	10	1	10%
Gunshot Wounds	25	10	40%	26	3	12%
Blunt Injuries	18	7	39%	5	1	20%
Total	57	18	32%	41	5	12%

complications accounted for 32% of nonfatal complications and 21% of the complications in dying patients.

Of the complications specific for duodenal injuries, duodenal fistula was observed in 10 patients, 4 of whom died. Five surviving and five nonsurviving patients had postoperative gastrointestinal bleeding. Data of other postoperative complications are detailed in Table 9.

Twenty-six patients underwent one or more additional operations to correct postoperative complications or to reestablish gastrointestinal tract continuity (Table 10); nine of these patients died. The secondary operations included 13 operations to drain various infections and 11 operations to control gastrointestinal or intra-abdominal bleeding. Nonfunctioning gastrojejunostomies were revised in four patients. Six patients had colostomies performed at their initial operation; these colostomies subsequently were closed. One patient underwent closure of a duodenal fistula and another patient was operated on to correct a pancreatic fistula.

Four patients who did not recover from severe shock expired during the first 24 hours following surgery. Their shock state was not altered by massive infusions of electrolyte solutions, plasma, colloid and whole blood. Each of these patients had multiple associated injuries that materially contributed to their fatal outcome.

Discussion

During the past 25 years, the routine use of whole blood transfusions, antibiotic therapy, a better understanding of fluid and electrolyte replacement, improved anesthesia and earlier surgical exploration have failed to lower appreciably the morbidity and mortality of traumatic duodenal injuries. We believe that certain modifications and refinements in operative technique and improvements in pre- and postoperative care can reduce the previous excessive morbidity and mortality from traumatic duodenal injuries to more acceptable levels.

There is considerable controversy about the optimal treatment of the injured duodenum in the medical literature. Various authors have proposed a spectrum of therapy from simple closure[7,26] on the one extreme to resection of the injured duodenum[3] on the other extreme. The majority of authors advocate additional surgical procedures to defunctionalize the duodenum, in order to protect and insure the integrity of the repair.[21] The latter procedures include: 1) diversion of the gastric secretions from the repair as in gastrojejunostomy,[24] duodenojejunostomy,[6,15] and duodenostomy;[9,16] 2) internal decompression of the repair as in afferent jejunostomy;[21] 3) exclusion of gastric secretions as in pyloric closure;[22] 4) removal of gastric secretions by gastrostomy;[5] and

TABLE 9. *Postoperative Complications*

Complication	Living Patients (43)	Dying Patients (19)
Infection		
Wound Infection	19	5
Intra-peritoneal Abcess	9	4
Septicemia	1	3
Pulmonary		
Bronchopneumonia	15	8
Atelectasis	8	1
Pleural Effusion	4	
Hemorrhage		
Gastrointestinal	5	5
Intra-abdominal	1	4
Gastrointestinal		
Duodenal Fistula	6	4
Pancreatic Fistula	6	1
Anastomatic Obstruction	2	2
Biliary Tract Fistula	3	1
Renal		
Anuria		3
Neurological		
Delerium Tremens	6	2
Total	85	43

TABLE 10. *Summary of Secondary Operations*

Operation	Living Patients (17)	Dying Patients (9)
Drainage of Abscesses		
Subphrenic	5	3
Pelvic	2	1
Intra-abdominal	1	
Subdiaphragmatic	1	
Control of Bleeding		
Gastrointestinal	3	5
Intra-abdominal	1	2
Revision of Gastro Jejunostomy	2	2
Closure of Fistula		
Duodenal	1	
Pancreatic	1	
Closure of Colostomy	6	
Total	23	13

5) inhibition of gastric secretions by antrectomy and vagotomy.[9]

The morbidity and mortality of the present series indicate that some form of internal decompression of the repair should be an integral part of the surgical treatment of traumatic perforations of the duodenum. This decompression may be accomplished by gastrojejunostomy or by jejunostomy which permits suction in the early postoperative period. An "afferent" jejunostomy tube for internal decompression provides the means for reducing the hydrostatic pressure normally present within the duodenal lumen.[2] This hydrostatic pressure arises from the large volume of biliary, duodenal, gastric and pancreatic secretions normally passing through the duodenum. Edema of the duodenal wall at the site of surgical repair, collection of fluid within the duodenal lumen, and decreased peristaltic acitvity follow injury and repair. These factors increase both the volume of fluid within the lumen and the duodenal emptying time. The increased hydrostatic pressure that results may be great enough to disrupt mechanically the repair. Use of internal decompression tends to prevent accumulation of fluid that may lead to a failure of the repair.

Ten patients in our series developed a duodenal fistula, and 4 of these patients died as a direct result of the fistula. Duodenal fistula, which is a most distressing postoperative complication may lead to uncontrolled loss of duodenal contents, starvation, severe wasting, cachexia, and fluid-electrolyte problems including metabolic alkalosis, dehydration, hyponatremia and hypokalemia.

Some authors advocate jejunostomy tubes for treatment of a duodenal fistula.[8,25] By inserting a jejunostomy tube at the time of primary repair, the surgeon may discourage fistula formation. If a duodenal fistula develops, the previously inserted jejunostomy tube provides an immediate means of treatment without resorting to subsequent surgical procedure.

The repair may also be decompressed by gastrojejunostomy. However, the patient may develop a marginal ulcer, if truncal vagotomy is not performed at the same time.[3,15] Four of our patients treated by gastrojejunostomy without truncal vagotomy developed marginal ulcers; two of these patients later bled massively and required emergency surgery.

The majority of patients with traumatic injuries of the duodenum are extremely ill when brought to surgery; frequently they have serious associated injuries that also require surgical correction. Any procedure that reduces the magnitude of operation or decreases the operating time is highly advantageous. The placement of two jejunal tubes and a gastrostomy may be accomplished rapidly as compared with the added operating time necessary to perform truncal vagotomy and gastrojejunostomy. When the "three tubes" (afferent jejunostomy for decompres-

sion, efferent jejunostomy for feeding, and gastrostomy for decompression proximal to duodenal repair) are used, the possibility of the patient later developing fistula or marginal ulcer is minimized.

A temporary gastrostomy is constructed to insure adequate gastric aspiration and decompression proximal to the duodenal closure. Many patients with duodenal injuries require prolonged gastric decompression; temporary gastrostomy eliminates the need for extended nasal intubation which often leads to respiratory and gastrointestinal complications.[12,20]

Simple repair without decompression may be adequate for small stab wounds of the first or second portion of the duodenum, especially when there are no associated abdominal injuries. Five stab wound patients of the present series had simple repair of a single injury, but one of these patients developed a duodenal fistula. If the surgeon elects only to repair the small stab wound, the fixation of a loop of jejunum over the repair may be indicated.[7]

Delay in diagnosis and consequent delay in surgical intervention were two factors that contributed to unsatisfactory results, especially in patients with blunt injury. Delayed diagnosis results from delayed hospitalization, inadequate history, especially in the inebriated patient, prolonged hospital observation, lack of initial symptoms or physical signs referable to the duodenum and failure to suspect this disorder on the part of the attending surgeon. In the present series, the surviving patients were operated on much sooner than those who subsequently died. This is in disagreement with Cocke and Meyer[7] who found that the number of hours from injury to operation apparently had no bearing on morbidity or mortality rates. Patients that were brought directly to the hospital had a much lower mortality than those patients treated for variable periods of time elsewhere and then transferred.

Twelve of 24 patients admitted in shock expired. Nine patients were admitted to the trauma unit in shock; four of these patients died. An additional 5 patients went into shock after being hospitalized; however, none of these patients were treated on the trauma unit. Aggressive management and prevention of shock were considered essential in the preoperative management of these patients. Further reductions in the mortality associated with duodenal injuries may come through improvement in the therapy of shock; trauma centers may provide the highly specialized care necessary to treat optimally the injured patient who is in shock and to prevent shock from occurring.[18,19]

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