Penetrating Wounds of the Abdomen:

Analysis of 776 Operative Cases

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MORTALITY rate in operative management of penetrating wounds of the abdomen has fallen 100 per cent in fifty years. This decrease is of interest to all surgeons, military and civilian. During World War I, the mortality rate for this type of casualty was 53.5 per cent;[30] it fell to 25 per cent during World War II,[3] to 12 per cent during the Korean War,[1] and today is approximately 3 per cent in civilian casualties. Varied components in improved prognosis in these injuries have been divided into four major categories: application of principles learned during the war years; improvement in surgical technic in hepatic, pancreatic and vascular trauma; ancillary care of the injured patient in the emergency room, operating room and intensive care area; and integrated surgical residency programs in which residents and nurses are trained in trauma.

Ambrose Paré[11] pointed out the difference in tissue damage produced by gunshot wounds as compared to knife injuries. Ziperman[33] further pointed out increased destruction by high velocity missiles. Wilson,[32] Moore and Singleton,[18] Poer[20] and others evaluated other differences between civilian and military abdominal wounds.

Presented at the Annual Meeting of the Southern Surgical Association, December 6–8, 1966, Boca Raton, Florida.

Material

There were 311 cases of penetrating wounds of the abdomen seen at the Robert B. Green Hospital, San Antonio, Texas from July 1950 to July 1956. Operative mortality rate was 6.4 per cent. These cases were reported previously[16] and are referred to as Series I. This institution is a city-county charity hospital, where residents operate under supervision of staff surgeons. San Antonio has a 40 per cent Latin American population. From January, 1957 to January, 1966, in 465 cases from the same institution operative mortality rate was 3.4 per cent; these cases are referred to as Series II. Combining Series I and Series II, 776 operative cases of penetrating wounds of the abdomen were analyzed.

Surgical Principles Learned During the War Years

Surgical principles learned during the war years apply mostly to the hollow viscera of the abdomen and especially to the gastrointestinal tract.

Incidence. Comparisons of age, race and sex of these patients are shown in Table 1. Abdominal wounds occurred in patients of all ages from one to eighty years; over 60 per cent were, however, in the ages between 20 and 40 years. Approximately 20 per cent of patients were younger than 20

TABLE 1. *Sex, Age, Racial Distribution*

Years	Sex		Age Group			Races		
	M	F	0–20	20–40	40–80	L	N	O
1950–56	281	30				242	47	22
1956–66	421	44	109	273	83	370	61	34
Totals	702	74				612	108	56
Per cent	90	10	23	60	17	79	14	7

Abbreviations: M—Male; F—Female; L—Latin American; N—Negro; O—Other races.

years and approximately 20 per cent were between 40 and 80 years.

Latin Americans comprised 79 per cent of those injured; 14 per cent were Negro, 7 per cent were of other categories. Ninety per cent of cases were men.

Seventy per cent of injuries were stab wounds, the majority inflicted by knives; 30 per cent were gunshot wounds, either pistol or rifle, frequently with multiple bullets.

Injuries were inflicted in all quadrants of the abdomen and some entered from the back, chest or buttocks. Of the most recent 465 cases, 38.5 per cent were in the left upper quadrant, 33.3 per cent in the right upper quadrant; most others were in the lower half of the abdomen.

As shown in Table 2, an average of three units of blood per patient was given in Series I as opposed to one unit per patient in Series II, in which 40 per cent required no blood.

Gastrointestinal Wounds. Table 3 shows 263 cases of gastrointestinal injuries in the 1957 to 1966 series with no mortality attributed specifically to the injury. Combining Series I and Series II, there were 102 gastric injuries treated by a simple two-layer closure technic. Division of the gastrocolic ligament was carried out to inspect the posterior wall of the stomach for perforations.

There were 31 (4%) duodenal injuries. The duodenum was mobilized when there was possibility of involvement of the posterior wall of the second, third, and fourth portions of the duodenum.

The small bowel was injured more frequently than any other abdominal viscus; 165 cases (21.1% excluding the duodenum) in the combined group.

Whether simple closure of wounds in the bowel or resection was performed depended on the number of holes in the intestine and on blood supply. If mesenteric vessels were divided and the blood supply compromised, resection was necessary.

The colon was the second most frequently injured viscus, 119 cases (15.3%) in the combined series. There were no deaths attributable to colonic injuries in 776 cases treated by surgical residents. Mobilization of retroperitoneal portions of

TABLE 2. *Analysis of Wounds and Blood Utilized*

	1950–56	1957–66	Total	%
Stab	247	297	544	70
G.S.W.	64	168	232	30
Blood	2.8	1		
Site*	LUQ-180	LLQ-78	RUQ-155	RLQ-52

Blood—average number of pints per case.

* Left upper, left lower, right upper, right lower, abdominal quadrant injured in Series 2.

TABLE 3. *Wounds of Gastrointestinal Tract*

Year	Cases	Stomach	Duodenum	Intestine	Colon
1950–56	(311)	40	17	53	44
1957–66	(465)	62	14	112	75
Total	(776)	102	31	165	119
Per cent		13.1%	4.0%	21.1%	15.3%

TABLE 4. *Wounds of Hollow Viscera*

Year	Biliary	Urinary	*Peritoneum
1950–56	9	25	95
1957–66	8	51	110
Total	17	76	205
Per cent	2.1%	9.8%	26.4%

* Negative Explorations. Total Cases Reviewed—776.

the colon was frequently necessary. With injuries of the sigmoid and rectum, wounds were closed primarily and proximal colostomies were performed with drainage. In other areas of the colon, colostomies were performed at the wound site. Colostomies were closed usually in three to six weeks. A few stab wounds of the colon were closed primarily, however.

Wounds of Hollow Viscera. Table 4 shows the incidence of wounds of biliary and urinary tracts. The gallbladder was injured 17 times (2.1%). Either cholecystectomy or cholecystostomy was carried out with a drain inserted through a stab wound. There were no injuries to major bile ducts.

There were 76 injuries (9.8%) of the urinary tract mostly of the bladder or kidney. There were several injuries to ureters in Series II, but none in Series I. Intravenous pyelograms were done prior to operation or on the operating table.

In 205 instances the peritoneum only was penetrated with no viscus or major blood vessel involved. Viscera were involved in 571 cases (73.6%). Laparotomy for stab wounds has decreased during the past nine years because of careful observation as reported elsewhere.[23] Diagnostic peritoneal lavage as described by Root[22] has advantages over the four quadrant abdominal tap and is now used when there is doubt.

Improvement in Surgical Technic

Improvements in technics are principally in surgery of the liver, pancreas and vascular system and have been applied during the past nine years to the 465 cases in Series II.

Hepatic Injury. Table 5 shows that the liver was injured in 177 cases (22.8%). There were four deaths attributable to liver injuries, one of the chief causes of death in Series II. Surgical management of liver injuries has been reviewed by Quattlebaum,[21] Sparkman,[25] and Crosthwait[5] and recently by McClelland[15] and Longmire.[14] Liver injuries may be divided into three categories of surgical management. Simple penetration or laceration of the liver edge may be treated by drainage after suture of the wound. More extensive damage may require debridement and large catgut sutures placed in overlapping rows to control bleeding and to reduce bile drainage. In this type of injury, drainage in the lumbar area may be required in addition to that provided anteriorly. The third type is the severe wound, in which a large amount of liver parenchyma is destroyed. This may require wide resection or lobectomy. Frequently wounds extend over the dome of the liver and hemostasis and exposure is the primary problem, especially in the right lobe.

Total isolation of the liver from its blood supply as described by Heaney including clamping of the vena cava above the liver may be required. Glenn[8] Merendino[17] and others emphasize the importance of T-tube drainage of the common bile duct and operative cholangiograms to determine the extent of hepatic damage.

There were 60 injuries (7.7%) to the spleen treated by splenectomy.

Pancreatic Injury. Table 5 also shows 32

TABLE 5. *Wounds of Solid Viscera*

Year	Cases	Liver	Spleen	Pancreas
1950–56	(311)	72	17	12
1957–66	(465)	105	42	20
Total	(776)	177	60	32
Per cent		22.8%	7.7%	4.1%

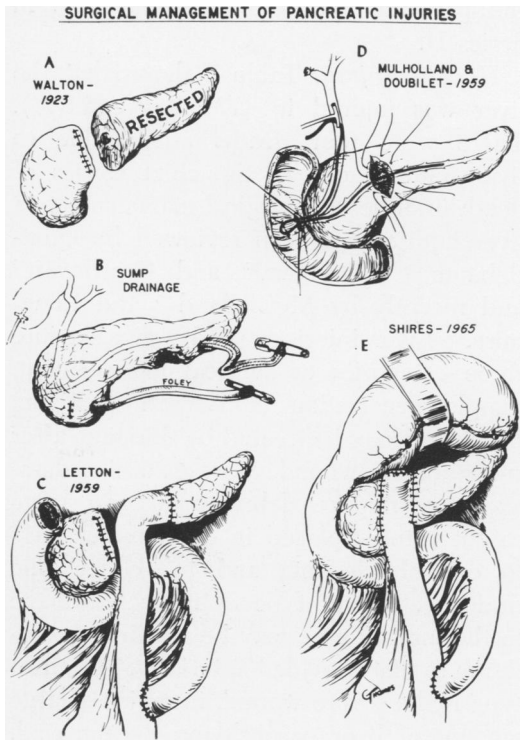

FIG. 1. The surgical management of pancreatic injuries. Various technics were proposed by different authors on the dates indicated.

cases (4.1%) of pancreatic injury in the combined group. These injuries were more frequently caused by gunshot than by stab wounds and are usually accompanied by multiple organ damage.

Surgical management of pancreatic injuries has been reviewed by Howard and Jordan,[10] Shires,[24] Thompson,[28] Stirum,[27] and others. Briefly these injuries may be divided into three categories as seen in Figure 1. 1)Simple pancreatic injury requires only drainage with a soft sump drain and a simple suture for hemostasis with minimal or no debridement; 2) extensive injury with transection of the pancreas may be treated by closure of the proximal segment of the pancreas and resection of the distal segment as Walton[31] described. Implantation of the distal cut edge of the pancreas into a Roux-en-Y loop of jejunum as described by Letton[13] may be carried out. If transection is an isolated injury, implantation of both ends of the pancreas to a Roux-en-Y loop of jejunum as described by Shires[24] may be performed. For isolated transection of pancreatic duct, the Mulholland and Doubilet[6] procedure may be done; 3) finally, with multiple abdominal injuries, repair of liver and vascular injuries is mandatory, while the repair of the pancreatic injury may be delayed, relying only on sump drainage as a life saving measure.

TABLE 6. *Vascular Injuries (Series II)*

Organ	Case	Treatment	Result
Heart	3	Sutured	1 survived
Aorta	4	Sutured	1 survived
Iliac vein	5	Sutured	4 survived
Vena cava	12	Sutured	10 survived
Mesenteric vein	27	Ligated	27 survived
Right colic artery	1	Ligated	1 survived

Vascular Injury. In Table 6 are listed 52 cases in Series II of vascular trauma reaching the operating room. Three abdominal aortic injuries were repaired by suturing and one by a prosthetic graft. One patient with sutured aorta survived. Nine vena cava injuries were due to gunshot wounds and three to stab wounds. In five patients injured iliac veins were sutured; four survived. There were multiple organs damaged in these cases. Mesenteric vascular damage involved smaller vessels in 27 cases and the right colic artery in one; simple ligation in all resulted in recovery. These injuries were caused mostly by stab wounds.

In vascular injuries a minimum time lapse before hemostasis is accomplished has been emphasized. Hemostasis is the first consideration and vascular repair is second. An average of 3,500 cubic centimeters of blood were transfused for each major vascular intra-abdominal injury that survived as opposed to the overall average of 500 cubic centimeters per patient.

In Series II, we accepted greater operative risks, but we salvaged more patients than in Series I. After hemostasis is accomplished by direct tamponade, vascular

clamps can usually be applied proximal and distal to the injury and the wound can be closed by suture. In veins, direct finger control of the proximal or distal vessel may be preferable. As in the intestinal tract, the posterior wall of the vein should be examined. If it is not feasible to roll the vessel over, it may be necessary to enlarge the anterior wound and to suture the posterior wall and then close the anterior wall. When large segments of veins are removed as in gunshot injuries, veins below the renals may be ligated if repair is not feasible. After debridement of arterial injuries, autogenous vein grafts, patch or prosthetic grafts may be required if direct suture or anastomosis is not applicable. The technic has been described by Beal *et al.*,[2] Ferguson,[7] Treiman [29] and others. Retroperitoneal hematomas were explored as emphasized by Streichen.[26]

When damage to renal vessels is suspected, intravenous pyelogram is performed to insure the presence and function of the opposite kidney.

Total Patient Care

Improvement in total patient care involves principally preoperative and postoperative care as well as anesthesia. During the period of Series I, a full-time anesthesiologist was not available and the intensive care unit had not been developed. Since addition of these facilities, morbidity and mortality rates in Series II have improved. The advantages of complete preoperative care in emergency rooms and operating rooms are still not broadly appreciated.

In the emergency room an adequate airway is insured; a large bore needle is placed into an upper extremity vein or external jugular vein for infusion of electrolyte solution, and the patient's blood is cross-matched and typed for transfusion. Type O Rh negative blood is used, if the situation is critical. A Levin tube is placed in the stomach and a Foley catheter in the bladder. If the patient does not respond rapidly, he is taken immediately to the operating room for further resuscitation. Time lapse from emergency room to operating room has decreased to approximately forty minutes in recent years. Triage of critically injured patients from less injured and rapid transport to the operating room of the critically injured has been emphasized by Noer,[19] Kennedy,[12] De Bakey [32] and others. Plain x-rays of the abdomen, chest x-rays, and intravenous pyelograms are obtained, when indicated, if conditions permit. Intratracheal intubation, while the patient is conscious, and central venous pressure monitoring are frequently utilized.

TABLE 7. *Cause of Death in 776 Cases*

Site of Injury	1950–1956	1957–1966
Vascular	10	5
Pulmonary	5	4
Liver	1	4
Heart	1	2
Cardiac arrest	1	1
Peritonitis	1	
Drug reaction	1	
Total deaths	21	16
Mortality rate	6.4%	3.4%

The causes of death in Series I and II are compared in Table 7. The chief causes of death were cardiovascular and severe liver injuries, in which exsanguination was the primary factor. Two deaths were due to stab wounds of the heart; if these two deaths are omitted, mortality in Series II was 3 per cent. Four pulmonary deaths were due to aspiration, bronchopneumonia, and pulmonary edema. All of the deaths were in patients with multiple organ damage. No deaths in Series II were attributed to peritonitis.

Complications. In Series II there were 52 pulmonary complications; atelectasis, pneumonia, aspiration, pulmonary edema and others. There were ten (2.1%) cases of subdiaphragmatic abscesses. Miscellaneous complications were 5 per cent and con-

sisted of wound infections, urinary infections, and four eviscerations.

Residency Program—Trauma Oriented

The residency training program has been trauma-oriented because of the large amount of trauma seen in this city-county hospital. The well integrated surgical residency which is trauma-oriented has been emphasized by De Bakey,[32] Shires,[24] Hartman[9] and others.

Summary

Seven hundred and seventy-six cases of penetrating wounds of the abdomen occurring from July, 1950 to January, 1966 at the Robert B. Green Hospital, San Antonio, Texas, have been reviewed. The operative mortality rate of 6.4 per cent the first 6-year period decreased to 3.4 per cent the second 9-year period. Four factors responsible for reduction in operative mortality rate are discussed: 1) the application of principles in surgical management of wounds learned during the war years; 2) improvement in surgical technic in the management of hepatic, pancreatic and vascular trauma; 3) improvement in total patient care; and 4) improvement in a surgical residency program which is trauma-oriented. The fact that the majority of patients were young and that there was little time lapse between injury and hospitalization are additional factors.

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Discussion

Dr. Roger T. Sherman (Memphis): Dr. Noer, Dr. Yeager, members and guests. I would like to pick a bone with this paper, but I can't. I have had the privilege of reading it and I must say it speaks for itself.

The application of the principles outlined by Dr. Pridgen have lowered the mortality rate in San Antonio from 6%, I think, to 3%, a 50% reduction; which only goes to show that if you apply these principles, remarkable results can be obtained. Those of us who are interested in penetrating abdominal wounds and are associated with large city hospitals have comparable results.

There are a couple of things I did want to emphasize. First, I think the vascular injuries of the vena cava which are so beautifully handled in San Antonio are difficult to manage as a general rule.

Three things are important. One, which Dr. Noer has emphasized for a number of years, is that these patients should be taken to the operating room for resuscitation and not left in the receiving ward.

The second is also emphasized in the paper. Working through the anterior wound of the vena cava to repair the posterior one, is easier than trying to roll the vena cava over.

The third point that we would like to emphasize is giving blood replacement in the upper extremity, rather than in the lower extremity.

Thank you very much.

Dr. Rush E. Netterville (Jackson): Dr. Noer, members and guests. Recently Dr. James Hardy and I reviewed our experience at the University of Mississippi Medical Center for the last 10½ years, and we found that we had 155 cases of penetrating wounds of the abdomen. Thirty-five patients had arrived in a state of shock. After the treatment of shock, laparotomy was performed in 148 cases; thoracotomy in three; and a thoracoabdominal incision was used in three. The one patient who was not explored had sustained a birdshot injury from a distance.

One or more organs had been involved in 138 patients. The most common injuries were to the mesenteric small bowel, 60 cases; liver, 44; colon, 34; stomach, 28; diaphragm, 13; spleen, 10; kidneys, 9; pancreas, 7; duodenum, 6; and major vessels, 6.

One hundred and three cases were free of complications following surgery, but 50 patients developed 71 complications. The average period of hospitalization was 10½ days. There were two deaths: one, a patient with multiple vascular injuries who exsanguinated on the operating table, and the other, a patient who was admitted in a state of shock 25 hours after sustaining injury.

Dr. Albert W. Hartman (San Antonio): First of all I want to compliment Dr. Pridgen and the group at Green, both on the good work they have done in caring for the patients and on the compilation of the data.

One of the factors that may have been overlooked in the improved mortality, was the improved anesthesia. I am sure that you who have worked in city hospitals have been aware of the difficulty in getting adequate anesthesia at all times. I think we have finally got that conquered.

I want to stress the importance of exploring all penetrating wounds of the abdomen. I am not sure how many people are smart enough to pick out which ones should or should not be explored. At the Robert B. Green over a period of 17 years, 205 patients have had negative explorations, with no deaths.

I think one of the results of the advances in the teaching of vascular surgery has been the improved results in the treatment of vascular injuries.

Robert B. Green is like the Army hospitals in World War II; they were placed in the drift of the wounded. Well, the Robert B. Green is definitely in the drift of the Latin American wounded, and that is the reason we can report so many cases from that hospital.

Thank you.

Dr. James E. Pridgen (Closing): I would like to thank Dr. Sherman, Dr. Netterville and Dr. Hartman for their discussions.

Peritoneal lavage as a test to determine intra-abdominal injury deserves further emphasis; it is of more value in cases of blunt abdominal trauma but also helpful in cases of penetrating wounds of the abdomen. Briefly, it is performed by placing a catheter into the abdominal cavity, introducing about 1,000 cc. of saline, turning the patient from side to side and removing the fluid from the abdomen. About one cc. of blood will definitely color 1,000 cc. of saline. This is a safe, relatively simple test which is considerably more accurate than the four quadrant abdominal tap.