Blunt Abdominal Trauma

A 5-year Analysis of 870 Patients Requiring Celiotomy

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This study represents the experience with blunt trauma to the abdomen of patients from a major regional trauma center. Eight hundred and seventy patients with blunt abdominal trauma are reviewed, representing 12.89% of the total admissions over a 5-year period. The motor vehicle continues to be the major cause (89.5%) of injury to these patients. Thirty per cent had positive blood alcohol. Intra-abdominal injuries in this group necessitating operative intervention were based on the use of peritoneal lavage. Negative celiotomies occurred in 10.2% of these patients. Of the injuries incurred, the spleen was involved 42%, the liver 35.6%, the serosa, diaphragm, bowel, and blood vessels were involved to a lesser extent. Only 0.4% of the patients suffered direct injury to the stomach, duodenum, and pancreas, data which should preclude routine exploration of retroperitoneal structures unless by obvious retroperitoneal injury is noted. Additional surgical intervention for associated injuries was seen in 50.54% of this patient group.

ACCIDENTS ARE THE LEADING cause of death among people aged 1 to 38 years. Among people of all ages, accidents are the fourth leading cause of death following heart disease, cancer, and stroke. Motor vehicles accounted for 46,300 fatalities, 50% of all accidental deaths in 1982, and resulted in disabling injury to 1.7 million.[1]

The blunt trauma resulting from vehicular accidents causes devastating injury. Its full effect is seldom limited to one organ system, and it has become the focal point of many medical disciplines.

This study began by reviewing the patients with blunt trauma for the year of 1978. From that study, a prospective interest was initiated and certain factors and events contributing the overall profile of the victim of blunt trauma began to be appreciated and studied on a year-to-year basis. Abdominal trauma, because of its diagnostic intrigue, became the central area of focus for this study. Whether associated organ system trauma was the major element in the victim's total illness, or whether the injury to the abdomen was paramount, was not always clear. The final analysis includes all patients requiring celiotomy from January 1, 1978 through December 31, 1982.

Patient Profile

In our setting, a major regional trauma center, the motor vehicle accident continues to be the major source from which these patients come. The great majority of patients arrive by helicopter directly from the scene, where an effective emergency medical system has already initiated early resuscitation. At the trauma center, full-time traumatologists continue the resuscitation and begin diagnostic evaluation. These favorable circumstances appear to have altered some of the observations on blunt trauma that have been reported in the past.

The 870 patients undergoing celiotomy in this study (Table 1) represent 12.9% of 6745 patients admitted during the 5 years studied (1978–1982). The average age was 29.76 years. There were 2.7 men for every woman. Blood alcohol values above 100 mg/dl were observed in 22.9% of the patients. An additional 6.66% had blood alcohol values between 0 and 100 mg/dl. Automobile accidents accounted for 69.4% of the victims, the motorcycle, 11.7%, and 9.3% were pedestrians. Industrial accidents account for 3.1%, domestic (home and farm) 4.1%, and 2.7% had unrecorded injuries.

Of these 870 patients (Table 2), 50.54% had associated injuries requiring surgical intervention. A total of 38.16% had two or more systems injured (Table 3).

Results

Abdominal Findings

The following data (Table 4) represent the incidence of injury to the organs of the abdomen. Attempts to pair

TABLE 1. *Profile on 870 Patients with Blunt Abdominal Trauma Undergoing Celiotomy*

| Year | Total Admission Per Year | Patients with Celiotomy | % | Average Age (Years) | Sex Ratio | | Blood Alcohol Levels (B.A.L.s) on Admission | | | Mechanism of Injury | | | | | |
					2.7 Men	1 Women	0 to 100 mgn/dl	100 mgn/dl or Higher	Total with Positive B.A.L.	Auto	Motorcycle	Pedestrian	Industrial	Domestic Home and Farm	Unrecorded
1978	1156	266	22.60	29.90	203	63	11/266	66/266	77–29%	186	30	27	9	12	2
1979	1229	189	15.37	30.25	136	53	10/189	33/189	43–22%	119	19	19	8	9	15
1980	1280	145	11.32	29.35	110	35	14/145	36/145	50–34.2%	105	19	15	2	4	0
1981	1437	150	9.39	29.58	103	47	14/150	36/150	50–33%	102	22	10	5	6	5
1982	1626	120	7.40	29.48	85	35	9/120	28/120	37–31%	88	12	10	3	5	2
Total	6745	870	12.9	29.76	637	233	58/870	199/870	257/870	600	102	81	27	36	24
Per cent					73%	27%	6.6%	23%	29.5%	69.4%	11.7%	9.3%	3.1%	4.1%	2.7%

injuries or define patterns of injuries eventually made little sense, though there was often more than one organ involved in each accident. Every time an organ injury was observed, it was counted in the total for that organ. The criteria for celiotomy in these patients was based exclusively on diagnostic peritoneal lavage.

With blunt trauma to the abdomen, splenic injury was the most frequent consequence occurring in 42% of these patients, and in 70 (8%), it was the only injury.

Three hundred and ten patients (35.6%) sustained injury to the liver, from minor capsular tears to major fractures involving the retrohepatic vena cava. Severe liver injury was the leading cause of intraoperative death in this study. Twenty-nine (9.4%) of these patients with major hepatic injury died intraoperatively. Fracture of the liver into the retrohepatic vena cava was always fatal. There were no successful resections of major liver fragments.

The occurrence of trauma causing bleeding into the retroperitoneal space was noted in 127/870 (14.59%) of the patients and did not include hematomas associated with the major retroperitoneal organs. Injury to the vena cava, kidney, and hematomas seen with pelvic fractures were not included in this category. Retroperitoneal hematomas were seldom opened except to evaluate specific organs in this space. In general, bleeding here serves to alert one that the patient has sustained a severe injury.

Insignificant injury to the serosa and bowel mesentery is the most common injury sustained in the abdomen secondary to blunt trauma and in most instances, was the cause of false-positive diagnostic peritoneal lavage. Serosal injury of the mesentery, which in the opinion of the surgeon required repair, was discovered in 113 (13%). Repair most often consisted of control of bleeding and the closing of rents in the small bowel mesentery.

The diaphragm was ruptured 46 (5.3%) times, 43 occurred on the left side, two on the right, and one was a bilateral rupture. Except for one patient who had a delay of 3 days before diagnosis, all patients were treated at the initial operation, from the abdominal side of the diaphragm.

Bowel injury was only described when resection for perforation was completed, except for the single duodenal rupture, which was closed primarily. There were 41 (4.2%) bowel injuries. Thirty of these were small bowel and 11 were colon. There was no apparent site of predelection to small bowel injury, the ileum was involved as often as the more commonly described proximal jejunum. The distribution of injuries to the colon included two to the ascending colon, seven to the transverse colon, and two to the sigmoid colon. These figures do not include resection for vascular injury.

Of the vascular injuries encountered, the abdominal aorta was ruptured in one patient and there were no

injuries to the iliac arteries. There were 27 (3.1%) major vascular injuries. The vena cava was ruptured on eight occasions. There were 17 vascular disruptions at the root of the mesentery.

Although the kidneys and bladder are not true abdominal organs, they are included in this study because their access is through the abdominal wall in the usual trauma setting. The kidney was fractured, or severely contused, requiring opening of the Gerota's fascia in 23 patients (2.7%), resulting in nine nephrectomies. The urinary bladder was ruptured 28 times, and in all but one there was associated pelvic fracture. Nine women had ruptured ovarian Graafian follicles as the sole finding at celiotomy.

One prepyloric rupture of the stomach was described. One duodenal rupture occurred and was repaired without resection. Paraduodenal hematomas were encountered in six other patients, but required no specific surgical intervention. In one patient with a fractured pancreas, the diagnosis on the basis of peritoneal lavage was initially ignored, but computed tomography 3 days later disclosed the injury. The remaining six injuries to the pancreas were all associated with injury to the pancreas during splenectomy. Though injury to the extrahepatic biliary ducts has been seen here, none occurred in this group of patients.

Associated Blunt Trauma

Table 3 depicts a detailed analysis of associated injuries that were treated surgically under the same anesthesia usually following the abdominal procedure.

Of the 870 patients undergoing celiotomy for blunt

TABLE 2. *870 Patients Undergoing Celiotomy for Blunt Abdominal Trauma: Associated Injury Requiring Surgical Intervention*

Number of Patients	Per cent	Associated Injuries
439	50.54	Associated injury
332	38.16	Two or more injuries
301	34.6	Extremities and axial skeleton
284	32.64	Facial
161*	18.5	Head central nervous system
65	7.4	Mandible and maxillary alveolus (dental)
50	5.74	Thorax (Aorta 16/50 = 32%)

* Intraventricular pressure monitoring or craniotomy (8.5 to 1).

trauma, associated injury requiring surgical intervention occurred in 439 (50.5%) and 332 (38.2%) had two or more injuries, *i.e.,* head and skeletal, or thorax and head, etc. Fractures to the extremities and/or the axial skeleton were the most common associated injuries occurring in 301 (34.6%) of the patients. Facial trauma was an accompanying injury in 284 (32.6%) of the patients. Central nervous system injury occurred in 161 patients (18.5%). A significant observation related to this study is that there were no patients in this group with cervical spine injury and paraplegia that required celiotomy, though diagnostic peritoneal lavage is our routine procedure on these patients. In this group of patients, central nervous system injury was always of the closed head injury category and neurosurgical intervention included the placement of an intracranial pressure monitoring device.

Fifty patients (5.7%) had injury to the thorax. Sixteen of these had associated rupture of the thoracic aorta. This

TABLE 3. *Associated Injury Requiring Surgical Operative Intervention in 870 Patients Undergoing Celiotomy*

Injury to Per cent of 870		Comment
439/870	50.45% had associated injury	
332/870	38.16% two or more associated injuries	
Extremities and axial skeleton 301/870 (34.6%)	Lower Extremity 208/301 (69%) *Pelvis 50/301 (16.6%) Upper Extremity 37/301 (12.3%) † Spine (paraplegia) 6/301 (2%)	* traumatic hemipelvectomies (motorcycle) † Injury with paraplegia occurred, 1 T-5, 1 T-11, 3 T-12, and 1 L-4.
Face 284/870 (32.64%)	Midface fractures 67/284 (23.5%) Unspecified laceration (face, scalp, ears, etc.) 217/284 (76.5%)	
Central nervous system* 161/870 (18.5%)	Requiring craniotomy 25/161 (15.5%) Requiring intraventricular pressure monitoring 136/161 (85%)	* Special note: there were no patients in this group of 870 with cervical spine injury resulting in neurological deficit.
Thorax 50/870 (5.74%)	Hemopneumothorax requiring chest tube or open thoracotomy 34/50 (68%) Ruptured aorta 16/50 (32%)	One patient had rupture of the *cervical* esophagus
Dental: oral surgery 65/870 (7.47%)	Maxillo-alveolar ridge 34/65 (54%) Mandible fracture 30/65 (46%)	

TABLE 4. *Incidence Organ Injury Due to Blunt Trauma in 870 Patients Requiring Operative Intervention*

Injured Organ	Number of Patients (%)	Classification of Injury	Comment
Spleen	367 (42.18)	Only abdominal injury in 70/367 patients (8%) Splenorraphy 33/367 (9%)	2% to 3% estimated incidental iatrogenic splenectomy 39% of patients in 1982 had splenorraphy
Liver	310 (35.63)	All injury from minor capsular tears to major fracture into retrohepatic vena cava	29/310 (9.35%) died intraoperatively of liver injury
Retroperitoneal hemotoma	127 (14.59)	See text	
Serosa and mesentery	113 (13)	Only reported when injury required repair—see text	
Diaphragm	46 (5.28)	43 left, 2 right, 1 bilateral	
Bowel	41 (4.71)	Injury requiring resection † small bowel 30/41 (73%) * colon 11/41 (27%)	† 1 duodenum—see text * 2 ascending, 7 transverse, 2 sigmoid
Vascular	27 (3.10)	Vena cava 8/27 (29%) "Root" of small bowel mesentery 17/27* Aorta 1 (0.01%), 1 iliac vein	* 5 Intraoperative deaths attributed to avulsion of superior mesenteric vessels
Genito-urinary	60 (6.89)	23 (2.7%) kidney—requiring opening renal capsule * 28 ruptured bladders † 9 ruptured ovarian cysts	9 nephrectomies * All but 1 associated with pelvic fractures † Graafian follicles
Upper gastrointestinal tract stomach	2 (0.02)	1 stomach rupture, 1 prepyloric perforation	
Duodenum	1 (0.01)	1 rupture of duodenum	6 paraduodenal hematomas described
Pancreas	2 (0.02)	2: 1 midbody transection—see text 1 distal pancreas	8 injuries associated with splenectomy

small group of patients always present a dilemma, but when hemodynamically stable, the abdomen was explored prior to the repair of the aorta. Excluding thoracotomy for ruptured aorta, most of these patients had a tube thoracostomy for pneumothorax, or hemothorax, or the combination of both. There was one patient with a rupture of the cervical esophagus.

Injury to the mandible and maxillary alveolus is separated from facial trauma artificially, because it comes under the discipline of oral surgery, which was involved in 65 (7.5%) of the patients.

Mortality

Overall mortality for the 6745 patients admitted during the 5-year period was 1142 (17%, Table 5). These included those patients admitted dead-on-arrival 126 (1.86%), those who died during resuscitation in the admitting area 317 (4.69%), and those who died intraoperatively 144 (2.13%). This group of patients represent 51.4% of our overall mortality.

The mortality for the patients undergoing celiotomy was 217 (25%, Fig. 1). In this group there was 9% intra-

TABLE 5. *Total Institutional Mortality*

Year	Admissions	Dead on Arrival*	Died in Admitting Area*	Died in Operating Room*	Late Deaths In Hospital	Total	Per cent
1978	1173	27	48	37	139	251	21.39
1979	1229	13	61	28	122	224	18.22
1980	1280	24	59	24	89	196	15.31
1981	1437	30	71	26	91	218	15.17
1982	1626	32	78	29	114	253	15.56
Totals	6745	126	317	144	555	1142	16.93
% of Admissions		1.86%	4.69%	2.13%	8.22%	16.93	

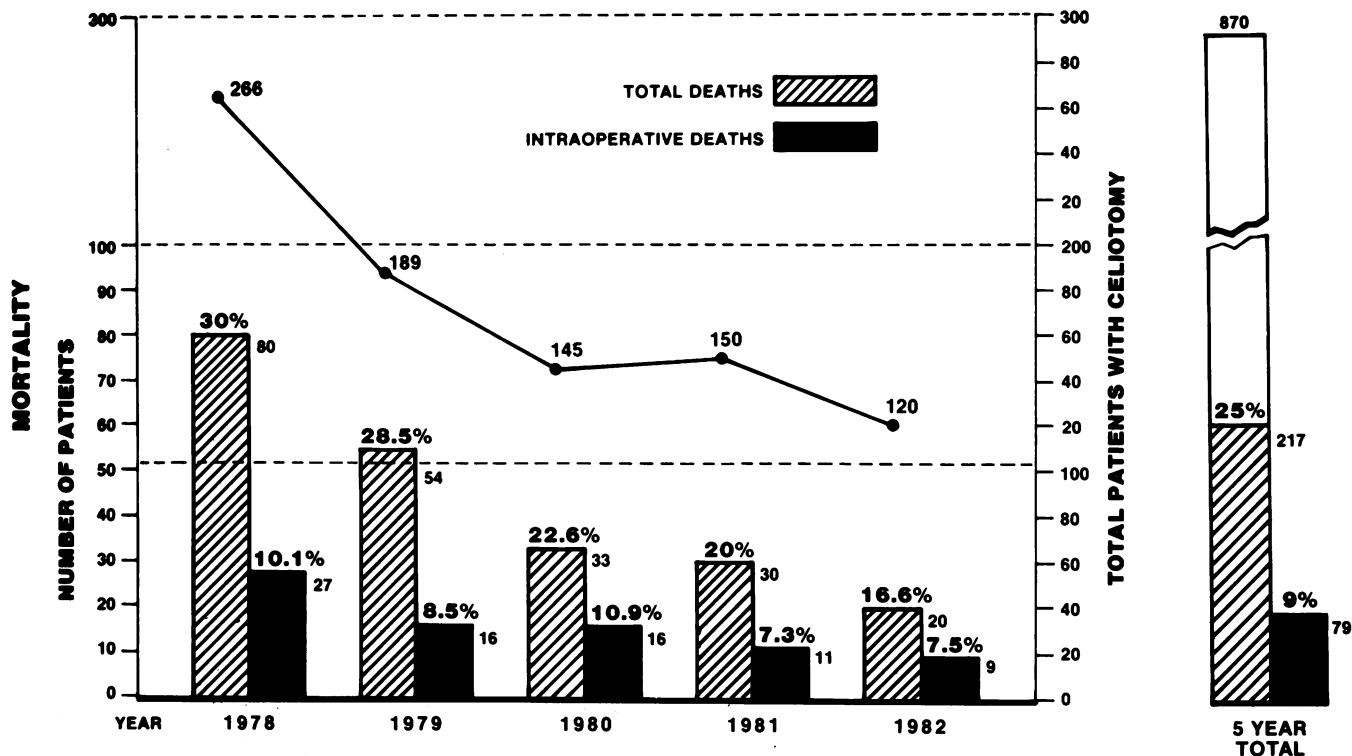* DOA, AA, OR deaths = 51.4% of total mortality.

BLUNT ABDOMINAL TRAUMA

FIG. 1. Mortality following celiotomy for blunt trauma in 870 patients.

operative mortality or 79 patients. There was a significant decline in the death rate from 30% in 1978 to 16.6% in 1982.

If both motorcycle riders and pedestrians are included with the automobile victims, 90% of our patients were injured in motor vehicular accidents. More than any other factor determining mortality and morbidity in this group of patients is the multiplicity of systems injured. A significant group of these patients not requiring specific surgical procedures suffered contusions of varying degree to lungs, heart, head, muscle mass, etc. In many instances, these injuries contributed more directly to the fatal outcome than the abdominal injury or other operable associated injury.

Discussion

The introduction of diagnostic peritoneal lavage by Root and associates[2] in 1965, and the subsequent acceptance by traumatologists, has made the diagnosis of injury to abdominal organs following blunt trauma more accurate and certain. In our institute criteria for celiotomy is based exclusively on the erythrocyte count of the effluence from peritoneal lavage.

In 1978, before our standard criteria for a positive diagnostic peritoneal lavage was established (erythrocyte count above 50,000), the incidence of false-positive studies alerted us to review this procedure (Table 6). At that time,

the midline infraumbilical incision, with its inherent difficulties, was used exclusively. The problem associated with this approach led the author to the use of a paraumbilical transrectus sheath incision.[3] This incision has gradually become the standard of this institution. In 1981, two false-negative lavages were observed—a small bowel perforation and one patient with midbody pancreatic transsection, in which the diagnosis on the basis of peritoneal lavage was initially ignored and computed tomography[4] 3 days later led to celiotomy with partial pancreatic resection and eventual recovery. The small bowel perforation developed abdominal signs, which led to a successful abdominal operation. In retrospect, it seems remarkable that only two false-negatives were seen.

The standardization of criteria and the use of the paraumbilical incision have decreased the rate of false-positive studies to the point where it should go no lower, lest we

TABLE 6. Results of Diagnostic Peritoneal Lavage*

Year	Number of Patients	False-positive	False-negative
1978	266	58 (22%)	0
1979	189	12 (6.3%)	0
1980	145	6 (4.1%)	0
1981	150	10 (6.66%)	2†
1982	120	3 (2.5%)	0

* Criteria for celiotomy: erythrocyte count >50,000.
† 1) transected body of the pancreas, 2) small bowel perforation.

miss potentially lethal injury. In this type of setting, a 5% false-positive result is near the minimum that should be accepted, in the management of these kinds of patients, where you are not able to clinically assess the abdomen, while the patient undergoes prolonged anesthesia for repair of injury to other systems or neurological injury renders the usual criteria for assessment of the abdomen invalid. Often, false-positive celiotomy is the result of an injury that has bled but is insignificant when the patient is explored.

Pneumococcal sepsis in children has raised the consideration of the need to leave the injured spleen, a relatively recent consideration for many surgeons, and the traditional surgical management of the ruptured spleen has been challenged. In 9% (33 of 367) of patients with splenic injury, splenorrhaphy was successful. Twenty of these were done in 1982 and represent 39% of the 51 spleens injured in that year. The operating time recorded by the anesthesiologist in gaining control varied from 30 minutes to 3 hours. The exact increase in the use of blood transfusions could not always be ascribed to continued bleeding of the spleen because of associated injuries, but the impression that extra blood was required was universal. The exact number of attempted splenorraphies aborted for failure to control the bleeding could not be accurately determined. Further, the true incidence of iatrogenic injury to the spleen could not be assessed, but was not greater than 2% to 3% in this series of patients. From this study, a reasonable criteria for attempting splenorraphy should include 1) the age of the patient, 2) absence of severe associated injury, 3) blood loss or transfusion requirement, *i.e.*, has dilutional coagulopathy developed (usually at about 6 units of packed cells), and 4) the degree of splenic injury. Fracture into the hilum usually precludes successful repair. Minimal experience with splenic auto transplants exists and surgeons routinely give a pneumococcal vaccine while still in the operating suite to all patients undergoing splenectomy.

Severe liver injury is the most difficult management problem encountered in these patients and was the leading cause of intraoperative death in this study. Using the criteria of Dickerman and Dunn,[5] the author classifies injuries to the liver on a scale of 1 to 5. The more serious injuries, Classes 4 and 5, are usually fatal injuries. Fracture of the liver into the retro hepatic vena cava was always fatal. In blunt trauma to the liver, there was little evidence that ligation of hepatic artery was effective. When devascularization by selective ligation of the hepatic artery is contemplated, the guidelines of Flint and Polk[6] are helpful. The author abandoned the attempt to use intracaval shunts because their success has been limited. There were no successful formal lobectomies for liver injury but resection for large devascularized fragments were successful. Pringle's[7] maneuver and applied pressure to the injured liver, by the senior surgeon, while his assistant

performs conservative resectional debridement, appears to be the most useful approach. If these patients require massive transfusions of blood, 6 or more units, coagulation defects invariably result, either dilutional or consumptive, and are probably secondary to the use of red cell fractionated blood. If it is anticipated that massive transfusion will be necessary, infusion of coagulation factors found in fresh frozen plasma should be instituted at the earliest possible time in the resuscitative process. When uncontrolled coagulopathy develops, early packing of the injured liver must be considered. Though not always necessary, but to be recommended for consideration, second, and occasionally third "look" procedures to evacuate clots and further debride dead hepatic tissue as indicated, is gaining increasing acceptance when there have been resections for debridement of the liver. This reduces the risk of infection from routine use of drains.

One of the less significant, but nevertheless interesting, observations from this study was bleeding from the ovary. Whether a Graafian follicle ruptures and bleeds secondarily to trauma or has ruptured physiologically, and is a source of bleeding discovered by peritoneal lavage, is unclear. The ovary certainly is strategically situated to avoid all but the most severe trauma. Presuming a Graafian follicle matures every 28 days and that blood associated with the rupture might be present for over 12 hours, there is a 1.7% incidence that a woman would have recently ovulated at the time of her injury. In these nine patients, the only bleeding described was from the ovary. Five of these nine patients were seen during 1978, and represent a vagary of diagnostic peritoneal lavage that was noted before the criteria requiring a erythrocyte count of 50,000 per milliliter in the effluence was established. In those women with occasional profuse ovulatory bleeding, this will continue as diagnostic paradox, as it has in the past.

The diaphragm in this series was, with one exception, repaired from the abdomen, although roentgenograms were made on all patients. The preoperative studies did not always demonstrate the defect. Careful routine examination of the diaphragm is necessary to avoid missing these injuries.

In this group of 870 patients, bleeding was the *sine qua non* for surgical intervention in the abdomen. It is noteworthy that the abdominal aorta was ruptured in only one patient, and no iliac artery injury was encountered. Injury to the visceral arteries, the renal pedicle, small bowel mesentery, spleen, and liver were the common presentations of arterial bleeding. Vascular disruption of the root of mesentery, which occurred in 17 patients, is a serious injury, difficult to manage, and in this group, was responsible for intraoperative death in five patients.

Due to the complexity of injury in the 870 patients who underwent celiotomy, it is not warranted to ascribe all mortality to the injury found in the abdomen. How-

ever, of the intraoperative mortality over 5 years of 9%, 55% occurred during the abdominal procedure. Certain injuries were fatal regardless of the most sophisticated intervention. The late deaths (16%) usually were associated with sepsis. Caplan and Hoyt,[8] of this institution, have studied these infections and concluded that invasive procedures used in these patients was the leading cause of infection. Multiorgan failure was present in all but a few of those who died. Central nervous death was most often the associated factor contributory to death in the remaining patients. The encouraging year-to-year improvement in observed mortality is the basis for some speculation (Fig. 1). The most significant factor is likely a result of a combined increase in experience of a young stable staff of surgeons over the 5-year period, and general improvement in postoperative support in respiratory care, nutritional adjuncts, and infection control. Not calculable in this study is the possibility that the severity of injury index has decreased since the energy crisis of 1979. The increasing national outrage against the drunk driver has stimulated legislative action to control this hazard. Public pressure on auto manufacturers, highway policing, and constant media awareness of safety devices, i.e., seat belts, air bags, etc., is combining to make motor vehicle travel safer. Although there has been an increasing number of admissions to our institute each year, the number of patients requiring celiotomy has dramatically declined over the 5 years studied. This tends to substantiate the decrease in the severity of injury.

An 11% drop in mortality from 20% in 1978 to 9% in 1982 in those patients surviving the initial care has been observed. That 51.4% of these patients do not survive the initial transport, resuscitation, and initial operative intervention is a disturbing statistic and deserves a separate assessment to learn where the system can be improved.

If urinary bladder rupture is excluded, all injuries in this group of patients were in the upper half of the abdomen. Palomar and Associates,[9] in a study of 34 patients with bladder rupture following blunt trauma, noted 74% had pelvic fractures. All bladder ruptures in this series, except one, were associated with pelvic fracture. In view of these data, rigid adherence to the vertical midline abdominal incision is not warranted. The mid-epigastric transverse incision gives superior exposure to the spleen and liver. These patients were all carefully evaluated, resuscitated, and are usually stabilized so that the abdominal procedure is seldom urgent. The presumed advantage of more rapid access to the abdominal cavity, through the midline incision in blunt trauma, does not outweigh the disadvantage of compromised exposure to the lateral flanks of the upper abdomen. This has been especially true in splenectomy, where injury to the colon, stomach, and pancreas is often followed by abscess formation as a sequelae to poor exposure and resultant technical iatrogenesis.

Roman and associates[10] report the duodenum is injured in 5% of all blunt abdominal trauma. One unexpected finding in this study has been the very low incidence of significant injury to the duodenum, pancreas, stomach, and extrahepatic bile ducts. The gallbladder has been removed on occasions where the parenchymal fracture of liver extended into the gallbladder fossa. In trauma, no two patients present with exactly the same combination of injuries and one must be conscious of the fact that injuries to these organs have been reported[11-19] but most of these studies deal with small series of patients collected over long periods of time. In view of our findings, without clear indications, restraint in searching for these injuries might avoid unforeseen technical complications.

As recently as 1959, Williams and Zollinger,[20] noted that 88% of patients with blunt abdominal trauma died from hemorrhage. Many greatly sophisticated aids in the diagnosis of the injured abdomen have been described since then. Foley and Teele[21] studied four patients with epigastric injuries after blunt trauma in whom ultrasonography was deemed helpful. Angiography of the abdomen has had many advocates in the recent past, including Osborn[22] and Freeark.[23] Radionuclide imaging of the injured patient has been described by Popovsky[24] and O'Mara.[25] Laparoscopy, though not popular among general surgeons in the United States, is reported by Taylor[26] to have found acceptance among European surgeons.

In 1979, Druy and Rubin[27] reported four patients in whom computed tomography was successful in the diagnosis of abdominal injury. Recently in San Francisco, Federle and associates[28] studied 100 patients with computed tomography and concluded it to have "major advantages over plain radiography, radionuclide studies, and angiography." The evaluation of computed tomography in trauma patients continues.

Peritoneal lavage has become the widely accepted standard among surgeons for the diagnosis of injuries within the abdomen. In Germany, Belgerden and associates,[29] reviewing 697 patients with blunt trauma, "operated solely on findings of diagnostic irrigation." Polk and Flint,[30] in a review of intraabdominal injuries in polytrauma, report peritoneal lavage as "a now-standard technique used to detect intraabdominal hemorrhage."

The contribution of the diagnostic peritoneal lavage in patients sustaining blunt abdominal trauma remains superior to that provided by all other means. To be aware of these additional aids in diagnosis and the proper application and limitations of each, is essential in today's care of the injured abdomen. However, in our system where 50% of the patients with abdominal trauma have additional major injury to another system, and 40% have two other major systems injured, where 30% have elevated blood alcohol levels, and where one continuous anesthesia is used as surgical teams follow each other in a tandem fashion, we rely exclusively on the diagnostic peritoneal

lavage. With great confidence, we believe it to be our best safeguard against the experience reported earlier by Williams and Zollinger.

Summary

This report has presented a study of 870 patients seen at the Maryland Institute for Emergency Medical Services Systems Shock Trauma Center, with blunt trauma requiring celiotomy. The vital statistics, the incidence of associated injury, and the predictable pattern of organ injury are documented. Certain clinical observations based on the collected data are made. The great majority of these patients arrived directly from the scene of the accident via helicopter and underwent very early resuscitation and diagnoses by trained full-time traumatologists. These favorable circumstances appear to have altered some of the observations on blunt abdominal trauma extant in reports from the recent past.

The motor vehicle accident continues to be the major source by which these patients were injured. The statistical information on motor vehicle accidents is collected and reported annually by the National Safety Council. These facts and this study bring greater emphasis for the need to regionalize centers of expert care for these victims. Through the information gained by the study of those injured in vehicular accidents, legislative, engineering, and public health forces can be brought together to eliminate this national disaster. To this end this study is presented.

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