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Intra-abdominal Abscess After Blunt Abdominal Trauma

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The relationship between blunt abdominal trauma and intra-abdominal abscess (IAA) is discussed infrequently; therefore we conducted a retrospective review of 4050 multiple blunt trauma admissions from January 1986 to July 1988. Of 325 patients who had a laparotomy for blunt abdominal trauma, we identified 15 (4.6%) who had 40 IAAs. The most common intra-abdominal injuries involved the spleen and liver. Splenectomy increased the risk for IAA in contrast to splenic salvage. Blunt injuries to the kidney and pancreas, when occurring in multiple trauma patients, carried a significant risk of IAA. Associated multiple extra-abdominal injuries and high transfusion requirements increased the risk for IAA formation. Most of the IAAs were located in the upper quadrants. There was a 46% incidence of multiple IAA, which in turn had an 80% chance of recurrence after initial drainage. *Enterobacter* species played an important role in the formation of IAA in our trauma patients. Three patients (20%) died. Poor prognostic indicators included a high injury severity score, high transfusion requirements, the presence of pelvic fracture, positive blood cultures, multiple organisms per abscess, and multiple-organ system failure.

TRAUMA IS ONE of the leading causes of death in the United States today. In traumatized patients who survive longer than 3 days, infection becomes the primary cause of late death. Although intra-abdominal infection in our unit represents only 8% of all infections, it still carries a significant morbidity rate. Recent radiographic localization techniques have permitted the earlier diagnosis and treatment of patients with intra-abdominal abscesses (IAA), but mortality rates remain as high as 40%.[1] Intra-abdominal abscess after penetrating abdominal trauma has been well documented, with incidences ranging from 3.3% to 45%.[2–4] However the relationship of blunt abdominal trauma and IAA has been seldom discussed; therefore we retrospectively reviewed our experience with IAA in patients who had sustained blunt abdominal trauma.

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Materials and Methods

Between January 1986 and July 1988, there were 4050 multiple blunt trauma admissions to our institution. The mechanisms of injury included motor vehicular accidents (MVA) (53%), falls (16%), motorcycle accidents (MCA) (9.3%), struck pedestrians (7%), and assaults (5.6%).

The trauma patients who are admitted to our unit undergo initial evaluation and spine immobilization, and aggressive fluid resuscitation is started when indicated. Type O unmatched blood is given to those patients who remain hypotensive (blood pressure [BP] less than 90) despite administration of 2 L of crystalloid infusion. All patients undergo radiographic evaluation of the cervical spine, chest, and pelvis. An abdominal examination follows; if evidence of peritonitis is present, these patients are explored. Patients with equivocal findings are further investigated by diagnostic peritoneal lavage (DPL) or computed tomography (CT) scan. A positive DPL is defined by the aspiration of 20 mL of gross blood from the peritoneal cavity or more than 100,000 red blood cells/cm^3 in the lavage effluent.

Once the decision is made to proceed with exploratory celiotomy, either cefazolin or cefoxitin is given prophylactically and continued for three doses after operation. If the bowel wall is noted to be injured, cefoxitin is given during operation as the preferred antimicrobial agent. The abdomen is explored in the usual manner through a midline incision, with four-quadrant packing, evisceration, and aspiration of intraperitoneal blood. Control of active hemorrhage is the first priority, followed by control of bowel contents. Standard techniques for hemostasis and organ repair are then applied. Closed suction drainage systems are used when indicated and are removed when the volume of the drainage has decreased, except when placed for pancreatic injuries—in this case, the drainage system remains in place for at least 1 week. A modified trauma score (TS) and injury severity score (ISS) are calculated.[5,6]

During the next few days, these patients are followed closely by the surgical and infectious disease staff. An infectious disease team follows all critical care patients at our center daily, closely monitoring temperature, white blood cell (WBC) counts, renal function, hepatic function, and the clinical status of the patient. Detailed microbiologic surveillance data are obtained and reviewed. If various parameters make us suspicious of an infectious process, then diagnostic studies are begun. To diagnose IAA we depend on physical examination, ultrasound examination, CT scan, and, rarely, paracentesis. Using these methods we identified 15 patients who developed IAA during the study period. A diagnosis of IAA was made when organisms were isolated from intra-abdominal collections gathered at surgery or by needle aspiration. We also included patients with organisms isolated from free peritoneal fluid. Three cases of acute cholecystitis were not included in this review. The criteria for organ failure as described by Fry[7] were applied.

Results

Of 4050 patients admitted to our center with blunt trauma, 325 (8%) underwent exploratory celiotomy. The mean TS and ISS for that subgroup were 14 ± 2 and 34.5 ± 15, respectively. Among the 325 patients with blunt abdominal trauma, 129 splenic injuries were detected, 83 of which required splenectomy. Other abdominal injuries are listed in Table 1.

Twenty-three IAA developed in 15 (4.6%) of the 325 patients who underwent celiotomy. This procedure was performed in 14 of them within 24 hours of admission. The mechanism of injury in this group was MVA in 12, struck pedestrian in 2, and MCA in 1. Ten patients were men and 5 were women. The ages ranged from 18 to 68 years (mean, 33 years). Five patients presented with a systolic BP ≤90 mmHg. The TS was available in 11 patients, and the average score was 11.8. The mean ISS of this group was 45.6. Thirteen patients had two or more intra-abdominal injuries (Table 1). Eight patients underwent splenectomy, including one done on hospital day 2 and another on hospital day 48 for a delayed rupture. Angiographic embolization was done for a renal artery injury and for a lacerated pelvic artery to control hemorrhage. All patients had at least one major extra-abdominal injury. These included injuries of the chest (10), pelvic ring (8), long bones (6), brain (8), and cervical spinal cord (1). The amount of blood transfused within the first 24 hours ranged from 3 to 77 units in 12 patients, with a mean of 22 units per patient.

TABLE 1. *Injuries*

	All Laparotomies for Blunt Abdominal Trauma (n = 325)	Patients with IAA (% of injuries) (n = 15)
Mean TS	14 ± 2	11.8 (11 patients)
Mean ISS	34.5 ± 15	45.6
Intra-abdominal injuries		
Spleen*	129	9 (6.9)
Liver	112	9 (8)
Pancreas	22	3 (13.6)
Renal	22	3 (13.6)
Small bowel	45	2 (4)
Urinary bladder	24	2 (8)
Colon	43	1 (2)
Biliary tract	Not available	1
Stomach	Not available	1

* The spleen was salvaged in 46 of 325 patients; 1 (2%) developed IAA. Splenectomy was necessary in 83 of 325 patients; 8 (9.6%) developed IAA.

The clinical signs of sepsis were present as early as the second postoperative day and as late as day 16 (mean, 7.8 days). The WBC count ranged from 12,300 to 40,000, with a mean of 22,600. The average temperature was 102.6 F when sepsis was first suspected. Only one patient had a tender abdomen at examination. Four patients presented with wound infections or dehiscence. One patient had frank pus coming from a drain site. All patients had abnormal chest radiographs. Unilateral pleural effusions or basilar atelectasis, which later coincided with subphrenic abscesses, were seen in five instances. Three patients had positive blood cultures for enteric organisms (Group D enterococci, *Escherichia coli*, *Pseudomonas* species, *Bacteroides* species).

Computed tomographic scan abnormalities consistent with abscess were found in 11 of the 12 patients in whom this procedure was performed in the initial evaluation. The patient with a false-negative scan had a right subhepatic abscess seen on sonography. Ultrasound examination was used for diagnosis in one patient. Another underwent nondirected exploratory laparotomy after blood cultures grew *Bacteroides fragilis*. The 15th patient had needle aspiration of infected ascitic fluid and was treated with antibiotics only, not with drainage.

In three patients radiographic-guided percutaneous aspiration of suspicious collections helped make the diagnosis. Percutaneous catheter drainage (PD) of IAA was successful as the initial treatment in 2 of 3 patients, and surgical drainage was successful in 7 of 11.

The majority (82%) of IAAs were intraperitoneal, with most of them located in the upper quadrants (Table 2). Five patients had single organisms isolated from the IAA (*Enterobacter*, 2; *E. coli*, 1; *Serratia*, 1; and *Candida* species, 1). The other patients (10) had multiple organisms, with an average of 2.9 organisms per patient (Table 3).

TABLE 2. *Location of IAA (40) Secondary to Blunt Trauma**

	Initial (%)	Recurrent (%)
Intraperitoneal		
Right upper quadrant	7 (30)	5 (29.4)
Left upper quadrant	5 (21.7)	5 (29.4)
Left paracolic	2 (8.6)	2 (11.7)
Interloop	2 (8.6)	
Lesser sac	1 (4.3)	1 (5.8)
Right paracolic	1 (4.3)	1 (5.8)
General peritonitis	1 (4.3)	
Subtotal	19 (82.6)	14 (82)
Retroperitoneal		
Pelvic	1 (4.3)	
Visceral		
Renal	1 (4.3)	
Hepatic	1 (4.3)	2 (11.7)
Pancreas	1 (4.3)	1 (5.8)
Subtotal	3 (13)	3 (17)
Total	23 (100)	17 (100)

* Table format adapted from Altemeier WA, et al. Intra-abdominal abscesses. Am J Surg 1973, 125:70–79.

Bacteroides species were seen in three patients. Five patients developed a total of 17 recurrent IAA. Successful drainage of recurrent IAA required a total of 14 procedures (PD in seven instances and surgical drainage in seven instances).

Twelve patients survived. Their length of stay (LOS) ranged from 39 to 152 days (mean, 82 days). Complications in these patients included adult respiratory distress syndrome (ARDS) (5), urinary tract infection (5), pneumonia (4), enterocutaneous fistulae (2), pancreatic fistula (1), and intravascular catheter-related sepsis (2). Their average ISS was 42.8, and the mean first 24-hour transfusion requirement was 18.6 units.

Three patients died. Their LOS ranged from 13 to 20 days (mean, 16 days). They all developed multiple-organ systems failure (MOSF). All had ARDS, liver failure, and renal failure. Two patients had disseminated intravascular coagulation (DIC) and one had cerebral infarction, which progressed to brain death. The average ISS for this group was 57 and the mean first 24-hour transfusion requirement was 33 units. Two of these three patients had positive blood cultures (*Enterobacter* species, *Bacteroides fragilis*, *Pseudomonas* species, and *E. coli*). One developed IAA associated with a leaking small bowel anastomosis. Another patient had an avulsed gallbladder at the initial operation, which may have been colonized. The third patient developed early MOSF with DIC, causing thrombosis of her brachial artery, which required an amputation. Her ascitic fluid was apparently hematogenously infected with *Enterobacter*, *Klebsiella*, and *Serratia*.

Discussion

Sepsis continues to be a primary cause of late death in the multiply injured patient. Although the risk of IAA after penetrating abdominal trauma has been described in several series, the risk of IAA after blunt abdominal trauma is not well documented. The incidence of IAA after penetrating abdominal trauma ranges from 3.3% to 45%.[2–4] Ivatory[2] reported an incidence of 3.3% in 872 patients who had sustained penetrating abdominal trauma. This rate increased to 6% when he considered only gunshot wounds. Our incidence of 4.6% is comparable, although only 25.2% of our patients had injury to the gastrointestinal tract. The incidence of IAA in those patients who have sustained penetrating abdominal trauma without bowel injury is negligible.[8]

The mean TS and ISS for patients undergoing celiotomy were 14 ± 2 and 34.5 ± 15, respectively, compared with 11.8 and 45.6 in the 15 patients who developed IAA. A TS less than 11 and an ISS greater than 40 are associated with mortality rates of at least 22.8% and 34.5% at our institution.[5,6] All of our patients had at least one serious extra-abdominal injury. Chest injuries predominated and included such injuries as multiple rib fractures, pulmonary contusion, ruptured thoracic aorta, and ruptured diaphragm. There were eight pelvic ring disruptions, which implies a significant impact of blunt force.

The mean transfusion requirement for the first 24 hours for our group of patients with IAA was 22 units (12 patients). Nichols[8] showed that the odds of a postoperative infection increased with each 10 units of blood. Infected patients in Dellinger's series had received 10.8 ± 12 units of blood for resuscitation after abdominal trauma.[3] Scott's study[9] demonstrated that the risk of developing an intra-abdominal septic focus exceeded 50% when transfusion requirements were 23 units or more. All these studies conclude that a prime determinant of abscess formation was the increased blood transfusion requirement and that blunt trauma increases the risk of abscess formation compared to penetrating injury because of greater blood losses.

Most of our patients sustained injuries to the spleen and liver (9 patients each), as would be expected in blunt

TABLE 3. *Bacteriology*

Organism	Number of Isolates (% of total)
Aerobic	
Enterobacter	10 (28.5)
Escherichia coli	5 (14.2)
Other gram-negative rods*	9 (25.7)
Streptococci†	5 (14.2)
Staphylococcus epidermidis	2 (5.7)
Subtotal	31
Anaerobic	
Bacteroides fragilis	3 (8.8)
Candida species	1 (2.8)

* Includes *Pseudomonas* (3), *Acinetobacter* (2), *Citrobacter* (1), *Klebsiella* (1), *Proteus* (1), and *Serratia* (1).

† Includes *Streptococcus pyogenes* (2) and group D enterococci (3).

trauma. Eighty-three patients underwent splenectomy, eight (9.6%) of whom developed IAA. Only one (2%) patient who had a splenic salvage procedure developed an IAA. Ellison's review[10] showed that splenectomy posed a risk for a subphrenic abscess in 3.4% to 10% of cases and that risk increased if there was an associated bowel injury or if drains were used.

In liver trauma, intra-abdominal sepsis is second to exsanguination as the leading cause of death and it is a primary cause of late death. Intra-abdominal abscess occurred in 17% of Scott's series[9] of patients who had sustained hepatic trauma. The need for hepatic resection, perihepatic packing, the presence of associated gastrointestinal tract injury, and the use of open drainage systems have all been implicated in the formation of IAA. In reviewing 770 patients from several major trauma centers, who had sustained liver trauma with blunt trauma, comprising 32% of cases, Moore[11] found a perihepatic abscess rate of only 4%. Feliciano[12] reported a 10.2% incidence of perihepatic abscess formation after perihepatic packing for hemorrhage in 58 patients. Nine (8%) patients with a total of 112 liver injuries developed IAA in our series; two of them required perihepatic packing to control hemorrhage.

Three (13%) patients with pancreatic injuries developed pancreatic abscesses. Pancreatic fistulae and/or abscesses developed in 29.3% and 7% of patients with pancreatic trauma in Sims'[13] and Stone's[14] series, respectively.

The three (13%) patients with renal injuries developed perirenal abscesses that were all associated with hematomas. One of these patients underwent renal artery embolization to control bleeding. The second patient developed an infected pelvic hematoma after a urinary bladder rupture and the third had a pelvic fracture that needed transcatheter embolization of pelvic vessels to control hemorrhage.

Hematoma and its hemoglobin content have been implicated in the development of intra-abdominal sepsis. Not only does the plasma provide a medium for bacterial growth but also the hemoglobin inhibits bacterial absorption from the peritoneal cavity, polymorphonuclear leukocyte chemotaxis, and intracellular killing.[15] The use of transcatheter gelfoam embolization for retroperitoneal or pelvic hemorrhage and its potential for ischemia have been documented.[16] The presence of ischemia, hematoma, and tissue injury secondary to trauma could increase the risk of secondary infection.

The elevated temperature and WBC count seen in our patients are consistent with other series of IAA.[17] One (6%) patient had a tender abdomen on examination and 4 (26.6%) patients presented with wound infections and/or dehiscence. Others have reported that physical examination may aid in the diagnosis of IAA in as many as 25% to 60% of patients.[18–21] Ipsilateral pleural effusion or basilar atelectasis is a nonspecific sign of intra-abdominal pathology and was present in 5 of 13 (38%) patients who had upper quadrant collections. Some report that plain radiographs may be helpful in at least 50% to 75% cases of IAA.[4,21,22]

More than one half (62.5%) of all IAAs were located in the upper quadrants. This could be related to the larger number of liver and splenic injuries and the cephalad flow of peritoneal fluid. Seventy-five per cent of Ivatory's patients had IAA in the upper quadrants after penetrating abdominal trauma.[2] Multiple intra-abdominal abscesses were discovered on initial laparotomy in 7 (46.6%) patients, with an average of two abscesses per patient. The reported incidence of multiple abscesses ranges from 8% to 31%.[19–21]

We relied on CT examination to aid in the diagnosis of IAA and it was positive in 11 of 12 attempts (91%), which is consistent with other series.[18,20] Ultrasound examination was helpful in three patients and identified a subhepatic collection not seen on CT scan; two of these patients had collections in the right upper quadrant and one had a collection in the left upper quadrant. Computed tomography and ultrasound-guided needle aspiration were accomplished in two patients each. One patient had a peritoneal tap at the bedside to diagnose infected ascitic fluid, and the remaining patient who developed MOSF underwent exploratory laparotomy after positive blood cultures were obtained.

Percutaneous catheter drainage was attempted in only three patients, using sonography once and CT guidance twice, and was initially successful in two patients who had single subphrenic abscesses. Deveney[20] concluded that PD may be superior to surgical drainage for subphrenic abscesses. Although it has been reported that 50% of patients with IAA are candidates for PD, our rate of use was only 37.5% (three of eight patients) if we include only those patients with single abscesses.[23] This may be due to the high incidence of associated infected hematoma in our patients. Initial surgical drainage was successful in 7 of 11 (63%) patients. Our overall initial success rate in the treatment of IAA is somewhat lower (60%) than other series, which report success rates close to 80%.[18,20,23–25] This could be related to the high incidence of multiple injuries and multiple abscesses in our study group.

Seventy per cent of the organisms isolated from IAA were aerobic gram-negative rods, with *Enterobacter* species comprising more than 29% of all strains. This is in contrast to the predominance of *E. coli* seen in IAA secondary to all causes.[17] The predominance of *Enterobacter* species in our series may be related to prophylactic use of cefazolin and cefoxitin, which may select out this organism, as reported in other series.[2,8] This organism is also the predominant gram-negative pathogen in catheter-related sepsis and other infections at our institution. *En-*

terobacter made up 32% of the organisms isolated in Ivatory's series. *Enterococcus* species were seen in three patients who also had other organisms isolated (mean of four organisms per patient). *Staphylococcus epidermidis* and non-group D streptococci comprised 11% of strains isolated. The etiology of these as intra-abdominal pathogens may be related to poor skin preparation during the initial laparotomy. Three (20%) patients had enteric organisms isolated from blood cultures. Butler[19] obtained positive blood cultures in 31% of his patients with IAA. The presence of multiple enteric organisms cultured from the blood was associated with an intra-abdominal source of sepsis in 78% of patients in Ing's series.[26]

Recurrent abscesses occurred in 5 (41.6%) of the 12 patients who survived, requiring 14 more drainage procedures before resolution. Four (80%) of these patients had multiple IAAs at relaparotomy. There was only one (14%) recurrence in the remaining seven patients who had a single abscess. This is consistent with Aeder's[25] recurrent abscess rate of 10% in patients with single abscesses. Deveney[20] had a 50% to 60% initial drainage success rate for his 12 patients with multiple IAAs treated surgically. Those patients with single abscesses had an average of 1.6 organisms isolated and an average length of stay of 60 days, whereas those with multiple abscesses averaged 2.1 organisms and 111 days in the hospital.

There were three deaths (20% mortality rate) in this series, which is consistent with other series in which mortality rates range from 17% to 30%.[2,18–21] In his series of 143 abscesses (40% of which were due to trauma), Fry[21] concluded that organ failure, lesser sac abscess, positive blood cultures, recurrent or persistent abscess, multiple abscesses, age more than 50 years, and subhepatic abscesses increased the risk of death. Butler[19] added the need for nondirected exploration as a risk for death. Ivatory[2] reported a 50% mortality rate in his patients who had MOSF. These patients had a higher abdominal trauma index score, a greater transfusion requirement, and a greater number of organs injured than did the non-MOSF group. Our data, summarized in Table 4, are consistent with those of others. The patients in the nonsurvivor group were older (40 *versus* 30 years) and had higher ISS (57 *versus* 42), with more intra-abdominal injuries (3 *versus* 2.3) and more extra-abdominal injuries (3.3 *versus* 2.3), along with a greater first 24-hour blood transfusion requirement (33 *versus* 18.6 units). Five of the survivors (42%) and all of the nonsurvivors suffered pelvic ring disruption. Multiple-organ system failure was the mode of sepsis presentation for all the nonsurvivors. A different modality was used to diagnose IAA in each of the nonsurvivors: CT scan, ascitic fluid aspiration, and nondirected laparotomy. The time of onset of sepsis was less in the nonsurvivor group (6 *versus* 8.3 days); multiple abscesses were present in the nonsurvivor group (66.6%) and the survivor group (42%); blood cultures were more often positive ($p < 0.05$) in the nonsurvivor group (2 patients) *versus* the survivor group (1 patient); and a mean of four organisms per abscess was isolated in the nonsurvivor group *versus* 1.75 organisms in the survivor group.

TABLE 4. *Comparison of Survivors and Nonsurvivors*

	Survivors	Nonsurvivors
No. of patients	12	3
Age (mean)	30.4	40.6
TS (mean)	12.4 (8 patients)	10.3
ISS (mean)	42.8	57
No. of intra-abdominal injuries (mean)	2.3	3
No. of extra-abdominal injuries (mean)	2.3	3.3
No. with associated pelvic fractures	5 (41%)	3 (100%)
First 24-hour transfusion requirement (mean)	18.6 units (9 patients)	33 units
Initial presentation (days)	8.3	6
Positive blood cultures (%)	1 (8.3%)	2 (66.6%)*
No. of organisms isolated (mean) per patient	1.75	4
No. of patients with multiple abscesses	5 (42%)	2 (66.6%)
Organ failure		
ARDS	5 (42%)	3 (100%)
Hepatic	0	3 (100%)
Renal	0	3 (100%)
DIC	0	2 (66.6%)
Cerebral infarction	0	1 (33.3%)
Length of hospitalization	82 days	16 days

TS, Trauma Score; ISS, Injury Severity Score; ARDS, adult respiratory distress syndrome; DIC, disseminated intravascular coagulation.
* $\chi^2 = 4.8$; $p < 0.05$.

In the survivor group, five patients developed single organ failure, all manifested by ARDS, and all survived despite a reported mortality rate of ARDS as high as 67%.[7,21,27] All three patients who developed MOSF died (all had ARDS, hepatic failure, and renal failure). The reported mortality rate among patients with three-organ failure surpasses 75%.[7,27]

Several series report the incidence of MOSF after IAA. Forty-four per cent of Fry's[27] 38 patients had MOSF; Ferraris[28] found that 80% of his 29 postoperative patients with either MOSF or single-organ failure had IAA; and Polk[29] explored 11 patients for MOSF and drainable collections of pus were found in 6 (55%). These studies conclude that, in patients with MOSF, a high index of suspicion for an intra-abdominal source of sepsis is warranted. The survival rate for those without and with drainable sources of infection was 18% and 33%, respectively.[1] Bunt[30] believed that the yield was low for nondirected laparotomies in critically ill patients with MOSF; it was well tolerated by the young trauma patient and probably should be avoided in the elderly. He reported an overall positive laparotomy rate of 63% in patients with MOSF. Those patients undergoing directed laparotomies had a 94% positive laparotomy rate, whereas only 13% of those with nondirected laparotomies had positive findings. Norton[31] concluded that MOSF secondary to IAA carried a high mortality rate (76%) and that surgical drainage will not reverse organ failure in most patients. Autopsy of the 16 patients who died demonstrated a persistent septic focus in only 3 (19%). Perioperative mortality rates in septic patients with MOSF undergoing relaparotomy ranges from 70% to 90%, regardless of whether a septic focus is found.[1,2,19,30]

Intra-abdominal abscess developed in 4.6% of our patients undergoing emergency laparotomy for blunt abdominal trauma. Most IAAs due to blunt abdominal trauma are located in the upper quadrants. Associated multiple extra-abdominal injuries and high transfusion requirements increase the risk of IAA formation.

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