Selective Management of Penetrating Truncal Injuries: Is Emergency Department Discharge a Reasonable Goal?

MARK F. CONRAD, M.D., JOE H. FATTON, JR., M.D., MANESH PARIKSHAK, M.D., KURT A. KRALOVICH, M.D.
From the Division of Trauma Surgery, Department of Surgery, Henry Ford Hospital, Detroit, Michigan

We undertook this retrospective review to examine the appropriateness of a protocol for the selective emergency department (ED) workup of asymptomatic penetrating truncal injuries. Records of consecutive patients presenting to our urban Level I trauma center with penetrating truncal injuries between January 1, 1997 and September 2000 were reviewed. Data obtained included: patient demographics, ED workup, ED disposition, complications, and follow-up. Selective ED workup included hospital triple-contrast CT, admission for observation, and local wound exploration for selected anterior abdominal stab wounds. Four hundred fifty-five patients presented with penetrating truncal wounds during the study period. One hundred ninety-four patients were taken directly to the operating room, 136 were discharged based solely on physical examination and plain radiographs, 18 were admitted for observation without ED workup, and 107 had selective ED workup. Sixty-two patients (58 of those selectively worked up) were discharged home after negative ED workup, 18 were managed operatively, and 27 were managed nonoperatively. There were two missed injuries that were later identified and managed with no complications. Follow-up was available on 66 per cent of ED workup patients (range 1-42 months). We conclude that selective management of certain penetrating truncal injuries appears appropriate. Patients having a negative selective ED workup can be safely discharged thereby avoiding the cost and resource utilization associated with hospital admission.

HISTORICALLY PATIENTS WITH penetrating injuries suspected of violating the peritoneum were assumed to have sustained a visceral injury regardless of physical signs and symptoms found at presentation.1-2 This is the principle on which the practice of mandatory exploration of these injuries is based. However, advances in noninvasive diagnostic imaging over the last decade have led many surgeons to question this practice.3-4

Although early operative intervention continues to be appropriate for patients who present in extremis, in recent years the practice of mandatory laparotomy for all patients has been questioned. There are several reasons to re-examine the management of penetrating truncal injuries. The shift in civilian armament from high-powered military weapons to lower-caliber hand guns has changed our approach to these injuries as wounds from guns with a lower muzzle velocity do not produce a significant secondary cavitation.5 Additionally nontherapeutic laparotomies have been associated with patient morbidity rates as high as 40 per cent and add to the increasing cost of patient care.6 Also the development of accurate noninvasive imaging techniques facilitates the evaluation of asymptomatic patients in the emergency department (ED) thus obviating the need for diagnostic exploration.

In the absence of generalized peritonitis or hemodynamic instability peritoneal penetration alone has been shown to be a poor predictor of significant organ injury after abdominal stab wounds and an organ-specific workup of select patients has become the standard of care.7-10 Also, in an effort to avoid nontherapeutic laparotomies several trauma centers have advocated CT evaluation or nonoperative management of asymptomatic abdominal gun shot wounds.11-13

We undertook this study to investigate the role of selective ED workup of penetrating truncal injuries and to determine whether ED discharge is a reasonable goal.
Methods

Patients

A retrospective review was performed of the records of all patients who presented to Henry Ford Hospital, an urban Level I trauma center, with a penetrating injury to the torso between January 1997 and September 2000. Patients were initially evaluated and resuscitated in the ED according to Advanced Trauma Life Support protocol. Patients with hemodynamic instability or frank peritonitis were taken to the operating room for exploratory laparotomy whereas stable patients underwent selective workup in the ED. Patients who presented without vital signs or who died in the resuscitation room were excluded from evaluation.

Demographic data including age, race, and gender were recorded for each patient. Patients were stratified by mechanism of injury, location of injury, diagnostic evaluation, and ED disposition. Follow-up consisted of a review of clinic notes and ED visits that occurred after the initial presentation with penetrating truncal trauma. CT scans were performed in the ED with the trauma service in attendance and were interpreted by the on-call surgical team in conjunction with a radiology resident. CT criteria used to determine peritoneal violation included: free intraperitoneal fluid, pneumoperitoneum, solid-organ injury, extravasation of contrast material, and penetration as determined by an identifiable bullet tract.

Protocol

Asymptomatic patients who presented with penetrating truncal wounds including the anterior abdomen, thoracoabdomen, back, flank, and pelvis were managed according to our institutional protocol. Patients were considered asymptomatic if they presented with no obvious peritoneal violation or signs of peritonitis on abdominal examination and remained hemodynamically stable after an initial bolus of 2 liters of lactated Ringer's solution in the ED resuscitation room. Patients with superficial or tangential injuries were evaluated and discharged on the basis of physical examination findings and plain radiographs.

The selective ED workup of asymptomatic patients was directed by injury mechanism and anatomic location. Protocol guidelines are summarized in Fig. 1. Most patients qualifying for selective workup received a triple-contrast CT scan of the abdomen and pelvis that included oral, intravenous, and rectal contrast. Injuries to the left thoracoabdomen were evaluated with triple-contrast CT scan.
laparoscopy or thoracoscopy because of the high risk of diaphragmatic injury in this location. Gunshot wounds to the anterior abdomen that were not easily shown to be superficial or to follow a tangential path were considered high risk and were generally explored regardless of presenting symptoms. Stab wounds to the anterior abdomen were evaluated with local wound exploration and patients were discharged home if no fascial violation was identified. Pelvic injuries were evaluated with triple-contrast CT, and depending on the suspected trajectory of the bullet rigid sigmoidoscopy or cystography was used. Asymptomatic patients with negative workup were discharged from the ED.

Laparotomies were considered therapeutic when injuries were identified and repaired on exploration. They were considered nontherapeutic when injuries requiring no intervention were found as in the case of small liver lacerations or if the abdomen was determined to be injury free.

Differences in hospital cost were determined using the Student's t-test with a P value of <0.05 being considered significant.

Results

There were 455 patients who presented with at least one penetrating truncal wound during the study period. Two hundred fifty-one (56%) patients presented with abdominal wounds, 114 (25%) with back wounds, 74 (16%) with thoracoabdominal wounds, and 16 (3%) with flank or pelvis wounds. Two hundred seventy (59%) patients had sustained gunshot wounds whereas the remaining 185 (41%) presented after being stabbed. The average age at presentation was 30.3 years (range 1-76). Patients were predominantly male [387 (85%)] with only 68 (15%) females. The ED disposition is summarized in Fig. 2.

One hundred ninety-four patients were hemodynamically unstable or had peritoneal signs on presentation and were taken directly to the operating room. These patients presented with 136 (70%) gunshot wounds and 58 (30%) stab wounds. Injuries were identified and repaired in 144 (74%) patients whereas the remaining 50 (26%) patients underwent negative or nontherapeutic explorations. Fourteen of the 50 (28%) negative explorations were laparoscopic procedures used to rule out peritoneal violation after anterior stab wounds or diaphragmatic injury with wounds to the left thoracoabdomen. Follow-up was available on 167 (86%) patients with an average of 3 months (range 1-42). There were 12 (7%) operative deaths and four (2%) deaths in the intensive care unit within the first 2 weeks. There were no missed injuries identified in this group of patients.

The remaining 261 (58%) patients were asymptomatic on presentation to the ED. This subset of patients included 216 males (83%) and 45 (17%) females. There were 134 (51%) gunshot wounds and 127 (49%) stab wounds. The distribution of injuries is summarized in Fig. 3.

One hundred thirty-six patients (52% of the 261 with an asymptomatic presentation) had superficial injuries or a tangential wound tract and were discharged solely on the basis of physical examination and plain radiographs. These patients presented with 78 (57%) gunshot wounds and 58 (43%) stab wounds. Follow-up was available on 68 (50%) patients with an average of 3.7 months (range 1-44). There were no missed injuries or complications identified in this group.

There were 18 (4%) asymptomatic patients who were admitted without selective workup in the ED. Of these patients seven (39%) were admitted for 24-hour observation against our protocol and eight (44%) were admitted for chest tube management. Two patients were admitted for observation of orthopedic injuries and one patient was intubated in the ED for agitation and required admission for management of his endotracheal tube. All patients in this cohort were discharged without incident. Follow-up was available on 12 of the 18 (67%) patients with an average of 1.25
months (range 1-46). There were no missed injuries or complications identified.

The remaining 107 (24%) patients were asymptomatic at presentation and underwent selective diagnostic workup in the ED. Positive CT scans were identified in 26 (24%) patients with 18 requiring surgical exploration; the remaining eight were observed and managed nonoperatively. There were four nontherapeutic laparotomies identified in this group. The remaining 81 of 107 (75%) patients had negative CT scans for which 62 (58%) were discharged home and 19 (18%) were admitted to the hospital and managed nonoperatively. Ten of these patients presented with a pneumothorax and had admission for chest tube management. The remaining eight patients—with extra-abdominal injuries requiring admission—were observed with serial hematocrit levels and discharged within 48 hours. The results of selective ED workup are summarized in Fig. 4.

Follow-up was available on 23 (88%) of the patients with a positive ED workup over an average of 10 months (range 1-42). There were no complications in this group. There were 48 (59%) patients from the negative ED workup cohort who were followed over an average of 8 months (range 1-43). One clinically asymptomatic patient with a low-grade liver laceration was discharged when his CT scan was initially read as negative. The lesion was identified the next morning and the patient was readmitted and followed without adverse sequelae. Additionally there was one patient who was admitted for chest tube management with a negative CT scan. He subsequently developed peritonitis on hospital day 2 and was found to have a jejunal injury at exploration. He recovered from this and was able to return to normal function.

Hospital charges for each cohort of patients are described in Table 1. There was a statistically significant difference between patients with negative workups who were discharged home and those with nontherapeutic laparotomies ($P < 0.0001$) and nontherapeutic laparoscopies ($P = 0.0024$). When all patients with a negative ED workup (regardless of disposition) were compared with all negative laparotomies/laparoscopies the hospital costs were $7,039 and $15,082 respectively ($P < 0.0001$).

**Discussion**

The evaluation and management of patients suspected of having an abdominal injury after penetrating trauma continues to evolve. Before the introduction of adjuvant diagnostic therapies surgeons relied on physical signs and symptoms to determine the need for laparotomy. However, this was determined not to be a reliable predictor of injury after penetrating abdominal trauma in which as many as 40 per cent of patients with significant hemoperitoneum presented with a benign abdomen. Military experience with high-velocity missile wounds showed that the consequences of missed bowel or vascular injuries after penetrating trauma can be devastating. This led surgeons to advocate the exploration of all penetrating abdominal wounds regardless of initial presentation. However, when applied to civilian trauma the policy of mandatory laparotomy was associated with a high incidence of nontherapeutic exploration—a procedure that is not without complication.

In the 1960s several authors questioned whether the presence of a penetrating abdominal wound should be an absolute indication for laparotomy suggesting that the clinical judgment of an experienced surgeon was a more appropriate guideline. This notion was eventually adopted for the management of torso stab wounds as several authors advocated the selective nonoperative management of these injuries. One prospective study randomized asymptomatic clinically stable patients to mandatory laparotomy or 48-hour observation with serial examinations and laboratory tests. These authors found that the nonoperative group had a shorter and more cost-efficient hospital stay with fewer complications than patients randomized to mandatory laparotomy. As a result the nonoperative
months (range 1-46). There were no missed injuries or complications identified.

The remaining 107 (24%) patients were asymptomatic at presentation and underwent selective diagnostic workup in the ED. Positive CT scans were identified in 26 (24%) patients with 18 requiring surgical exploration; the remaining eight were observed and managed nonoperatively. There were four nontherapeutic laparotomies identified in this group. The remaining 81 of 107 (75%) patients had negative CT scans for which 62 (58%) were discharged home and 19 (18%) were admitted to the hospital and managed nonoperatively. Ten of these patients presented with a pneumothorax and had admission for chest tube management. The remaining eight patients—with extra-abdominal injuries requiring admission—were observed with serial hematocrit levels and discharged within 48 hours. The results of selective ED workup are summarized in Fig. 4.

Follow-up was available on 23 (88%) of the patients with a positive ED workup over an average of 10 months (range 1-42). There were no complications in this group. There were 48 (95%) patients from the negative ED workup cohort who were followed over an average of 8 months (range 1-43). One clinically asymptomatic patient with a low-grade liver laceration was discharged when his CT scan was initially read as negative. The lesion was identified the next morning and the patient was readmitted and followed without adverse sequelae. Additionally there was one patient who was admitted for chest tube management with a negative CT scan. He subsequently developed peritonitis on hospital day 2 and was found to have a jejunal injury at exploration. He recovered from this and was able to return to normal function.

Hospital charges for each cohort of patients are described in Table 1. There was a statistically significant difference between patients with negative workups who were discharged home and those with nontherapeutic laparotomies (P < 0.0001) and nontherapeutic laparoscopies (P = 0.0024). When all patients with a negative ED workup (regardless of disposition) were compared with all negative laparotomies/laparoscopies the hospital costs were $7,039 and $15,082 respectively (P< 0.0001).

Discussion

The evaluation and management of patients suspected of having an abdominal injury after penetrating trauma continues to evolve. Before the introduction of adjuvant diagnostic therapies surgeons relied on physical signs and symptoms to determine the need for laparotomy. However, this was determined not to be a reliable predictor of injury after penetrating abdominal trauma in which as many as 40 per cent of patients with significant hemoperitoneum presented with a benign abdomen.14 Military experience with high-velocity missile wounds showed that the consequences of missed bowel or vascular injuries after penetrating trauma can be devastating. This led surgeons to advocate the exploration of all penetrating abdominal wounds regardless of initial presentation. However, when applied to civilian trauma the policy of mandatory laparotomy was associated with a high incidence of nontherapeutic exploration—a procedure that is not without complication.6

In the 1960s several authors questioned whether the presence of a penetrating abdominal wound should be an absolute indication for laparotomy suggesting that the clinical judgment of an experienced surgeon was a more appropriate guideline.7-8 This notion was eventually adopted for the management of torso stab wounds as several authors advocated the selective nonoperative management of these injuries.9-10 One prospective study randomized asymptomatic clinically stable patients to mandatory laparotomy or 48-hour observation with serial examinations and laboratory tests. These authors found that the nonoperative group had a shorter and more cost-efficient hospital stay with fewer complications than patients randomized to mandatory laparotomy.15 As a result the nonoperative...
management of certain asymptomatic stab wounds with observation and serial examinations has become the standard of care in most institutions.

Despite a general acceptance of the nonoperative management of knife wounds this approach is considered by many to be too aggressive for patients with gunshot wounds and mandatory laparotomy remains the standard of care at most institutions. Arguments in support of this practice include the high incidence of intra-abdominal injuries associated with high-velocity missiles that create a large cavity as they travel trans-corporally. However, we have seen a shift in armament in our civilian population from high-powered assault weapons to smaller-caliber handguns as the inciting events have changed from drug-related disputes to predominantly domestic violence. Such small-velocity bullets do not leave a wide damage path and are likely to produce fewer injuries requiring intervention. A second argument is that the nontherapeutic laparotomy is associated with minimal morbidity. Renz and Feliciano6 prospectively followed 254 patients who underwent unnecessary trauma laparotomies (in all but four the mechanism of injury was penetrating trauma) and found a 41.9 per cent overall complication rate, and an analysis of the cohort of patients with intra-abdominal injuries that required no further intervention revealed a 61.3 per cent morbidity.6 Despite this high procedural morbidity mandatory laparotomy is still considered the conservative approach to penetrating torso injuries.16

Building on the accepted safety of the nonoperative management of select blunt liver and kidney injuries Chmielewski et al.3 described 12 patients with gunshot wounds to the right upper quadrant who were successfully observed with serial abdominal examinations and hematocrit levels. All of these patients had liver injuries on presentation and 60 per cent had concomitant lung injuries. A second series by Renz and Feliciano17 included 13 patients with right thoracoabdominal injuries of whom seven were identified to have hepatic lacerations. These patients were successfully managed nonoperatively with a mean hospital stay of 5.1 days.17 More recently several larger studies have confirmed the safety of nonoperative management of certain abdominal gunshot wounds.4-18 Demetriades et al.4 reported 92 of 106 patients who were successfully managed without an operation after penetrating torso trauma. Their protocol for observation included 24 hours in the surgical intensive care unit with serial abdominal examinations and hematocrit levels. In the 14 patients who required delayed operation nine of the operations were nontherapeutic and there were no major complications or deaths observed.4 Recently Velmahos et al.18 reported a series of 792 patients who were selected for nonoperative management on the basis of physical examination. Their observation protocol was similar to that of Demetriades et al.4 with 12 to 24 hours in an intensive care unit setting. They found delayed laparotomies in 4 per cent of patients and were able to decrease their nontherapeutic laparotomy rate to 14 per cent with a complication rate of 0.03 per cent in the group that was initially observed.18

There have been several reports from the Los Angeles group describing the nonoperative management of wounds to the buttocks, back, and pelvis.19-21 All three series used a protocol for observation that involved a 24-hour admission to the intensive care unit with serial abdominal examinations and hematocrit levels. Patients who remained asymptomatic were subsequently discharged after an average hospital stay of 48 hours. Velmahos et al.19 observed 130 patients with back wounds and ultimately performed four delayed laparotomies; all of these were nontherapeutic. In the second series 42 patients with buttock injuries were managed according to the above protocol. In this cohort two patients eventually underwent nontherapeutic laparotomies.20 The third report describes 18 patients with transpelvic wounds managed in accordance with the observation protocol with three eventually receiving laparotomy.21 Collectively these series differed from those described previously in that there was minimal use of adjuvant tests such as diagnostic peritoneal lavage, CT scanning, intravenous pylorography, or sigmoidoscopy.

CT has been shown to be an effective screening tool for asymptomatic patients with penetrating truncal trauma.11-13 The traditional trauma CT uses a minimal bolus of oral contrast and is often criticized as a poor study for determining the presence of an injury to the bowel. However, recent improvements in scanner speed and image quality have made CT an excellent test for determining the trajectory of a penetrating missile or knife blade. And the administration of rectal contrast before scanning can aid in evaluating the colon. Grossman et al.13 reported a series of 50 (2% of patients presenting with torso gunshot wounds) patients who underwent CT scanning for the purpose of determining bullet trajectory in asymptomatic patients. There were 29 negative CTs in this group leading to the discharge of most patients within 48 hours.13 Similarly Ginzburg et al.11 reported 83 patients with penetrating torso trauma who were evaluated with CT scanning. Of those studied 53 were negative for intra-peritoneal injury. These patients were observed for 23 hours and discharged with no missed injuries identified.11 Finally Chiu et al.12 evaluated 75 patients with CT scan and found that it predicted the need for laparotomy with an accuracy of 95 per cent.

Our institutional protocol for the evaluation and management of penetrating truncal trauma has evolved
management of certain asymptomatic stab wounds with observation and serial examinations has become the standard of care in most institutions.

Despite a general acceptance of the nonoperative management of knife wounds this approach is considered by many to be too aggressive for patients with gunshot wounds and mandatory laparotomy remains the standard of care at most institutions. Arguments in support of this practice include the high incidence of intra-abdominal injuries associated with high-velocity missiles that create a large cavity as they travel trans-corporally. However, we have seen a shift in armament in our civilian population from high-powered assault weapons to smaller-caliber handguns as the inciting events have changed from drug-related disputes to predominantly domestic violence. Such small-velocity bullets do not leave a wide damage path and are likely to produce fewer injuries requiring intervention. A second argument is that the nontherapeutic laparotomy is associated with minimal morbidity. Renz and Feliciano6 prospectively followed 254 patients who underwent unnecessary trauma laparotomies (in all but four the mechanism of injury was penetrating trauma) and found a 41.9 per cent overall complication rate, and an analysis of the cohort of patients with intra-abdominal injuries that required no further intervention revealed a 61.3 per cent morbidity.6 Despite this high procedural morbidity mandatory laparotomy is still considered the conservative approach to penetrating torso injuries.16

Building on the accepted safety of the nonoperative management of select blunt liver and kidney injuries Chmielewski et al.3 described 12 patients with gunshot wounds to the right upper quadrant who were successfully observed with serial abdominal examinations and hemoglobin levels. All of these patients had liver injuries on presentation and 60 per cent had concomitant lung injuries. A second series by Renz and Feliciano17 included 13 patients with right thoracoabdominal injuries of whom seven were identified to have hepatic lacerations. These patients were successfully managed nonoperatively with a mean hospital stay of 5.1 days.17 More recently several larger studies have confirmed the safety of nonoperative management of certain abdominal gunshot wounds.418 Demetriades et al.4 reported 92 of 106 patients who were successfully managed without an operation after penetrating torso trauma. Their protocol for observation included 24 hours in the surgical intensive care unit with serial abdominal examinations and hematocrit levels. In the 14 patients who required delayed operation nine of the operations were nontherapeutic and there were no major complications or deaths observed.4 Recently Velmahos et al.18 reported a series of 792 patients who were selected for nonoperative management on the basis of physical examination. Their observation protocol was similar to that of Demetriades et al.4 with 12 to 24 hours in an intensive care unit setting. They found delayed laparotomies in 4 per cent of patients and were able to decrease their nontherapeutic laparotomy rate to 14 per cent with a complication rate of 0.03 per cent in the group that was initially observed.18

There have been several reports from the Los Angeles group describing the nonoperative management of wounds to the buttocks, back, and pelvis.19-21 All three series used a protocol for observation that involved a 24-hour admission to the intensive care unit with serial abdominal examinations and hematocrit levels. Patients who remained asymptomatic were subsequently discharged after an average hospital stay of 48 hours. Velmahos et al.19 observed 130 patients with back wounds and ultimately performed four delayed laparotomies; all of these were nontherapeutic. In the second series 42 patients with buttock injuries were managed according to the above protocol. In this cohort two patients eventually underwent nontherapeutic laparotomies.20 The third report describes 18 patients with transpelvic wounds managed in accordance with the observation protocol with three eventually receiving laparotomy.21 Collectively these series differed from those described previously in that there was minimal use of adjuvant tests such as diagnostic peritoneal lavage, CT scanning, intravenous pylorography, or sigmoidoscopy.

CT has been shown to be an effective screening tool for asymptomatic patients with penetrating truncal trauma.11-13 The traditional trauma CT uses a minimal bolus of oral contrast and is often criticized as a poor study for determining the presence of an injury to the bowel. However, recent improvements in scanner speed and image quality have made CT an excellent test for determining the trajectory of a penetrating missile or knife blade. And the administration of rectal contrast before scanning can aid in evaluating the colon. Grossman et al.13 reported a series of 50 (2% of patients presenting with torso gunshot wounds) patients who underwent CT scanning for the purpose of determining bullet trajectory in asymptomatic patients. There were 29 negative CTs in this group leading to the discharge of most patients within 48 hours.13 Similarly Ginzburg et al.11 reported 83 patients with penetrating torso trauma who were evaluated with CT scanning. Of those studied 53 were negative for intra-peritoneal injury. These patients were observed for 23 hours and discharged with no missed injuries identified.11 Finally Chiu et al.12 evaluated 75 patients with CT scan and found that it predicted the need for laparotomy with an accuracy of 95 per cent.

Our institutional protocol for the evaluation and management of penetrating truncal trauma has evolved
over the last decade. As the clarity and definition of CT scanners have improved we have become more reliant on this modality for the identification of intraperitoneal injury in asymptomatic trauma patients. Previously described protocols for the nonoperative management of penetrating torso injuries involve observation in a critical care unit for at least 24 hours. Although we advocate this approach for the observation of patients with solid-organ injury those patients in whom no injury is identified or in whom the bullet tract is shown to be extraperitoneal can be safely discharged from the ED. We were successful in achieving this goal in 58 per cent of our 107 asymptomatic patients who presented with possible peritoneal violation. There were 18 additional patients who were admitted for observation despite a negative CT scan. Ten of these had concomitant extra-abdominal injuries that required hospital management, and the remaining eight were observed for 48 hours in violation of our protocol.

It has been our experience that patients who present with superficial or tangential injuries can be evaluated and subsequently discharged on the basis of physical examination and plain radiographs. Soft-tissue defects are irrigated in the ED and patients are observed for a brief period—usually 6 to 8 hours—as they metabolize any preinjury narcotics that may have been ingested. This practice differs from that of other nonoperative management protocols in which as many as 61 per cent of the patients presented with injuries that were unlikely to have violated the peritoneum. In identifying suitable patients for nonoperative management of liver injuries Chmielewski et al described six (3%) patients with tangential injuries who underwent CT scanning or diagnostic peritoneal lavage before discharge. These studies were not used in the workup of our patients with superficial injuries. In addition the 136 patients with superficial injuries were not included in our theoretical determination of nontherapeutic laparotomy as they were not likely to have an intraperitoneal injury.

There were two missed injuries in the cohort of patients with selective ED workup. The first, a jejunal injury, was likely an error in diagnosis rather than a false negative CT scan. On review of this scan fluid can be identified in the left pelvic gutter; this was initially missed as the scan was initially read as negative. The patient subsequently developed peritoneal signs and was explored and found to have the jejunal injury. This patient suffered no sequelae secondary to the delay in exploration. The second missed injury involves a questionable liver laceration that was originally read as a negative CT scan. On the official reading by the attending radiologist a possible laceration to the liver (grade I) was identified and to err on the side of caution the patient returned to the hospital for 24 hours of observation. The sensitivity of CT scanning in predicting intra-abdominal injuries was 98 per cent in this series.

There were 26 CT scans that had positive intraperitoneal findings, and this led to 18 explorations; four of these were nontherapeutic. One nontherapeutic laparotomy was performed on a patient who presented with a gunshot wound to the anterior abdomen and free air on CT scan. The only injury identified at exploration was a psoas hematoma that required no intervention. The other three patients presented with asymptomatic gunshot wounds to the anterior abdomen and an equivocal bullet tract on CT scan. Two of these were thought to have potential colon injuries given that the bullet appeared to have traveled in close proximity to the colon. In all three patients no injury requiring intervention was found upon exploration. The specificity of CT scanning in predicting intra-abdominal injury and the need for operative intervention was 96 per cent in this series.

One of the most frustrating aspects of the care of trauma patients is the lack of long-term follow-up. Patients who are discharged directly from the ED are notorious for missing scheduled clinic visits if they feel well. It is common to find reports in the literature with follow-up of less than 40 per cent at one week. We were able to obtain follow-up on 53 per cent of our asymptomatic patients with an average of 6 months (range 1-44). Our worst follow-up involved the cohort of patients with superficial or tangential injuries (50%), it improved for patients with negative ED workup (59%), and the patients most likely to be seen in clinic were those with a positive ED workup requiring admission (88%). These figures are similar to those of previous reviews of our penetrating trauma population. Understanding that we are not the only Level I trauma center in the greater Detroit area it is possible that patients with delayed injuries presented to other facilities and were treated without our knowledge. We attempt to prevent this from happening by supplying the patient with detailed discharge instructions that describe signs of early peritonitis and by providing phone numbers to address any patient concerns. Patients were also given return appointments, although almost half of these were never kept. With these discharge policies we have a general perception that patients with complications after trauma will return to our facility for evaluation and care.

Had we followed a protocol requiring mandatory laparotomy for all wounds with possible peritoneal violation our theoretical nontherapeutic laparotomy rate would have been 41 per cent. However, through the selective workup of asymptomatic patients the nontherapeutic laparotomy rate was reduced to 11 per
cent, and a quarter of these were laparoscopic procedures. Evaluation of the cohort of patients who presented with gunshot wounds showed a nontherapeutic laparotomy rate of 14 per cent; this is superior to the theoretical rate of 29 per cent had laparotomy been performed on all patients with questionable injuries. However, there is still room for improvement. Of the 22 nontherapeutic laparotomies performed for gunshot wounds 17 involved injuries to the anterior abdomen. Early in the study period we had a low threshold for exploration when the injury involved the anterior abdomen. However, by the last year of the study we were more likely to perform an ED workup on asymptomatic patients with anterior abdominal wounds. In fact the four nontherapeutic laparotomies after ED workup were all for anterior abdominal gunshot wounds.

In the 1998 evaluation by Ginzburg et al.11 of the role of CT in the selective management of torso gunshot wounds the authors found a significant cost advantage in evaluating the abdomen with CT scanning over diagnostic laparotomy. Our experience supports this conclusion. The financial burden created by penetrating trauma patients continues to increase. Patients who were discharged after a negative ED workup incurred one-fifth the expenses of those who underwent nontherapeutic laparotomy and one-half the expenses of those who underwent negative laparoscopic evaluation. Additionally patients with superficial injuries were discharged from the ED and incurred fewer hospital charges than those who required ED workup. This reduction in expense is critical to the success of a major trauma center that must function with limited resources allocated to this population that is usually younger and uninsured.

Conclusion

The presence of a penetrating injury to the torso is no longer an absolute indication for exploratory laparotomy. However, patients with hemodynamic compromise or generalized peritonitis on presentation should still be explored. The selective workup of certain patients with penetrating truncal injuries appears appropriate and those patients with superficial wounds or a negative CT scan can be safely discharged from the ED. The institution of our protocol for the selective workup of patients in the ED has resulted in a significant financial savings with minimal risk to the patient. This study confirms our hypothesis that ED discharge is a reasonable goal in select patients with asymptomatic penetrating truncal injuries.

REFERENCES


cent, and a quarter of these were laparoscopic procedures. Evaluation of the cohort of patients who presented with gunshot wounds showed a nontherapeutic laparotomy rate of 14 per cent; this is superior to the theoretical rate of 29 per cent had laparotomy been performed on all patients with questionable injuries. However, there is still room for improvement. Of the 22 nontherapeutic laparotomies performed for gunshot wounds 17 involved injuries to the anterior abdomen. Early in the study period we had a low threshold for exploration when the injury involved the anterior abdomen. However, by the last year of the study we were more likely to perform an ED workup on asymptomatic patients with anterior abdominal wounds. In fact the four nontherapeutic laparotomies after ED workup were all for anterior abdominal gunshot wounds.

In the 1998 evaluation by Ginzburg et al.11 of the role of CT in the selective management of torso gunshot wounds the authors found a significant cost advantage in evaluating the abdomen with CT scanning over diagnostic laparotomy. Our experience supports this conclusion. The financial burden created by penetrating trauma patients continues to increase. Patients who were discharged after a negative ED workup incurred one-fifth the expenses of those who underwent nontherapeutic laparotomy and one-half the expenses of those who underwent negative laparoscopic evaluation. Additionally patients with superficial injuries were discharged from the ED and incurred fewer hospital charges than those who required ED workup. This reduction in expense is critical to the success of a major trauma center that must function with limited resources allocated to this population that is usually younger and uninsured.

Conclusion

The presence of a penetrating injury to the torso is no longer an absolute indication for exploratory laparotomy. However, patients with hemodynamic compromise or generalized peritonitis on presentation should still be explored. The selective workup of certain patients with penetrating truncal injuries appears appropriate and those patients with superficial wounds or a negative CT scan can be safely discharged from the ED. The institution of our protocol for the selective workup of patients in the ED has resulted in a significant financial saving with minimal risk to the patient. This study confirms our hypothesis that ED discharge is a reasonable goal in select patients with asymptomatic penetrating truncal injuries.

REFERENCES


