Selective Nonoperative Management of Gunshot Wounds of the Anterior Abdomen

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Objective: To investigate the role of selective nonoperative management of gunshot wounds to the abdomen.

Design: A prospective, protocol-guided study including all gunshot wounds of the anterior abdomen.

Patients and Methods: The patients were assessed and managed according to a written protocol. Patients with hemodynamic instability or peritonitis or associated spinal cord or head injury or requiring a general anesthetic for an extra-abdominal injury were managed by laparotomy. The rest of the patients were selected for initial nonoperative management with serial physical examinations.

Results: During a 16-month period, 309 patients with gunshot wounds of the anterior abdomen were treated. Eighteen patients in extremis (5.8%) underwent an emergency department–performed thoracotomy. Another 185 patients (59.9%) met the criteria for operation and underwent a laparotomy. The incidence of nontherapeutic operations was 2.2%, and that of negative operations was 8.6%. One hundred six patients (34.3%) were selected for observation. Fourteen of the initially observed patients underwent a late operation, but it was therapeutic in only 5. Overall, 92 patients (29.8%) were successfully managed nonoperatively. The overall sensitivity of the initial physical examination was 97.1%. The estimated bullet trajectory was not reliable in identifying the need for operation because of 224 patients with likely peritoneal penetration only 169 (75.4%) had significant injuries requiring surgical repair.

Conclusion: In the appropriate environment, many civilian abdominal gunshot wounds can be managed nonoperatively.

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PATIENTS AND METHODS

PATIENTS

A prospective protocol-guided study was performed at the Los Angeles County and University of Southern California Medical Center, Los Angeles, one of the largest level I trauma centers in the country (6900 trauma admissions in 1995), with a dedicated Division of Trauma and Critical Care with 7 full-time trauma faculty. The faculty are in-house on a 24-hour basis, lead all trauma team activations, and supervise all operations.

The study included all patients with a bullet entry or exit in the anterior abdomen. Patients with obviously superficial wounds were not included in the study.

During a 16-month period (March 1994 to June 1995), 309 patients with GSWs of the anterior abdomen were treated. Most patients (290 [93.9%]) were male; their mean age was 24.7 years (range, 7-77 years); and their ethnic profile was as follows: Hispanic, 235 (76%); black, 45 (14.7%); white, 15 (4.9%); and Asian, 14 (4.6%). Two hundred thirteen patients (69%) had a single GSW, 44 (14.2%) had 2 GSWs, and 52 (16.8%) had 3 or more GSWs. The mean time from injury to admission, which could be documented in 235 patients, was 49 minutes.

METHODS

All study patients were assessed and managed according to a written protocol. The protocol included epidemiological data, the time from injury to admission, the number of bullets, and bullet entry and exit sites. The probability of peritoneal penetration on the basis of estimated bullet tract (penetration most likely, unlikely, or cannot comment) was a subjective assessment made by the chief trauma resident (postgraduate year 4 or 5). The abdominal examination was classified as obvious peritonitis or mild tenderness around the bullet tract with no peritoneal signs. Any extra-abdominal injuries were recorded and described. The initial and subsequent hematocrit indexes were recorded. In all patients, chest and abdominal x-ray films were taken unless severe hemodynamic instability dictated immediate transportation to an operating room.

Patients with hemodynamic instability caused by bleeding, peritonitis (rigidity, rebound tenderness, significant tenderness away from the bullet wound), associated spinal cord, or severe head injury, or those who required an extra-abdominal operation, were selected for emergent laparotomy. A second-generation cephalosporin therapy was started in the emergency department and continued for 24 hours.

Patients with minimal or equivocal abdominal signs were selected for nonoperative management, irrespective of the site of entry or exit of the bullet, and irrespective of alcohol or other drug use. Similarly, patients with mild hypotension or tachycardia who responded rapidly to small volumes of intravenous resuscitation were observed if the abdomen was soft and not tender, and no blood transfusions were required in isolated abdominal trauma. These patients were admitted to the Surgical Admitting Unit, which is also the base station of the trauma team on call. In this area, monitoring of blood pressure, pulse rate, serial hematocrit indexes, and oxygen saturation is routinely performed on all patients.

Patients selected for observation underwent chest and abdominal radiography and urinalysis. Intravenous pyelography or abdominal contrast computed tomographic scan or both were obtained, according to the attending surgeon's preference. Laparoscopy was performed on patients with left thoracoabdominal injury and a soft abdomen. No prophylactic antibiotics or analgesic drugs were administered. The observation included frequent clinical assessments by the attending surgeons and recording of blood pressure, pulse rate, temperature, oxygen saturation, and serial hematocrit indexes. If signs of peritonitis developed, or an unexplained notable drop of the hematocrit index or other evidence of ongoing blood loss was present, an operation was performed; otherwise, the patient was transferred to the general surgical department within 24 hours of admission and subsequently discharged after 24 to 48 hours unless associated injuries required further inpatient care.

Table 1. Estimated Bullet Tract and Need for Therapeutic Operative Intervention

<table>
<thead>
<tr>
<th>Bullet Tract</th>
<th>No. of Patients</th>
<th>Urgent Operations</th>
<th>Therapeutic Urgent Operations</th>
<th>Observation</th>
<th>No. of Observed Patients With Delayed Therapeutic Operations</th>
<th>Total No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most likely peritoneal penetration</td>
<td>224</td>
<td>161 (71.8%)</td>
<td>165 (73.7%)</td>
<td>43 (19.2%)</td>
<td>4</td>
<td>169 (75.4%)</td>
</tr>
<tr>
<td>Unlikely peritoneal penetration</td>
<td>68</td>
<td>3 (4.4%)</td>
<td>1 (1.5%)</td>
<td>65 (95.5%)</td>
<td>1</td>
<td>2 (2.5%)</td>
</tr>
</tbody>
</table>

pressure was 90 mm Hg or lower. Thirty-nine (78%) of these patients required a laparotomy, which was therapeutic in 34 (87.2%). The remaining patients were observed; in 1 of them, peritoneal signs were later noted and he underwent a laparotomy that was therapeutic.

The initial Glasgow Coma Scale score was less than 13 without head trauma in 38 patients, most likely resulting from shock or alcohol and other drug use. In an unpublished prospective study for our center of the 519 patients with trauma, only 150 (29%) had negative test results for alcohol or other drug use: 27 (71.1%) of them underwent a laparotomy (which was therapeutic in 24 [88%]), and the remaining 11 patients were observed and none of them had a notable intra-abdominal injury requiring treatment. Overall, 14 patients (31.1%) in this group of patients with a score of less than 13 on the Glasgow Coma Scale but no head injury had no notable intra-abdominal trauma.
ASSOCIATED INJURIES

Overall, 144 patients (46.6%) had extra-abdominal injuries (extremities, 28.8%; chest, 15.2%; neck, 6.5%; and head, 4.2%). Forty-eight (33.3%) of these patients were selected for observation; in 2 observed patients (4.2%), laparotomies were delayed because of increasing abdominal pain, but findings from both operations were normal.

INVESTIGATIONS

Besides the standard chest and abdominal x-ray films in fairly stable patients, a computed tomographic scan was performed on 19 patients (6.1%). The computed tomographic scans showed abnormal findings in 7 patients and demonstrated solid organ injuries (liver, spleen, kidney) in 6 patients and spinal injury in 1 patient. Five patients with solid organ injuries were selected for observation (Figure 1 through Figure 3): 1 of them required subsequent operation for ongoing bleeding from the liver and the remaining 4 patients had an uneventful recovery.

"One-shot" intravenous pyelograms were performed in 43 patients (13.9%), and they showed abnormal findings (renal injury) in 10. Two of the patients with abnormal intravenous pyelographic findings were successfully treated nonoperatively.

Laparoscopic evaluation was performed in 5 patients; abnormal findings were noted in 3 patients who had laparotomies performed, 1 of which was nontherapeutic (nonbleeding superficial liver laceration).

MANAGEMENT

Eighteen patients in extremis or with no signs of life underwent an emergency department-performed thoracotomy; none of them survived. Another 185 patients (59.9%) underwent an emergency celiotomy because of signs of peritonitis or hemodynamic instability or both or because of associated severe head or spinal cord injury. The operation was therapeutic in 165 patients (89.2%), gave normal findings in 16 (8.5%) and was nontherapeutic in 4 (2.2%) (Figure 4). Four of the patients with normal laparotomy findings had spinal injury or required another extra-abdominal operation and, by protocol, were automatically selected for laparotomy.

The overall mortality was 12.1% (37 deaths). Excluding the deaths in the group of 18 patients who underwent an emergency department-performed thoracotomy, the mortality for those undergoing laparotomy
was 10.3% (19 deaths). Seven of these deaths were from massive hemorrhage and occurred in the operating room. The remaining 12 deaths were from irreversible shock and bleeding (6 patients) or multiorgan failure (6 patients) and occurred in the surgical intensive care unit. There was no death in the group of 106 patients who were selected for initial observation.

Of the 100 patients (34.3%) who were selected for nonoperative management, 11 patients had an admission systolic pressure of 90 mm Hg or lower, 11 patients had Glasgow Coma Scale scores of less than 13 but no head injury, 48 patients had extra-abdominal GSWs, and 33 patients had 2 or more GSWs. In 44 (41.3%) patients of this group, the bullet tract was assessed as most likely to have penetrated the peritoneum.

Fourteen patients in the initially observed group of 106 required subsequent operation because of increasing tenderness (13 patients) or evidence of continued bleeding (1 patient). Nine of the laparotomies gave normal findings or were nontherapeutic and 5 were therapeutic. Details of the 5 therapeutic operations are given in Table 2. The sensitivity of the initial physical examination was 97.1%. The diagnosis was delayed in 4 of the patients by 6 to 13.5 hours. All 4 patients had colon injuries that were managed by primary repair. In 1 of these patients, a psoas abscess developed and was successfully managed by percutaneous aspiration. In a fifth patient, the diagnosis was established on admission by means of computed tomography, which showed a liver and right kidney injury (Figure 1), and the patient was selected for observation because of hemodynamic stability and a soft abdomen. During the observation period, the abdomen became distended and the hematocrit index dropped. The patient underwent transfusion of 6 U of blood and, in violation of the protocol, was observed for 48 hours before he was operated on. He had postoperative abdominal compartment syndrome, acute respiratory distress syndrome, and candidiasis, and he required prolonged hospitalization until final discharge from the hospital.

The most commonly wounded intra-abdominal organ in the group of 217 patients who underwent laparotomy was the small bowel (81 [37.3%]). The incidences of other organ injuries were as follows: colon, 59 (27.3%); liver, 59 (27.2%); kidney, 34 (15.7%); diaphragm, 33 (15.2%); vessels, 31 (14.3%); stomach, 27 (12.4%); spleen, 15 (6.9%); and bladder, 14 (6.5%). Overall, the 13 nontherapeutic operations included 6 liver injuries, 2 kidney injuries, 1 splenic injury, 1 extraperitoneal bladder perforation, and 3 mesenteric or mesocolic hematomas.

The hospital stay in the group of patients with therapeutic laparotomies was 12.5 days, and the complication rate was 39.3%. Overall, 199 early and late operations were performed. The findings from 23 (11.6%) of them were normal and 6 (3%) were nontherapeutic. The mean hospital stay in the group of patients with normal surgical findings or nontherapeutic operations was 6.4 days, the complication rate was 27.6% (8 patients), and the mean hospital charges were $18,123. In at least 5 (21.7%) of the patients, the complications were probably directly related to the anesthesia or laparotomy (Table 3). The mean hospital stay in the successfully observed group was 3.3 days, and the mean hospital charges were $8595.

**COMMENT**

Selective nonoperative management of abdominal knife injuries has become an acceptable practice in many trauma centers. The selection of patients for operation or observation is based almost exclusively on clinical examination. This policy has been shown to be safe and effective in reducing the number of nontherapeutic laparotomies. However, the role of nonoperative management in abdominal GSWs is highly controversial and mandatory operation has remained the accepted standard of care.
Probable not directly related to the anesthesia or laparotomy.

Figure 5. Management of 309 patients with abdominal gunshot wounds (GSWs). Asterisk indicates that 4 patients had an associated spinal cord injury or required general anesthesia for extra-abdominal injuries.

Valentine et al strongly suggested that laparotomy should be performed "regardless of physical examination or estimated trajectory." Similarly, Sawidson et al stated that "exploratory laparotomy should be performed in all GSWs of the abdomen when even the slightest question of penetration exists." Two reasons are cited for this aggressive approach. The first reason is the high incidence of intra-abdominal injuries, which in many series has been reported to be as high as 98%. Henderson et al, in a retrospective series of 250 patients with abdominal GSWs, reported a positive exploration rate of 85%. Liebenberg and Maasch, in a study of 105 patients, reported positive laparotomy findings in 103 patients (98%) and concluded that virtually all patients with abdominal GSWs require laparotomy. Moore et al reported intra-abdominal injuries in 235 (96%) of 245 cases with GSWs. However, these studies do not distinguish between a normal finding on laparotomy and a therapeutic laparotomy. Many patients with minor solid organ injuries do not benefit from a surgical procedure.

Several other series have reported intra-abdominal injuries in only 70% to 80%. These figures suggest that between 20% and 30% of abdominal GSWs may be eligible for nonoperative management. In our study, only 38.4% of all patients or 75.4% of those with likely peritoneal penetration had injuries severe enough to require surgical repair. Similar data were reported in previous prospective studies from South Africa.

The second reason in support of mandatory laparotomy is the unreliability of the initial physical examination findings in evaluating the abdomen. Moore et al reported that 26 (17%) of 156 patients with intraperitoneal trauma had unimpressive physical signs on admission. Lowe et al found that 41.5% of patients with no clinical signs on admission had intra-abdominal injuries. Similarly, Thal et al suggested a low accuracy for clinical examination. It is difficult, however, to draw conclusions on the reliability of physical examination results from retrospective reviews. It is also possible that surgeons practicing mandatory laparotomy for all abdominal GSWs did not perform a careful clinical examination if the findings were used to make therapeutic decisions. Most trauma surgeons currently accept the concept of selective nonoperative management for knife injuries of the abdomen, based on physical examination findings. It seems paradoxical to believe that physical examination results are reliable in knife injuries but unreliable in GSWs. In theory, physical examination in GSWs should have a higher sensitivity than in knife wounds because of the greater number of intra-abdominal lesions associated with GSWs. In a previous prospective study of 146 patients, Demetriades et al reported a false-negative result of 4.8% and a false-positive result of 3.4%.

The first large reports suggesting that carefully selected patients with abdominal GSWs can safely be managed nonoperatively came from 2 different centers in South Africa. Muckan et al reported a series of 111 patients, 22 (20%) of whom were successfully managed nonoperatively. In a prospective study of 146 patients by Demetriades et al, 41 patients (28%) were observed and 7 of them required subsequent operation without any serious consequences. The remaining 34 (23.3%) of the patients were successfully observed. This concept was cautiously accepted by very few American centers and only for GSWs involving the right upper abdominal quadrant. Chmielewski et al described 12 such patients (6.5% of all abdominal GSWs) who were managed nonoperatively. Renz and Feliciano reported 13 right thoracoabdominal injuries managed nonoperatively. In our present large series of 309 patients, 92 (29.8%) were successfully managed nonoperatively.

The greatest concern with nonoperative management is that hollow viscus perforations may be missed.
during the initial clinical examination. However, the subsequent examination should be able to identify these patients. In our study, the sensitivity of the initial examination was 97.1%. The diagnosis was delayed in 4 patients (by 6 to 13.5 hours) (Table 2), but with no serious consequences. It has been shown in many studies\textsuperscript{1,14,19} that delay by a few hours does not increase morbidity and mortality.

The estimated bullet trajectory has limited value in predicting the need for laparotomy. Surprisingly, 24.6% of all patients with most likely peritoneal penetration did not have an injury that required surgical repair. Contrary, only 2.9% of patients with unlikely peritoneal penetration needed a therapeutic operation. Low-velocity bullets have an unpredictable trajectory because they may follow fascial planes of lower resistance.

Diagnostic laparoscopy has been successfully used in the evaluation of abdominal GSWs. Peritoneal penetration or hemoperitoneum are considered as indications for a laparotomy.\textsuperscript{13,20} This approach is obviously better than mandatory operation, but it still requires general anesthesia. Also, peritoneal penetration or free blood is not necessarily associated with significant injury requiring surgical repair. We are currently using laparoscopy as a standard investigative tool for evaluation of the diaphragm in patients with left thoracoabdominal GSWs and without evidence of perforitis or significant intraperitoneal bleeding.

It has been suggested that alcohol or other illicit drug use may interfere with the abdominal examination. However, other studies\textsuperscript{13} have shown that physical examination findings in these patients are reliable. In our population with trauma, prevalence of alcohol and other drug abusers high. In our recently completed prospective, unpublished study, 178 (76.4%) of 233 patients with penetrating trauma were under the influence of alcohol or other illicit drugs or both. We evaluated these patients exactly like the rest of the victims.

We believe that the policy of mandatory operation for all abdominal GSWs should be reexamined. It has been shown that unnecessary operations for trauma are associated with a high incidence of complications and prolonged hospital stay.\textsuperscript{21-24} In a recent editorial, Nance and Nance\textsuperscript{25} suggested that the time has come to challenge a philosophy that accepts an unnecessary laparotomy in at least 20% of subjects. Selective nonoperative management should be used for GSWs as it is already being used in patients with blunt trauma or stab wounds.

The present study has demonstrated that a significant number of patients can safely be managed nonoperatively. Had we followed a policy of mandatory operation in this series of 291 patients (excluding those with 18 emergency department–performed thoracotomies), 121 patients (41.6%) would have had an unnecessary operation. Had we operated on all victims with likely peritoneal penetration or perforitis, 57 patients (19.6%) would have had an unnecessary operation. By following a policy of selective nonoperative management based on clinical examination results, only 29 (10%) of these patients had an unnecessary laparotomy. Consequently, the current protocol at our trauma center is as shown in Figure 5.

In conclusion, in the appropriate clinical setting, abdominal GSWs should be managed just like knife wounds. A selective, nonoperative management based largely on the findings from serial clinical examinations is safe and eliminates many unnecessary operations.

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REFERENCES