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The Nonoperative Management of Penetrating Abdominal Trauma

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HISTORY

During the last century, the management of penetrating abdominal trauma has evolved full circle, back to the acceptance of selective nonoperative management. This has allowed for the safe nonoperative management of patients sustaining penetrating abdominal trauma without an intra-abdominal injury. With advances in imaging technology however, and the parallel evidence accrued from the management of blunt solid-organ injury, nonoperative management of penetrating trauma has even been extended to select patients who have documented liver, kidney, and spleen injuries.

Throughout most of the nineteenth century, penetrating abdominal trauma was managed expectantly. In 1887, the American Surgical Association recommended that penetrating abdominal injuries in the civilian sector be managed with exploration, but even at the start of World War I, nonoperative management remained the standard practice. Not until 1915, with the exceedingly high mortality rates in the large number of injured patients seen at the beginning of the war, was a policy of routine exploration adopted. This policy then became the standard of care during World War II and into the 1960s, until the concept of nonoperative management was re-introduced for selected patients. This strategy of selective nonoperative management began first with stab wounds and is now widely practiced for this type of injury. By the 1990s, the nonoperative management of gunshot injuries was being used at major trauma centers in the United States and Africa, and a significant body of evidence attesting to its safety has been accumulated. Most recently, as the ability to image missile trajectory and solid-organ damage with CT has evolved, the selective nonoperative management of solid-organ injury after penetrating trauma has been introduced and is undergoing careful evaluation.

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BENEFITS OF NONOPERATIVE MANAGEMENT

The impetus for selective nonoperative management comes largely from the significant rates of nontherapeutic laparotomy following penetrating trauma and the high incidence of complications accompanying nontherapeutic laparotomy. For patients sustaining abdominal stab wounds, retrospective evaluation of a protocol of mandatory exploration found a negative laparotomy rate of 37% in a series of 459 patients [1]. A similar study of 330 patients demonstrated that only 32% of patients had clinically significant injuries [2]. In a prospective series of 651 patients who had abdominal stab wounds, mandatory exploration would have resulted in a nontherapeutic laparotomy rate exceeding 45% [3]. For patients sustaining stab wounds specifically to the back, a prospective study of 230 patients demonstrated the rate of clinically significant injuries to be even lower, at 15% [4].

The rate of clinically significant intra-abdominal injuries resulting from abdominal gunshot trauma is higher than that resulting from stab wounds. A prospective evaluation of 309 patients who had abdominal gunshot wounds demonstrated no clinically significant injuries in approximately one third of the patients [5]. A prospective series of 203 patients sustaining gunshot injuries specifically to the back showed that two thirds of patients had no clinically significant injuries [6]. In a large retrospective evaluation of all abdominal gunshot injuries, including 1405 anterior and 451 posterior wounds, presenting to the Los Angeles County and University of Southern California Medical Center over a period of 8 years, 47% had no clinically significant injuries [7].

Therefore, routine mandatory laparotomy for penetrating abdominal injuries would result in a significant number of nontherapeutic operations. These nontherapeutic laparotomies are not benign. The incidence of complications attributed to nontherapeutic laparotomies for penetrating trauma ranges from 8.6% to 25.9% [1,8–10]. Complications can occur in up to 19.7% of patients without peritoneal violation and no other extra-abdominal injuries [10]. In addition, long-term complications such as hollow viscus obstruction, although exceedingly difficult to capture in the trauma population, have been documented [11]. In a study of patients undergoing nontherapeutic laparotomy from stab wounds, 102 patients had a 5% rate of incisional hernia during a mean follow-up of 57 months [1].

These complications result in an increased length of hospital stay [1,5,7,12] and increased hospital charges. With a cost differential of approximately \$9500 US for patients undergoing nontherapeutic operations compared with successful nonoperative management, Velmahos and colleagues [7] calculated a \$9.5 million US savings in hospital charges from an 8-year experience in the nonoperative management of abdominal gunshot injuries.

CONTRAINDICATIONS TO NONOPERATIVE MANAGEMENT

In the initial assessment of patients sustaining penetrating abdominal trauma, physical examination remains the critical initial filter for selecting patients who can undergo nonoperative management safely. On initial assessment, patients who demonstrate hemodynamic abnormality, diffuse abdominal

pain, or peritonitis require exploratory laparotomy to exclude injury. In this group of patients, there is a high likelihood of a clinically significant injury. Penetrating injuries in a hemodynamically "stable" patient who has peritonitis should trigger an emergent operation. Even with hemodynamic "stability," a review of 139 consecutive patients who had penetrating trauma and peritonitis demonstrated an intra-abdominal injury rate of 97%, with 11% of patients having 750 to 1500 cm³ and 7% having more than 1500 cm³ of free intraperitoneal blood present at opening. Of these "stable" patients, 25% became hypotensive intraoperatively, with 39% of patients requiring blood transfusion [13]. Patients who have a concomitant head injury or require a nonabdominal operative procedure and are unable to cooperate in serial clinical examination also are not suitable candidates for nonoperative management. Finally, omental evisceration, predominantly after stab wounds, is not an absolute contraindication for nonoperative management. Prospective evaluation of patients who have stab wounds and omental or hollow viscus evisceration has demonstrated that serial physical examination can identify patients who have clinically significant intra-abdominal injuries requiring repair [3,14–16].

NONOPERATIVE MANAGEMENT OF STAB WOUNDS

Today, there has been widespread acceptance of the selective nonoperative management of stab wounds to the abdomen. In 1969, Shaftan [17] and Nance and Cohn [18] provided the evidence that formed the foundation for this practice in select patients. This evidence was solidified by a large, prospective study by Demetriades and Rabinowitz [3] that enrolled 651 patients who had anterior abdominal stab wounds. The sensitivity of serial physical examination in this series was 97.4%. Of the 306 patients initially managed nonoperatively, only 3.6% required a subsequent laparotomy, with no morbidity or mortality attributed to the delay in operation. Had the study patients undergone mandatory exploration, the nontherapeutic laparotomy rate would have been 48%. This finding confirmed that the initial physical examination and subsequent serial examinations are highly sensitive in detecting patients who require operation. This conclusion has been reinforced by several studies [2,19-22]. A cost-benefit analysis by Leppaniemi and Haapiainen [19] showed that selective nonoperative management directed by physical examination is a safe option for decreasing nontherapeutic laparotomy rates, resulting in a cost benefit of \$2800 US for each patient managed nonoperatively. Although the majority of studies did not separate the location of the stab wound, injuries to the back have an even higher likelihood of being managed successfully with a nonoperative approach. A prospective evaluation of 230 stab wounds to the back by Demetriades and colleagues [4] resulted in 85% being managed nonoperatively based on clinical examination.

For patients undergoing selective nonoperative management of stab wounds with serial clinical examination (Fig. 1), the repeated examinations are performed ideally by a single dedicated team. The patient should not receive narcotic analgesics or antibiotics, which may mask clinical findings. The physical examination



Fig. 1. Diagnostic algorithm for penetrating abdominal trauma. GSW, gunshot wound; SW, stab wound.

should be complemented by the evaluation of changes in temperature, blood pressure, heart rate, and serial laboratory examination of the hemoglobin and white blood cell count. The actual duration of the required observation period was examined in a study from the Ryder Trauma Center. They demonstrated that all 68 patients failing nonoperative management in a 650-patient series of stab wounds did so within a 12-hour window [23]. The total duration of clinical observation should be individualized on the basis of the clinical and laboratory findings.

For abdominal stab wounds, adjunctive diagnostics have not been shown to increase significantly the sensitivity of the detection of injuries by clinical examination. The use of diagnostic peritoneal lavage (DPL) for the detection of clinically significant intraperitoneal injury has been examined. The procedure is cumbersome, invasive, and time consuming. Although DPL is highly sensitive for the presence of intraperitoneal blood, a positive result by itself does not predict a therapeutic laparotomy. For the detection of hollow viscus injuries such as colon, the false-negative rate of DPL can exceed 30% [24]. The true specificity of DPL is complicated further by the variability between studies in the criteria used for a positive study and the time after injury when it is performed. Likewise, the utility of focused abdominal sonography for trauma (FAST) in the assessment of patients sustaining abdominal stab wounds is questionable. Two prospective and one retrospective evaluation of FAST for the assessment of hemodynamically stable patients who had penetrating abdominal trauma found a sensitivity of only 46% to 67% [25-27]. It is rare for the trauma ultrasound examination to contribute to clinical decision making in patients who have sustained penetrating abdominal trauma undergoing serial clinical examination [25].

The use of diagnostic laparoscopy for the assessment of patients who have abdominal stab wounds has been evaluated also. In general, laparoscopy is highly sensitive for the detection of peritoneal violation. Even in the hands of experienced laparoscopists, however [28,29], it is not sensitive for hollow viscus or retroperitoneal injuries, and the finding of positive peritoneal penetration simply identifies a patient at risk of intra-abdominal injury. This finding still requires exclusion of intra-abdominal injury by conversion to laparotomy or continued clinical examination. Unfortunately, using peritoneal violation detected at laparoscopy alone as the indication for laparotomy will result in a high rate of nontherapeutic laparotomy [1–3]. Clinical examination is also not optimal as after the administration of a general anesthetic for the laparoscopy, the benefit of clinical examination is lost for many hours.

Laparoscopy, however, may play a role in the management of patients who have left thoracoabdominal stab wounds and suspected diaphragmatic injuries (Fig. 2). This injury may be clinically silent in the initial observation phase and is difficult to assess radiographically. Approximately one third of patients who have an external wound in the area bounded by the nipple to scapular tip superiorly and the costal margin inferiorly have a diaphragmatic injury [30,31]. A prospective study by Murray demonstrated a diaphragmatic injury in 26% of patients sustaining stab wounds to the left thoracoabdominal region but without an indication for laparotomy. Based on this data, at the Los Angeles County and University of Southern California Medical Center, patients who have sustained a penetrating injury to the region at risk are observed for 8 to 12 hours to exclude intra-abdominal hollow viscus injury. They then undergo laparoscopic evaluation of the diaphragm; injury, if detected, can be repaired with minimally invasive techniques.



Fig. 2. Occult diaphragmatic injury after left thoracoabdominal stab wound seen at laparoscopy.

Finally, the role of CT scanning in abdominal stab wounds with suspected solid-organ injury is well documented, but its role in the remainder of stab wound patients is not clear. In gunshot injury the trajectory of the missile can be followed clearly; in most stab wounds, following the path of the injury is difficult. Some evidence supports the use of CT scanning for posterior wounds [32,33], but there is little evidence that the addition of CT to serial clinical evaluation will alter the clinical management of patients. A recent prospective study by Salim and colleagues [34] demonstrated that, in patients who had anterior abdominal stab wounds and no indication for laparotomy, CT had a 100% negative predictive value when clinical follow-up to discharge was used as an aggregate reference standard. This finding introduces the possibility that advanced multislice CT with reconstructions may be able to trace the path of the knife injury more accurately and distinguish patients who require operation or serial clinical examination from patients whose wounds have a non-threatening trajectory and who safely can be discharged home.

In summary, for abdominal stab wounds, evaluable patients presenting with a hemodynamic abnormality, diffuse abdominal pain, or peritonitis require immediate laparotomy. For the remainder of patients with a reliable examination, serial clinical and laboratory examination is an effective and safe method for detecting those who have clinically significant injuries requiring repair. This examination ideally is performed by a dedicated trauma team in a holding area where close continuous clinical examination can be performed. For left thoracoabdominal injuries, diagnostic laparoscopy can be performed to evaluate the diaphragm for injury. As multislice CT technology improves, the role of CT screening in patients who have abdominal stab wounds will require further evaluation.

NONOPERATIVE MANAGEMENT OF GUNSHOT INJURIES

Unlike abdominal stab wounds, the nonoperative management of abdominal gunshot injuries is not universally accepted. At most centers, patients sustaining an abdominal gunshot injury undergo a mandatory laparotomy. As outlined in the 1996 editorial entitled "It Is Time We Told the Emperor About his Clothes" [35], this practice is based on unsupported assertions rather than on rigorously tested evidence. Although the rate of intra-abdominal injury is higher with gunshot wounds than with stab wounds, a protocol of mandatory laparotomy still results in a significant number of nontherapeutic procedures. A nontherapeutic laparotomy can be expected in approximately one third of patients, a percentage that increases to two thirds for gunshot injuries localized to the back [5,6]. A series of prospective studies at the Los Angeles County and University of Southern California Medical Center enrolled 309 patients who had gunshot injuries to the anterior abdomen (over 16 months) and 203 patients who had gunshot wounds to the back (over 12 months). For anterior injuries, a mandatory exploration protocol would have resulted in a 42% rate of unnecessary laparotomy [5]. For back gunshot wounds, mandatory laparotomy would have resulted in a 70% rate of unnecessary laparotomy [6]. Critical to successful nonoperative management of abdominal gunshot wounds are patient selection and adjunctive trajectory imaging with CT.

The absolute contraindications for selective nonoperative management of gunshot wounds are the same as for stab wounds. The patient must be able to undergo serial examination, be hemodynamically stable, and not have diffuse abdominal pain or peritonitis. Once the patient has been fully examined to ensure that there are no contraindications to nonoperative management, a clear picture of the external wounds and intracorporeal retained missile fragments is required to assess which body regions are at risk of injury. Inadequate assessment of all potentially injured structures is a major pitfall. For example, a patient may sustain an abdominal gunshot injury with no missile visible on the abdominal radiographs. The bullet or fragment may have taken a cranial trajectory traversing the mediastinum or neck, leaving these areas at risk of injury. Potential injuries sustained from an abdominal gunshot wound therefore are not limited to the intra-abdominal contents. This assessment can be particularly difficult in patients sustaining multiple gunshot injuries.

A second pitfall is incorrectly assuming that an external wound is either an entrance or exit wound. Even in the most superficial tangential wound, this determination is difficult without having available all the information obtained from the physical examination, imaging, operation, and autopsy. Incorrect documentation of entry or exit wounds may carry negative legal ramifications later in the patient's course.

Once the body regions at risk of injury have been identified, the next step in selective nonoperative management is detailed imaging. Although the kinetic energy, deformation or fragmentation of the missile, and increased depth of penetration can result in increased tissue damage on impact, this straight-line tissue destruction with its associated air bubble trail also can be advantageous, in that the resultant path can be tracked readily on CT [36]. These images can provide detailed trajectory information (Fig. 3). For this reason, CT has become an integral part of the nonoperative management of abdominal gunshot injuries.

The missile trajectory can be seen to be (1) clear of peritoneal violation, (2) breaching the peritoneum without obvious injury, or (3) directly resulting in a hollow viscus or solid-organ injury. If it can be seen that the trajectory does not involve peritoneal violation, these patients can be managed safely non-operatively. Any associated injuries will direct the remainder of the patient work-up. In patients who have clear peritoneal violation but no obvious organ injury, serial clinical evaluation is required. Like the serial clinical observations of patients who have stab wounds, the repeated examinations are performed ideally by a single dedicated team. Unlike stab wounds, however, the optimal time for observation before safe discharge for gunshot wounds is not known and requires further study.

When the trajectory is in line with a hollow viscus structure, or when there is collateral evidence of injury (such as free fluid or air in the vicinity of a hollow viscus structure along the trajectory of the missile), operation is required. If, however, the injured intra-abdominal organ is solid (liver, spleen, kidney; Figs. 4–6), there is increasing evidence that a routine protocol of mandatory exploration is not warranted [37–40]. This strategy is consistent with the accumulated body of evidence gained from the nonoperative management of blunt solid-organ injuries. The same management adjuncts that have facilitated nonoperative management of blunt injury can be applied to the nonoperative management of penetrating solid-organ injuries. CT allows excellent discrimination of the wound track through the organ parenchyma and allows the early and late diagnosis of complications ranging from pseudoaneurysm formation to bile leakage. Concurrent advances





Fig. 4. Nonoperative management of a stab-wound-injured spleen.

in endovascular and percutaneous interventional techniques with image guidance have allowed these complications to be characterized further and treated without operation.

In a prospective, protocol-driven study of penetrating solid-organ injuries (70% gunshot), 152 patients who had 185 solid-organ injuries were studied [37]. Forty-three patients who had 47 solid-organ injuries were selected for non-operative management. Overall, 28% of liver, 15% of kidney, and 4% of spleen injuries were managed successfully nonoperatively. The success rate of nonoperative management in patients who had isolated solid-organ injuries was 69%. Even in patients who had severe (grades 3–5) liver injuries, the success rate of nonoperative management was 62%. These patients had a significantly shorter hospital length of stay than patients undergoing operative management. Therefore, solid-organ injury from gunshot trauma without concomitant hollow viscus injury is not a contraindication to nonoperative management.



Fig. 5. Nonoperative management of a stab wound to the kidney.



Fig. 6. Nonoperative management of a gunshot injury to the liver.

The summarized experience with the nonoperative management of abdominal gunshot injury at the Los Angeles County and University of Southern California Medical Center in 1856 patients sustaining abdominal gunshot injuries (1405 anterior abdomen and 451 back) over an 8-year period demonstrated that of the 792 patients initially selected for nonoperative management, 10% developed symptoms requiring exploration [7]. Fifty-seven of these had a therapeutic laparotomy, and 0.6% had complications attributed to the delay in laparotomy from attempted nonoperative management. All patients who had complications were managed successfully. Overall, 38% of patients were managed successfully nonoperatively. Had a policy of mandatory laparotomy been followed in this large series, 47% of patients would have had a nontherapeutic laparotomy (39% anterior and 74% back). This protocol of selective nonoperative management also was associated with decreased length of stay and hospital charges.

SUMMARY

The management of penetrating injuries to the abdomen has evolved back to a selective nonoperative approach. Using clinical examination for screening, evaluable patients without hemodynamic instability or peritonitis can safely undergo a trial of nonoperative management. For stab wounds, this involves serial clinical examination with delayed laparoscopic evaluation of the diaphragm for left thoracoabdominal injuries and CT scanning for suspected solid-organ injuries. The same contraindications to nonoperative management apply to gunshot injuries. Gunshot injuries undergoing nonoperative management require detailed trajectory imaging with CT. The presence of peritoneal violation without definite organ injury requires serial clinical examination. Isolated solid-organ injury is not an absolute contraindication to nonoperative management and may benefit from advanced endovascular and percutaneous interventions to facilitate management. Selective nonoperative management of both stab wounds and gunshot injuries is safe and has been shown to decrease the rate of unnecessary laparotomy, length of hospital stay, and management costs.

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