Value of Digital Exploration for Diagnosing Injuries to the Left Side of the Diaphragm Caused by Stab Wounds

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Hypothesis: The digital exploration of stab wounds in the left thoracoabdominal region allows the early diagnosis of diaphragmatic lesions.

Design: Diagnostic test study. The digital exploration of the diaphragm was compared with laparotomy (the gold standard) and thoracoscopy.

Setting: The study setting was the Hospital Universitario San Vicente de Pau´l (Medellı´n, Colombia). This is a referral trauma center for the general community.

Patients: The study included 82 consecutive patients who were admitted to our institution during a 12-month period with injuries caused by stab wounds to the left thoracoabdominal region and who did not have indications for immediate surgery. Digital exploration of the wound was performed by the attending surgeon in the emergency department. If a lesion of the diaphragm was identified, a laparotomy was performed; if no diaphragmatic lesion was found, a diagnostic left thoracoscopy and/or laparotomy was performed. Results of the laparotomy (n=63) or thoracoscopy (n=19) were used as the standard of reference for the determination of sensitivity, specificity, and predictive values of digital exploration.

Intervention: The integrity of the diaphragm was determined by digital exploration through the stab wound.

Main Outcome Measures: Sensitivity, specificity, predictive value, and likelihood ratio were calculated.

Results: For the detection of diaphragmatic lesions, digital exploration demonstrated a sensitivity of 96%, a specificity of 83.3%, a positive predictive value of 91%, and a negative predictive value of 93.7%.

Conclusion: Digital exploration is a reliable method for the detection of injuries to the left side of the diaphragm caused by stab wounds.

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The diaphragm is frequently compromised when knife or gunshot wounds penetrate the lower chest or upper abdomen. Patients with lesions in this area who have signs indicative of visceral injury must be treated surgically. A high percentage of these patients do not show such signs, and they represent a diagnostic challenge for trauma surgeons. Early detection of these lesions is extremely important; delays in diagnosis are associated with high morbidity and mortality rates resulting from herniation and strangulation of abdominal viscera through the diaphragmatic defect. Various methods have been used for the early diagnosis of diaphragmatic injuries. In this study, we present our experience using digital exploration of stab wounds to the left thoracoabdominal region for the diagnosis of diaphragmatic lesions.

RESULTS

Of the 82 patients in whom a digital exploration was performed, 51 (62.2%) had digital findings that indicated the presence of a diaphragmatic lesion (positive exploration). These patients underwent laparotomy; in 50 of them, injury to the diaphragm was confirmed and sutured. In the remaining patient with a positive digital exploration, no injury was found during the laparotomy. This case represents the single false-positive result of the procedure. Digital exploration was negative in 25 patients (30.5%). The integrity of the diaphragm was confirmed in these 25 patients with diagnostic thoracoscopy. In addition, laparotomy was performed in the first 12 patients with a negative digital exploration. In these 12 patients, findings during the laparotomy confirmed the absence of diaphragmatic injury. Because
PATIENTS AND METHODS

This is a longitudinal cohort study that was designed to evaluate the efficacy of digital exploration of the diaphragm performed through the stab wounds as an early diagnostic procedure for possible injuries to the left hemidiaphragm. The study included all patients 12 years and older who were admitted during a 12-month period (May 1, 1994, through April 30, 1995) to the emergency department of our institution with injuries caused by stab wounds to the left lower chest or upper abdominal region and who did not have indications for immediate surgical intervention. The thoracoabdominal region was defined as the area between the left costal margin (inferior boundary) and an imaginary line crossing both nipples and the scapular tips (superior boundary). We used digital exploration to examine all patients with a left thoracoabdominal stab wound. If a lesion of the diaphragm was identified, laparotomy was performed as a therapeutic procedure. If no diaphragmatic lesion was identified, a diagnostic left thoracoscopy and/or laparotomy was performed to evaluate the findings of digital exploration.

During the study period, 212 patients with stab wounds to the left thoracoabdominal region were admitted to our institution. Of these, 130 patients were hemodynamically unstable or had signs of peritoneal irritation and were taken immediately to surgery. The remaining 82 patients who did not require emergent surgery constituted the population focus of this study. There were 79 men and 3 women. The mean age was 27.8 years (range, 16-62 years). The study was approved by the investigations review board of our institution. Informed consent was obtained from the patients or from a close relative.

TECHNIQUE FOR DIGITAL EXPLORATION

Digital exploration was performed in the emergency department immediately following admission. After surgical cleansing, the wound was infiltrated with 1% lidocaine hydrochloride. Integrity of the diaphragm was determined through digital exploration with the index finger. Injuries were felt as a defect in the continuity of the diaphragm's surface. This exploration was performed by the attending surgeon in charge of the emergency department. Results of digital exploration were classified as positive for diaphragmatic injury when a defect was found or as negative when the diaphragm was intact and the physician who performed the exploration was satisfied with the examination. In patients for whom the digital exploration was incomplete because of interposition of ribs or cartilage or lack of patient collaboration, the results of digital exploration were classified as inconclusive.

TECHNIQUE FOR THORACOSCOPY

Thoracoscopy was performed by an attending surgeon who was not involved in the digital exploration. The procedure was performed in the operating department using general anesthesia. The patient was in a supine position and turned slightly to the right with the help of a cushion. An incision was made in the fifth left intercostal space near the midaxillary line, through which the laparoscope was inserted to visualize the pleural surface of the diaphragm. Clots and fresh blood were aspirated. After the thorascopic evaluation was completed, a thoracostomy catheter was placed through the surgical incision.

TECHNIQUE FOR LAPAROTOMY

Laparotomy was done by the same surgeon who performed the thoracoscopy. Once surgical cleansing of the abdomen was completed, an incision was made in the midline. After the abdominal cavity was entered, the peritoneal surface of the left side of the diaphragm was visualized and its integrity determined.

STATISTICS

Results of the laparotomy (n=63) or thoracoscopy (n=19) were used as the standard of reference for determination of sensitivity, specificity, predictive values, and likelihood ratio (LR) of digital exploration of the diaphragm. The LR expresses the odds of a given result of a diagnostic test in a patient with (as opposed to without) the target disorder.1 thoracoscopy has been shown to be highly specific for ruling out injuries of the diaphragm,2 we decided not to perform laparotomy on the remaining 13 patients with negative digital explorations. In 6 patients (7.3%), it was not possible to establish integrity of the diaphragm with digital exploration. These inconclusive examinations resulted from interposition of ribs or cartilage (n=4) or lack of patient cooperation (n=2). The 6 patients underwent thoracoscopy, and an injury of the diaphragm was detected in 2 of them; in both patients the injury was repaired during the laparotomy. Thoracoscopy in the remaining 4 patients revealed an intact diaphragm, and laparotomy was not required. All patients whose digital exploration did not disclose injuries of the diaphragm received clinical follow-up, either by review of their medical records or by direct questioning and physical examination. None of these patients required subsequent interventions for complications resulting from the thoracoabdominal wound. Among the 52 patients with diaphragmatic injuries, 30 patients (57.7%) had isolated injuries of the diaphragm. The remaining 22 patients had associated visceral injuries, the most common of which involved the stomach (n=15; 28.8%), spleen (n=10; 19.2%), and colon (n=4; 7.7%). There were no complications related to the digital exploration of stab wounds in our patient population.

In summary, 52 (63.4%) of 82 patients with stab wounds to the left thoracoabdominal region and without indications for laparotomy on admission had a diaphragmatic lesion diagnosed by surgical exploration. This included 50 of 51 patients with positive digital explorations and 2 of 6 patients with inconclusive examinations. According to these results, digital exploration
showed a sensitivity of 96% and a specificity of 83.3%. Positive and negative predictive values were 91% and 93.7%, respectively. The LR for a positive digital exploration was 28.9, for a nonconclusive digital exploration, 0.28, and for a negative exploration, 0.

The incidence of diaphragmatic lesions caused by blunt trauma and knife wounds ranges between 0.8% and 5.8% of all abdominal lesions. Diaphragmatic injuries are more common on the left side, and the diaphragm is injured in 32% to 47% of patients with stab wounds in the thoracoabdominal region. The mortality rate during the first hours following penetrating thoracoabdominal trauma varies between 2% and 14% and results from injuries to organs other than the diaphragm. However, when there is a delay in the diagnosis of injuries to the left side of the diaphragm, the mortality rate increases to 18%, and if there is herniation or visceral strangulation, it rises to between 25% and 66%. Delay in diagnosis of injuries to the right side of the diaphragm is not a serious event; to our knowledge, there have been no reported cases of delayed incarceration of a hollow viscus from a previous stab wound to the right hemidiaphragm. In addition, the liver does not herniate through small defects in the diaphragm.

Depending on the time elapsed between trauma and diagnosis of the lesion, penetrating thoracoabdominal wounds are classified as early or late. Patients may be asymptomatic or exhibit general, thoracic, and/or abdominal manifestations of variable severity. Between 38% and 59% of patients have physical findings related to injuries in associated organs. When there is hemodynamic instability or destruction of the thoracoabdominal wall, immediate surgery is required after resuscitation, including volume replacement, ventilation, and insertion of a thoracostomy tube. In patients with gunshot injuries to the lower chest, the resulting vector of connecting entrance and exit orifices can often suggest if the diaphragm is injured; in these cases surgical exploration is indicated. When there is no exit orifice, a plain radiographic study of the thorax and/or abdomen is indicated to verify location and possible penetration of the abdominal cavity, which in turn would be an indication for laparotomy.

Clinical manifestations in patients with diaphragmatic injuries vary according to the status of the pleura and lungs and can include thoracic pain, dyspnea, and decreased breath sounds depending on the extent of hemothorax or pneumothorax. When these are present, insertion of a thoracostomy tube is usually indicated. Although the presence of bowel sounds in the chest is a highly specific sign of a diaphragmatic hernia, this sign is not found in the early posttrauma period unless a large diaphragmatic defect allows the occurrence of herniation. Abdominal manifestations include pain, distention, and peritoneal irritation, which must be distinguished from a false acute abdomen caused by thoracic trauma. Evidence of visceral lesions is an indication for surgical exploration.

The biggest diagnostic problem arises when a patient with a lesion in the thoracoabdominal region, as previously defined, has no symptoms. Several diagnostic methods, both invasive and noninvasive, have been used to determine diaphragmatic integrity in patients without an indication for immediate surgery. Plain radiographs of the chest are not usually helpful. Results may be normal in more than half of patients with diaphragmatic injuries and are considered diagnostic only when the presence of hollow viscera can be demonstrated in the thorax (1%-17%). Other nonspecific radiographic findings include obscured diaphragmatic shadow, hemothorax, pneumothorax, and elevation of the diaphragm, which suggest diaphragmatic injury but must be confirmed with a different method. Contrast radiographic studies are useful when herniation of the stomach, intestine, or colon has occurred. Although these studies are valuable to determine late stages of diaphragmatic hernia, their usefulness for the acute phase is limited because they do not reveal cases where there is no visceral herniation or where the omentum is displaced to the thorax.

Ultrasoundography also is useful for the diagnosis of diaphragmatic rupture due to blunt trauma when herniation of the liver occurs through the defect, but interposition of gas from the colon and stomach interferes with a complete evaluation of the left hemidiaphragm. In penetrating lesions without visceral herniation, this technique has no value.

Computed tomography is not helpful for the early diagnosis of penetrating diaphragmatic lesions without visceral injury. Its use is usually restricted to blunt trauma cases and late stages of posttraumatic diaphragmatic hernia. Recent studies have reported the use of magnetic resonance imaging for diaphragmatic rupture; its main limitation is the lack of availability for the emergent patient.

Diagnostic pneumoperitoneum consists of injecting 500 cm³ of air into the abdominal cavity and visualizing its passage into the thorax with fluoroscopy. It has several limitations: a negative result does not rule out a lesion of the diaphragm because the defect can be blocked by the viscera or omentum, preventing the development of pneumothorax. If there is an associated lung injury, it is difficult to identify why the air is in the thorax; the pulmonary lesion can also cause pneumothorax. Currently this technique is being replaced by other more sensitive methods. Diagnostic peritoneal lavage was widely used until the late 1980s for the diagnosis of abdominal trauma. This method has a sensitivity of 87.5% and a specificity of 96.6% for the diagnosis of diaphragmatic lesions.

Laparotomy is the gold-standard technique used for comparison with other diagnostic invasive and noninvasive procedures. Some physicians think that it should be performed in all patients with a suspected lesion of the diaphragm. However, this is questionable because of the high number of negative laparotomy rates (78%) as well as high morbidity (40%) and mortality rates (0.8%-2.4%). Many physicians have recommended local exploration of abdominal stab wounds to detect penetration of the peritoneal cavity. However, exploration of thoracoabdominal injuries has been discouraged because of possible complications. Feliciano et al have suggested that penetrating wounds to the thorax that do
not require immediate thoracotomy or laparotomy are best managed with finger palpation of the diaphragm at the time of thoracostomy tube insertion.

At our institution, digital exploration of traumatic injuries has been widely used for several years for the immediate diagnosis of stab wounds to the left thoracoabdominal region. The procedure is performed in the emergency department using local anesthesia, and the diaphragm is evaluated for its integrity. In 1987, Restrepo and Cano \(^{(2)}\) were the first authors to publish their results with this method. In a series of 33 patients, they reported a sensitivity of 100% and a specificity of 93.9%.

With the development of minimal-access surgery techniques, interest has emerged in the use of videolaparoscopy and videothoracoscopy for trauma cases. Salvino et al. \(^{(2)}\) and Ivatury et al. \(^{(2)}\) have described the role of laparoscopy in the diagnosis of penetrating thoracoabdominal trauma. The specificity of the method was 100%, and the sensitivity was 83%. \(^{(2)}\) Furthermore, successful repair of diaphragmatic injuries using laparoscopy has been documented. \(^{(2)}\)

Thoracoscopy has a well-established role in the treatment of the emergent patient with trauma to the thorax. \(^{(2)}\) The use of local anesthesia with the procedure limits an adequate visualization of the diaphragm. \(^{(2)}\) Various authors have described the advantages of this method as easy to perform, safe with minimal invasion, \(^{(2)}\) and with a sensitivity of 100% and a specificity of 90% for the diagnosis of diaphragm lesions. \(^{(2)}\) At our institution, thoracoscopy is the procedure currently being used for all stable patients with gunshot wounds to the thoracoabdominal region and without abdominal signs or symptoms, or when the digital exploration of stab wounds is inconclusive. In this study, diagnostic thoracoscopy was performed in 31 patients, 25 with a negative digital exploration and 6 with an inconclusive digital exploration. With this procedure, a lesion of the diaphragm was detected in 2 patients with inconclusive digital explorations. Laparotomy was performed in these 2 patients, and in both cases the diagnosis was confirmed. Thoracoscopy in the remaining 29 patients revealed no lesion of the diaphragm; this was confirmed in 12 patients by laparotomy (Figure 1).

Figure 2 shows the flowchart with the procedures currently used at our institution for patients with stab wounds to the left thoracoabdominal region. Small lateral and posterior injuries of the right side of the diaphragm are managed conservatively. Laparotomy is performed only if the patient shows clinical signs of a lesion associated with the liver.

In this study, 82 patients with stab wounds in the left thoracoabdominal region who were hemodynamically stable and had no indication for immediate laparotomy were evaluated with digital exploration. Diaphragmatic injuries were found in 52 (63%) of these patients. This figure is higher than that usually reported in the literature (32%-47%) \(^{(2)}\) because we explore every patient with such injuries regardless of clinical status. Therefore, we diagnose injuries in patients who would not otherwise be diagnosed.

Our study presents the digital exploration of traumatic injury as a simple, accurate procedure for the early diagnosis of diaphragm lesions in patients with wounds to the left thoracoabdominal region who have no indication for surgery. We found a sensitivity of 96%, a specificity of 83.3%, a positive predictive value of 91%, and a negative predictive value of 93.7%. Because a lesion of the diaphragm requires surgical intervention, and considering the findings of sensitivity and negative predictive value obtained in this study, we conclude that a negative result of the digital exploration is a reliable indicator to rule out the presence of a diaphragmatic lesion; owing to its high specificity, a positive result supports the diagnosis. The LR confirms the utility of the procedure (LR=29 for a positive result of digital exploration; LR=0 for a negative examination result) because it indicates the accuracy of the test to identify the lesion.

Digital exploration offers other advantages: it requires no general anesthesia or additional incisions, has a low cost, and selects a large group of patients who need

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**Figure 1.** Results of digital exploration for diaphragmatic injury.

**Figure 2.** Flowchart for the approach of penetrating injuries to the thoracoabdominal region.
no further diagnostic studies. Some explorations yield inconclusive results because of poor cooperation from the patient, who is under local anesthesia. In other cases this occurs because the lesion compromises the rib or the costal cartilage. In these situations the procedure can be performed using general anesthesia, or thoracoscopy may be considered as an alternative diagnostic method.

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