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Diagnostic peritoneal aspiration — the foster child of DPL: A prospective observational study

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KEYWORDS
Diagnostic peritoneal aspirate (DPA);
Diagnostic peritoneal lavage (DPL);
Focused abdominal sonogram for trauma (FAST);
Blunt trauma

Abstract *Background:* The abdomen is routinely considered as a possible source of bleeding in hypotensive and unevaluable blunt multitrauma patients. These patients are often unstable to be transported for abdominal computed tomography (CT). Emerging data on Focused Assessment with Sonography for Trauma (FAST) exam questions its initially reported high accuracy. We hypothesized that Diagnostic Peritoneal Aspiration (DPA), without a full lavage, accurately detects intraperitoneal blood if present in sufficient volume to cause hypotension and warrant emergent operation.

Methods: Over 24 months (July 2002–June 2004), 62 severe blunt trauma patients (Injury Severity Score: 32 ± 17) with admission systolic blood pressure equal to or less than 90 mmHg were enrolled prospectively. Percutaneous DPA was performed after FAST. Aspiration of any quantity of blood was considered a positive test. Sensitivity and specificity of DPA and FAST were calculated against findings from abdominal CT, laparotomy, or autopsy.

Results: Twenty-two patients (35%) required emergent laparotomy and 39 (63%) died. DPA was performed in less than 1 min with no complications. Sensitivity and specificity of DPA was 89% and 100%, respectively, whereas for FAST it was 50% and 95%. Two (3%) false negative DPA were recorded; one patient had a minor liver laceration with 250 ml of free blood and the other a leaking retroperitoneal pelvic hematoma in the presence of cirrhosis with 600 ml of bloody ascitic fluid. There were no false positive DPA. Nine (14.5%) false negative and two (3%) false positive FAST were recorded in patients who were found to have at laparotomy 1575 ± 1070 ml of hemoperitoneum on average.

Conclusions: Percutaneous DPA is accurate, rapid, safe, and superior to FAST for the diagnosis of abdominal blood as the source of hemodynamic instability, requiring emergent surgery, in blunt multitrauma patients.

Introduction

A variety of tests are used to identify abdominal bleeding in blunt multitrauma patients including clinical examination, focused assessment with sonography for trauma (FAST),

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computed tomography (CT) and diagnostic peritoneal lavage (DPL).[1] Hemodynamically stable patients usually are evaluated by CT. Transport to CT of hemodynamically unstable patients is deemed unsafe. Because clinical examination is often unreliable in this population, FAST and DPL are currently the only remaining diagnostic tools available to identify major intra-abdominal bleeding.

In recent years, FAST has replaced DPL in most occasions because it is non-invasive and similarly sensitive. However, the initial enthusiasm about FAST has slowly tempered by reports doubting its accuracy.[2–10] In hypotensive patients, the margin of error for any diagnostic test should be very low, as a false result may have catastrophic consequences. Although DPL is a sensitive test (admittedly oversensitive), its low specificity, invasive nature, and somewhat complex technique may limit its use. Infusing and collecting the lavage fluid and calculating cell counts on it is a time-consuming exercise when time is of the essence.

Percutaneous diagnostic peritoneal aspiration (DPA) may offer an acceptable alternative to FAST and DPL in the specific population of hypotensive blunt multitrauma patients. By eliminating the lavage part, the procedure time decreases to a minimum and sensitivity is reduced to recognize only significant amounts of intra-abdominal blood (rather than any volume of blood) likely to be the cause of hypotension. The goal of this study is to examine the sensitivity and specificity of DPA in identifying significant abdominal bleeding that requires emergent operation. Additionally, this study compares DPA with FAST.

Materials and methods

All patients who underwent DPA during the 24-month period from July 2002 to June 2004 were included in the study. According to our institutional policy, FAST exam was performed on all patients with suspected blunt abdominal trauma. In the presence of hemodynamic instability, defined as systolic blood pressure of equal to or lower than 90 mmHg despite standard initial resuscitation, the patient was taken to the operating room if the FAST was positive for free intra-abdominal fluid. If the FAST was negative, percutaneous DPA was performed according to standard closed technique.[11,12] DPA was also performed when FAST was equivocal.

All procedures were done by junior or senior level surgical residents under the direct supervision of an experienced trauma surgeon. Any amount of blood aspirated was considered to be a positive test. No fluid was infused and consequently no lavage was performed. If the DPA was positive, the patient was taken to the operating room; if it was negative, the patient was resuscitated further and had a CT when stabilized.

All patients were followed prospectively until discharge from the hospital or death. Data on patient demographics, injury severity, hemodynamics, diagnostic tests, procedures, and hospital course was collected. Autopsy reports for patients who died were reviewed. The primary outcome of the study was the sensitivity, specificity, and positive and negative predictive value of DPA. This was calculated using the results of operation for operated patients, autopsy for patients who died, and CT for patients who survived and were not operated on, as the standard of reference. In the same way, sensitivity, specificity, and positive and negative predictive values were calculated for FAST. The secondary outcomes of the study were safety, failure, and time required for completion of DPA. Safety was based on DPA-related complications, defined as inadvertent abdominal injuries or wound infection. Failure was defined as the inability to insert the catheter towards the pelvis. The study was approved by our Institutional Review Board.

Results

Description of the study population

Among 8870 trauma patients admitted during the study period, 6628 suffered blunt injury. Of them 62 (1%) were consistently hypotensive despite resuscitation, unevaluable on clinical exam, and subjected to DPA for suspicion of abdominal bleeding. Forty-seven patients were involved in pedestrian (23), motor vehicle (22), or motorcycle (2) accidents and 15 in falls from a height. There were 41 (66%) males and 21 (34%) females with a mean age of 45 ± 20 years (range: 13–101). At the time the DPA was performed the mean systolic blood pressure (SBP) was 48 ± 42 mmHg. Fifty-five (89%) patients required emergency intubation and nine (14.5%) emergency room thoracotomy. The mean Glasgow Coma Score was 8 ± 5 and Injury Severity Score 32 ± 17. Twenty-two (35%) patients underwent emergent laparotomy which revealed on average1184 ± 1045 ml of hemoperitoneum upon opening. The severe trauma of this population reflected in a mortality of 63% (39 patients).

DPA

DPA was completed successfully in all patients percutaneously in less than 1 min. No complications were recorded related to DPA. The results of DPA were considered against the chosen standards of reference: laparotomy in 23 patients, autopsy in 10, and CT in 29. Seventeen true positive, no false positive, 43 true negative, and two false negative DPA results were detected. One false negative result was obtained in a patient with severe head trauma who had a previous midline laparotomy, and the DPA was performed at a paramedian location. Despite being negative, the patient was taken to the operating room due to ongoing drop in hematocrit, hypotension, and exclusion of other potential sources of bleeding. Multiple adhesions were detected and 250 ml of blood was found from a Grade I liver laceration that had stopped bleeding. No further maneuvers were performed and the abdomen was closed. This patient had a true positive FAST. The other false negative result occurred in a cirrhotic patient with severe head injury and also a previous midline laparotomy. The patient arrested in the Emergency Room, and a thoracotomy was performed with no injuries identified. DPA was again performed in a suboptimal position at the left abdomen (as the patient was slightly turned to the right for the thoracotomy) and retrieved no blood. The patient was taken to the operating room for closure of the thoracotomy. A

laparotomy was also performed and revealed 600 ml of bloodstained ascitic fluid confined by adhesions at the right abdomen. A non-bleeding Grade II liver laceration and a leaking pelvic hematoma were identified. This patient had also a false negative FAST. Both patients died as a consequence of their severe head injury and not due to bleeding. Among the 22 patients who received a laparotomy, DPA detected a minimum of 300 ml to a maximum of 3000 ml of blood. The liver, spleen, or mesentery were, as expected, the most common sources of bleeding. The sensitivity, specificity, and positive and negative predictive values of DPA were 89%, 100%, 100%, and 96%, respectively (Table 1).

FAST

FAST was true positive in nine patients, false positive in two, true negative in 40, false negative in nine, and not performed in two patients (due to extreme obesity in one and equipment unavailability in the other). Of the nine patients with false negative FAST, eight were taken to the operating room based on a positive DPA and found to have an average of 1575 ± 1070 ml of hemoperitoneum upon opening the abdomen from a variety of intra-abdominal injuries. One of these patients also had a false negative DPA, and the reason and outcome of his operation were described above. The remaining false negative FAST patient was not operated on despite a positive DPA. In this instance, FAST was negative and DPA was positive, and the patient was taken to CT which showed a Grade I liver laceration with free fluid; this was managed nonoperatively but required blood transfusion.

All nine false negative patients died, and intra-abdominal bleeding was considered as the cause of or contributing factor to death in six cases (67%). Of the three remaining cases, two died of hepatorenal syndrome and one of an associated head injury. The two false positive FAST results were in reality equivocal and therefore were followed by a DPA, which was found to be negative. A subsequent confirmatory CT revealed no injury. For the purposes of this analysis we consider these two equivocal FAST exams as positive, because in the absence of DPA, we would have offered the patient an immediate operation as the safest way of treatment. The sensitivity, specificity, and positive and negative predictive values of FAST were 50%, 95%, 82%, and 82%, respectively (Table 1).

Discussion

Technology has taken over time-honored clinical skills. Sadly but unavoidably, the role of clinical examination dwindles as new devices provide precise information about internal organs and potential injuries. CT has emerged as the main diagnostic tool to evaluate patients with suspected blunt abdominal trauma.[1,13] However, the subpopulation of multi-trauma blunt injured patients who are unevaluable and in shock, even after adequate resuscitation, cannot be safely transported to the CT scanner. Such patients present a major diagnostic dilemma since a number of body regions have to be excluded as the potential source of hemorrhage. Although the surface can be evaluated by visual inspection, the chest by a plain radiograph or by inserting a chest tube, and the pelvic retroperitoneum by reviewing a plain radiograph, the abdominal cavity remains a difficult cavity to assess.

FAST has become part of standard care in the initial evaluation of the trauma patient. However, the overwhelmingly encouraging results of the initial publications [14–17] are met with increasing skepticism, as newer studies reveal potential flaws and suboptimal accuracy.[2,3,5,6,8]

Despite adequate training, responsible mentoring, and exposure to high patient volumes, our experience with FAST at LAC + USC Medical Center has been far from optimal. Unpublished yet prospectively collected data from our institution have found a sensitivity of 56% for FAST (Murray JA, personal communication). Among patients in shock, the sensitivity was still only 50%. Although errors are inherent in every technique, a less than optimal sensitivity may prove detrimental when the population examined consists of bleeding and hypotensive patients. We feel that even if FAST remains useful as ''a piece in the diagnostic puzzle'', it may not be relied upon exclusively to make ultimate decisions about the need of emergent laparotomy or not.

DPL, a powerful diagnostic tool in the armamentarium of the trauma surgeon up to a few years ago,[1,18–22] is being used with decreasing frequency. Its invasive nature, potential for complications, and frustrations related with the technique (such as inability to retrieve adequate volumes of fluid for cell count measurement) are considered disadvantages. Its unnecessarily high sensitivity combined with lack of specificity may lead to non-therapeutic laparotomies in the era of expectant management of a variety of injuries. Despite occasional studies praising the value of DPL in the era of CT,[18,19,23] the technique will not and should not regain its place as the principal diagnostic tool for suspected intra-abdominal bleeding. DPL may still play a role in the immediate or delayed diagnosis of blunt hollow visceral injuries[24,25] but its overall use nowadays is waning.[26] There is concern that nowadays surgeons have little experience in performing DPL[27] and that simulation techniques are used for training.[28]

It is therefore evident that for the specific subpopulation of clinically unevaluable, persistently hypotensive, and potentially bleeding blunt trauma patients, there is a vacuum of accurate diagnostic tests. Our study shows that DPA, the aspiration part of DPL without the lavage, stands out as the most suitable intervention for accurate detection of intra-abdominal bleeding. DPA, particularly when performed percutaneously, combines the benefits of short duration, fast diagnosis, and adequate safety. As additionally shown in a previous study from our institution,[12] the percutaneous technique can be performed rapidly with essentially no morbidity. These results have been confirmed by a meta-analysis of the existing evidence on open and percutaneous

Table 1 Results of FAST and DPA compared to standards of autopsy, CT and laparotomy findings

	Sensitivity	Specificity	+ Pred. value	− Pred. value
FAST	0.50	0.95	0.82	0.82
DPA	0.89	1.0	1.0	0.96

techniques.[29] More importantly, DPA does not have an excessively high sensitivity that may lead to unnecessary laparotomies. In contrast to a full lavage, that can become positive with as little as 15 ml of intra-abdominal blood,[30] DPA's goal is to diagnose only significant amounts of blood. In the face of shock such bleeding usually requires surgical control.

Based on this logic, we hypothesized that DPA will have excellent sensitivity and specificity for the diagnosis of significant intra-abdominal bleeding. Indeed, the sensitivity of 89% and specificity of 100% support this hypothesis. The only two false negative DPA results occurred in patients in whom the technique was suboptimal due to pre-existing midline laparotomy scars. Even so, the amounts of blood found on these patients (250 ml in one from a Grade I liver laceration and 600 ml of bloodstained ascitic fluid in the other from a Grade II liver laceration and a retroperitoneal rent) were not considered contributory to their picture of shock. Active bleeding was not found in any of them, and the laparotomy was non-therapeutic. If these two patients were considered true rather than false negatives (for the purpose of identifying *physiologically significant volumes of blood*), then the sensitivity of DPA would be 100%. The absence of any false positive confirms the reliability of the test in avoiding non-therapeutic operations, a common problem with DPL. The only patient who could be considered as a false positive because he finally did not undergo an operation required blood transfusion during nonoperative management. Even so, the specificity of DPA would be 97%.

In summary, we recommend the use of DPA in patients who, following severe blunt trauma, are unevaluable, hypotensive, and suspected to be bleeding in the abdomen. DPA is superior to FAST in such patients and should be considered as the diagnostic test of choice in order to make the critical decision about the need for rapid transfer to the operating room versus expectant management.

References

1. Feliciano DV. Diagnostic modalities in abdominal trauma. *Surg Clin North Am* 1991;**71**:241—56.
2. Miller MT, Pasquale MD, Bromberg WJ, Wasser TE, Cox J. Not so fast. *J Trauma* 2003;**54**:52—60.
3. Chiu WC, Cushing BM, Rodriquez A, Hosm, Mirvis SE, Shanmuganathan K, et al. Abdominal injuries without hemoperitoneum: a potential limitation of FAST. *J Trauma* 1997; **42**:617—25.
4. Gruessner R, Mentges R, Duber Ch, Ruckert K, Rothmund M. Sonography versus peritoneal lavage in blunt abdominal trauma. *J Trauma* 1989;**29**:242—4.
5. Richards JR, Schleper NH, Woo BD, Bohnen PA, McGahan JP. Sonographic assessment of blunt abdominal trauma: a 4-year prospective study. *J Clin Ultrasound* 2002;**30**(2):59—67.
6. Shanmuganathan K, Mirvis SE, Sherbourne CD, Chiu WC, Rodriquez A. Hemoperitoneum as the sole indicator of abdominal visceral injuries: a potential limitation of screening abdominal US for trauma. *Radiology* 1999;**212**(2): 423—30.
7. Scalea TM, Rodriquez A, Chiu W, Brenneman F, Fallon WF, Kato K, et al. Focused assessment with sonography for trauma (FAST): Results from an international consensus conference. *J Trauma* 1999;**46**(3):466—72.
8. Stengel D, Bauwens K, Sehouli J, Porzsolt F, Rademacher G, Mutze S, et al. Systematic review and meta-analysis of emergency ultrasonography for blunt abdominal trauma. *Br J Surg* 2001;**88**:901—12.
9. Ballard RB, Rozycki GS, Newman PG, Cubillos JE, et al. An algorithm to reduce the incidence of false-negative FAST examinations in patients at high risk for occult injury. *J Am Coll Surg* 1999;**189**(2):145—50.
10. Stassen NA, Lukan JK, Carrillo EH, Spain D, et al. Abdominal seat belt marks in the era of focused abdominal sonography for trauma. *Arch Surg* 2002;**137**:718—23.
11. Lazarus HM, Nelson JA. A technique for peritoneal lavage without risk of complication. *Surg Gynecol Obstet* 1979;**149**(6): 889—92.
12. Velmahos GC, Demetriades D, Stewart M, Cornwell 3rd EE, Asensio J, Belzberg B, et al. Open versus closed diagnostic peritoneal lavage: a comparison on safety, rapidity, efficacy. *J R Coll Surg Edinb* 1998;**43**:235—8.
13. Livingston DH, Lavery RF, Passannante MR, Skurnick JH, et al. Admission or observation is not necessary after a negative abdominal CT scan in patients with suspected blunt abdominal trauma: results of a prospective, multi-institutional trial. *J Trauma* 1998;**44**(2):273—82.
14. Rozycki GS, Ochsner MG, Jaffin JH, Champion HR. Prospective evaluation of surgeon's use of ultrasound in the evaluation of trauma patients. *J Trauma* 1993;**34**(4):516—27.
15. Hoffman R, Nerlich M, Muggia-Sullam M, Pohlemann T, et al. Blunt abdominal trauma in cases of multiple trauma evaluated by ultrasonography: a prospective analysis of 291 patients. *J Trauma* 1992;**32**(4):452—8.
16. Bode PJ, Niezen RA, van Vugt AB, Schipper J. Abdominal ultrasound as a reliable indicator for conclusive laparotomy in blunt abdominal trauma. *J Trauma* 1993;**34**(1):27—31.
17. Yoshii H, Sato M, Yamamoto S, Motegi M, Okusawa S, Kitano M, et al. Usefulness and limitations of ultrasonography in the initial evaluation of blunt abdominal trauma. *J Trauma* 1998; **45**(1):45—51.
18. Hawkins ML, Bailey RL, Carraway RP. Is diagnostic peritoneal lavage for blunt trauma obsolete? *Am Surg* 1990; **56**(2):96—9.
19. Blow O, Bassam D, Butler K, Cephas GA, Brady W, Young JS. Speed and efficiency in the resuscitation of blunt trauma patients with multiple injuries: the advantage of DPL over abdominal CT. *J Trauma* 1998;**44**(2):287—90.
20. Bivins BA, Sachatello CR, Daugherty ME, Ernst GB, Griffen Jr WO. Diagnostic peritoneal lavage is superior to clinical examination in blunt abdominal trauma. *Am Surg* 1978; **44**(10):637—41.
21. Fabian TC, Mangiante EC, White TJ, Patterson CR, Boldreghini S, Britt LG. A prospective study of 91 patients undergoing both CT and peritoneal lavage following blunt abdominal trauma. *J Trauma* 1986;**26**(7):602—8.
22. Gonzalez RP, Ickler J, Gachassin P. Complementary roles of DPL and CT in the evaluation of blunt abdominal trauma. *J Trauma* 2001;**51**(6):1128—36.
23. Nagy KK, Roberts RR, Joseph KT, Smith RF, An GC, Bokhari F, et al. Experience with over 2500 diagnostic peritoneal lavage. *Injury* 2000;**31**:479—82.
24. Menegaux F, Tresallet C, Gosgnach M, Nguyen-Thanh Q, Langeron O, Riou B. Diagnosis of bowel and mesenteric injuries in blunt abdominal trauma: a prospective study. *Am J Emerg Med* 2006;**24**:19—24.
25. Fang JF, Chen RJ, Lin BC, Hsu YB, Kao JL, Kao YC, et al. Small bowel perforation: is urgent surgery necessary? *J Trauma* 1999; **47**:515—20.
26. Demetriades D, Velmahos GC. Technology-driven triage of abdominal trauma: the emerging era of nonoperative management. *Annu Rev Med* 2003;**54**:1—15.

27. Maxwell-Armstrong C, Brooks A, Field M, Hammond J, Abercrombie J. Diagnostic peritoneal lavage analysis: should trauma guidelines be revised? *Emerg Med J* 2002; **19**:524—5.
28. Bowyer CM, Liu AV, Bonar JP. Validation of SimPL—a simulator for diagnostic peritoneal lavage training. *Stud Health Technol Inform* 2005;**111**:64—7.
29. Hodgson NF, Stewart TC, Girotti MJ. Open or closed diagnostic peritoneal lavage for abdominal trauma? A meta-analysis. *J Trauma* 2000:1091—5.
30. Bellows CF, Salomone JP, Nakamura SK, Choe EU, Flint LM, Ferrara JJ. What's black and white and red (read) all over? The bedside interpretation of diagnostic peritoneal lavage fluid. *Am Surg* 1998;**64**(2):112—8.