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Diagnostic Accuracy of Ultrasonography in Blunt Abdominal Trauma

Background/Objective: Patients in unstable clinical conditions with blunt abdominal trauma require rapid evaluation of the abdominal organ injury to assess the need for laparatomy. This prospective study was conducted to determine the use of emergency sonography for evaluating patients with blunt abdominal trauma and to compare the accuracy of sonography with the results of diagnostic peritoneal lavage (DPL), exploratory laparatomy and CT scan.

Patients and Methods: Emergency sonography was performed prior to any of the diagnostic methods, peritoneal lavage, exploratory laparatomy and CT, on 204 patients with blunt abdominal trauma. Sonography was performed with the "focused abdominal sonography for trauma" (FAST) technique and six areas of the abdomen were examined to detect free peritoneal fluid.

Results: Sonography showed a sensitivity of 95.4%, specificity of 78.4% and an overall accuracy of 89% in the diagnosis of free peritoneal fluid. The positive and negative predictive values of sonography were 89.2% and 90.6%, respectively.

Conclusion: Sonography is a reliable and accurate method for the emergency evaluation of blunt abdominal trauma.

Keywords: Abdominal Injuries, Peritoneal Fluid, Ultrasonography

Introduction

Trauma is an injury to the body resulting from an exchange with the environmental energy, in which the energy intensity is more than the body's capacity to tackle with.[1]

Nowadays, trauma is the most common cause of mortality in those aged 1-45 years[2,3] and causes loss of more efficient days than cardiovascular diseases and cancers.[1] Generally, 10% of total trauma-caused mortalities are due to abdominal organ injuries.[4,5] It was found that one of the chief reasons for the increase in trauma-caused mortality is the delay in making proper diagnosis in patients suffering from perilous abdominal injuries.[3] Wrong assessment of the intensity of abdominal trauma is also a main reason of preventable mortalities in blunt abdominal trauma.[2]

The most important matter in the treatment of patients suffering from blunt abdominal trauma is accurate and exact inspection of those who require immediate surgery. The latest studies have shown that clinical examination is not reliable enough for judging probable abdominal injuries.[6] Surgeons have long been considering an exact and rapid method which may correctly reveal chief injuries of the abdominal organs. Diagnostic peritoneal lavage (DPL) is one of the first methods used to evaluate abdominal injuries. This method was introduced by Root in 1965.[4,7-9] Despite the very high sensitivity (96%), DPL is an invasive method and is associated with a complication rate of 1% caused by trauma to the vesica and large blood vessels.[5,10,11]

Also its low specificity causes unnecessary operations in 29%-39% of patients.[3,12] Efforts to examine the abdominal organs with a

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more specific method guided Druy and Ruben to initiate blunt abdominal trauma examination using computed tomography (CT).[3,13] It has been proved that DPL is at least as sensitive as CT in detection of hemoperitoneum; the sensitivity of both techniques is >90%.[2]

Several studies have shown that sonography can replace DPL or CT.[5,7,14-16] At present, it is being used in many European and Asian countries as the first step in examining patients suffering from blunt abdominal trauma.[9] However, there are also some reports which stated that relying on sonography, as the only means of abdominal examination and as a replacement for DPL or CT, may result in an incorrect diagnosis.[6,17,18] It is necessary to use DPL and CT in selected cases as a guide to be more confident.[1,2,9]

Another study reported that if sonography is used as the only diagnostic method in blunt abdominal trauma, up to 29% of abdominal injuries will remain unrevealed.[19] We conducted this study to see whether the diagnostic accuracy of sonography in diagnosing free peritoneal fluid, as an indicator of abdominal organ injury, be high enough to replace CT or peritoneal lavage in examining patients with blunt abdominal trauma or not.

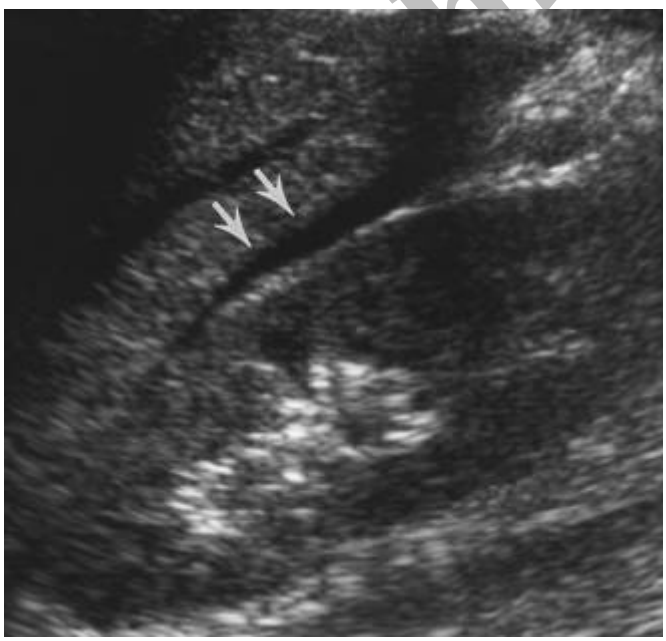

Fig. 1. A 33-year-old man with free peritoneal fluid in the Morrison pouch due to splenic rupture.

Patients and Methods

In this diagnostic test study, 4557 patients with blunt abdominal trauma admitted to the emergency ward of Imam Khomeini hospital, Tabriz, were examined sonographically intending to find free peritoneal fluid. This study was conducted in a 24-month period from April 2004 to April 2006. Every patient suffering from blunt abdominal trauma was examined by abdominal sonography in the sonography ward or if necessary, at the patient's bedside. Of course, all of the above process only took place if the sonographic examination, from the ethical point of view, did not impose any delay in the patients' management process. All of patients, based on the surgeons'clinical assessment, were suspected of abdominal trauma. The device used in the study was a Siemens Sonoline Adara with a 3.5 MHz curvelinear probe. The sonographies were performed by an experienced trauma sonographist.

The examination of all patients was done using the "focused abdominal sonography for trauma" (FAST) technique within at most 3-4 minutes in which six areas of the abdomen were examined. These regions include left upper quadrant, Morrison pouch, right upper quadrant, pelvis, right and left paracolic gutters.

In this examination the minimum depth of the free peritoneal fluid necessary to be considered positive was planned to be more than 2 mm (Fig. 1).

To prevent diagnostic errors, only those patients whose bladders were full and provided accurate observation of the pelvis, entered this examination. Meanwhile, patients suffering from subcutaneous emphysema or noncooperative patients with any other causes that hampered accurate examination of the above-mentioned regions (*e.g.,* severe obesity) were excluded from the study. The results of the conducted sonographies were written before complementary examinations by surgical operation and its positive and negative results were compared with complementary methods such as CT or DPL.

Abdominal and pelvic spiral CT was achieved with 10-mm slice thickness, 150 mL oral and IV Ultravist 300 mg/mL contrast and using Siemens Somatom single detector device. The result of CT of the abdomen and the pelvis was studied by the radiologist. The cri-

terion for comparison with DPL was the presence of more than 100,000 erythrocytes/mm^3 or the presence of amylase or food stuff in the peritoneal lavage.

Patients whose sonographic examination revealed free peritoneal fluid and their CT or DPL was positive or the patient's clinical condition revealed an organ injury were considered "true positive." When sonographic examination showed free peritoneal fluid, but the result was not confirmed by CT or DPL, the patients were considered "false positive." A negative ultrasonography together with a positive CT or DPL was considered "false negative" and a negative sonography confirmed by CT or DPL, was considered "true negative."

Ultimately, the sensitivity (Se), specificity (Sp), accuracy index (Acc), positive predictive value (PPV), negative predictive value (NPV) and unnecessary laparotomy ratio were calculated.

Results

After 24 hours of admission, 4353 of 4557 patients who had negative sonography, were excluded from the study. These patients had no surgical problems and were in good general condition. Nonetheless, for 204 patients whose abdominal injury was strongly doubtful, complementary tests, such as CT or DPL, were done. Among them, 61 patients, according to their clinical conditions, underwent an immediate surgical operation without further examination. Two-hundred and four individuals whose sonograhic examination results were confirmed or denied by golden standard tests, formed the basis of statistical analysis of the present study. Of the total of 204 patients examined by sonography, 162 (79.5%) were men and 42 (20.5%) were women.

The mean age of patients was 28.9 (range: 3–80) years. The majority of patients were 21 to 30 years old.

The sonography result was positive in 140 patients, of which 124 were true positive and 16 were false positive. Sonography result was negative in 64 patients, of which 58 were true negative and six were false negative.

Results of FAST sonography abdominal and pelvic CT, DPL and explorative laparotomy in our patients are shown in Table 1.

Based on these data, the sensitivity, specificity and accuracy index of sonography in blunt abdominal trauma were 95.4%, 78.4% and 89%, respectively. The PPV and NPV of sonography in blunt abdominal trauma were 89.2% and 90.6%, respectively.

We also found that sonography, if used as the only criterion for indication of surgical operation, will result in unnecessary laparotomy in 11.3% of patients.

The surprising point was that concurrent liver and spleen injury was found in only two patients—a frequency much lower than the figures reported earlier.[4]

Discussion

The accuracy of clinical diagnosis of blunt abdominal trauma has been reported from 37% to 87% in different studies,[6] and imaging methods have always been taken into consideration for injured patients in need of surgery.

CT has a high specificity for the diagnosis of the injured organ, but it cannot be used as a screening method in all trauma patients because it is time-consuming, preparation of the patient is necessary, it is expensive, and most importantly, it is impossible to be performed in severly ill patients. Although DPL caused unnecessary surgical operations in 29% of patients because of its high sensitivity, surgeons still consider it as the golden standard method. Nevertheless, being portable, easily available, harmless to the patient, able to examine the posterior peritoneum pleura and pericardium, sonography can be ideal for examining injured patients.

There are significant differences between the results obtained in this study regarding organ involvement rate in blunt abdominal trauma and those of other studies.[1]

The sensitivity of 95.4% obtained in our study, is comparable with the results of other reports conducted in Europe, Japan and United States.[2-10] The

Table. 1. Information of Focused Abdominal Sonography for Trauma (FAST)

		CT, DPL, LAP		
		Positive	Negative	Total
FAST	Positive	124	16	140
	Negative	6	58	64
	Total	130	74	204

FAST: Focused abdominal sonography for trauma, **DPL**: Diagnostic peritoneal lavage, **LAP**: Laparotomy

Table 2. Previous Studies

Previous Studies	n	Se	Sp	Acc	PPV	NPV	GS
Selim	454	86	95	94	94	98	CT,DPL,LAP,FU
Sirlin	1047	89	98	97	97	99	CT,DPL,LAP,FU
Healy	796	88	97	-	-	92	CT,DPL,LAP,FU
Bodner	1671	87	99	99	99	99	CT,DPL,LAP,FU
Hoffman	291	89	97	94	94	95	CT,DPL,LAP
Mckenny	299	86	99	98	-	-	CT,DPL,LAP,FU
Glaser	1151	99	98	-	97	99	CT,DPL,LAP

n: Number of Patients**, Se:** Sensitivity**, Sp:** Specificity**, Acc:**Accuracy index**, PPV:** Positive predictive value**, NPV:** Negative predictive value**, GS:** Gold Standard, **CT**: Computed tomography, **DPL**: Diagnostic peritoneal lavage, **LAP**: Laparatomy, **FU:** Follow up

specificity (78.4%) for sonography in our study, however, was lower than other studies. This difference can be attributed to false positive cases including three patients with retroperitoneal hematomas caused by pelvis fracture and retroperitoneal trauma caused by blunt trauma. Recent studies showed that it is impossible to differentiate free peritoneal fluid from reteroperitoneal fluid by sonography.[3]

Among the 4557 referred patients, there were three patients with unknown cirrhosis, which caused false positive sonographic results. In two cases, the serosal fluid was a result of DPL. Large bladder diverticula was mistaken for free peritoneal fluid in one patient; in another case the fluid in the splenocolic curve was erroneously reported as the free fluid surrounding the spleen. In this study, only six patients with major abdominal injury—which are much fewer than previous studies—were detected with no free peritoneal fluid in their sonographic evaluation (4.6%). In previous studies 29% of patients have been reported as not having free peritoneal fluid in their sonographic evaluation.[19]

In these six patients, there were two with hollow organ perforation; one with ileal and another with jejunal tear. Prior examinations have shown that cases in whom abdominal trauma was present, despite the fact that no free peritoneal fluid was detected, are consequences of hollow organ tears.[3] There was also a case of extensive subcapsular spleen hematoma, which was not accompanied by free peritoneal fluid in CT.

Another reason for the low specificity of the test is that sonography is more accurate in identifying low quantities of pelvic peritoneal fluid than CT.[6] Some of the patients participating in our study were examined by CT for diagnostic confirmation, which could result in false positive sonographic reports. For these patients, CT cannot identify fine mesenteric hematomas or mild free peritoneal fluid.

The sensitivity obtained in this study is similar to the sensitivity reported in most previous studies (Table 2); this seriously depends on the proficiency of the radiologist performing the evaluations.

In Froster's report of 17 surgeons using sonography for patient assessment, it was revealed that the PPV rate was 60% for surgeons with 1-year experience, 76% for surgeons with 1–3 years of experience and 92% for surgeons with more than three years of experience.[20]

Pak-art reported a sensitivity of 37% and a specificity of 96% of sonography in his research. He also mentioned "performance of the sonography by surgery residents" as the main reason for the low sensitivity of his study.

It is apparent in Table 2 that the specificity of our study is significantly lower than other studies, which should be attributed to the number of false positive cases of our study; sonography is not able to differentiate peritoneal fluid, blood, serosal secretion, lymph and urine from each other. It is obvious that in patients with congestive heart failure or cirrhosis who have preexisting free fluid in their peritoneal recesses, sonography cannot accurately confirm or rule out the presence of intra-abdominal injury. It is ob-

vious that in these studies, the specificity of 95%–100% cannot be realistic. Logically the specificity of sonography for the diagnosis of visceral injury, according to its limitations, must be less than that; which was what we found in our study.

Of course, if we observed patients for 24 hours as a golden standard method, just like some of the studies mentioned in Table 2, then the specificity and accuracy rate would increase to 99.6% and the NPV rate would increase to 99.9%.

Based on these explanations, sonography is an accurate examination method for screening patients suffering from blunt abdominal trauma, but we do not recommend sonography as the only diagnostic method. Diagnosis should be made based on sonographic examination results and in light of patient's clinical presentation. In suspicious cases or complicated patients, other methods should be used.

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