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Sensitivity of transabdominal ultrasonography in detection of intraperitoneal fluid in humans

H. Paajanen[1], **P. Lahti**[2], **I. Nordback**[1]

[1] Department of Surgery, Tampere University Hospital, SF-33520 Tampere, Finland
[2] Department of Radiology, Central Hospital of Mikkeli, Finland

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Abstract. The sensitivity and specificity of ultrasonography in detection of free intraperitoneal fluid is over 90 %. The lowest detectable volume of free fluid in humans is unknown. The distribution of intraperitoneal fluid was studied in 86 patients by transabdominal US in group A ($n = 21$, 10 ml of fluid), in group B ($n = 15$, 50 ml of fluid) and group C ($n = 50$, splenic trauma). Ultrasound detected fluid in 15 of 21 patients in group A, and in all patients in groups B and C. In group A 10 ml of fluid was found in 71 % of cases behind the bladder, and in only 5–14 % of cases in the upper abdomen. In group B 50 ml of fluid was found in all patients in the lower pelvis, but in only 20 % in Morison's pouch and in 7 % around the spleen. In group C 200–4500 ml of fluid was detected by US in 72 % of patients in the perisplenic space, in 60 % in Morison's pouch and in 42 % in the retrovesical space. Small volumes of free intraperitoneal fluid (10–50 ml) can be detected with current US scanners, but only near the site of injury. These results support the role of US as a primary imaging modality in abdominal trauma.

Key words: Ultrasonography – Free peritoneal fluid – Spleen – Splenic injury

Introduction

Evaluation of traumatized abdomen continues to be clinically challenging. Diagnostic peritoneal lavage [1], CT [2], laparoscopy [3] and US [4–6] have all been used in the detection of parenchymal injuries after abdominal trauma. The overall sensitivity and specificity of US in detection of organ damage and free abdominal fluid has been over 90 % [7–10]. Although previous US studies demonstrate the patterns of fluid accumulation after trauma [5, 10], there are only few reports of the lowest detectable volume of fluid and optimal scan views in detection of small amounts of fluid [11, 12]. Goldberg was one of the first investigators in the evaluation of ascites by US [13, 14]. We investigated in the present study what the minimum volume of free fluid to be visualized by US is and the most appropriate site of detection after injecting fluid into human peritoneal cavity. To our knowledge, only one such experimental US study with pigs has been reported [12]. The relationship of fluid volume and US findings was studied in three clinical situations: after injecting approximately 10 ml of fluid, i. e. contrast medium in hysterosalpingography (HSG, group A), after injecting 50 ml of contrast medium in herniography (group B) and after splenic injury (group C; 200–4500 ml of blood).

Materials and methods

Because of ethical reasons, we utilized two radiological examinations (HSG and herniography) and a clinical situation (splenic injury) to evaluate the sensitivity of US in the detection of various volumes of fluid. We did not include any control group in our study, because each patient was used as own control: prior to performing HSG or herniography, the patients were evaluated by US to determine whether or not they had pre-existing intra-abdominal fluid related to either ascites or pelvic fluid, a common finding in women of menstrual age. If such patients were found, they were excluded from the study. In HSG (group A, $n = 21$) 10 ml of water-soluble contrast was injected into the abdominal cavity through uterine tubes. Only the successful studies were approved; the patients were excluded if any marked leakage of contrast into vagina was noticed due to incomplete fit of the cannula into the cervical canal. In herniography (group B, $n = 15$) 50 ml of contrast was injected into the abdominal cavity and the pelvic X-rays were obtained to find out clinically nonevident inguinal hernia [15]. Supine patient was in the 45° anti-Trende-

Correspondence to: H. Paajanen

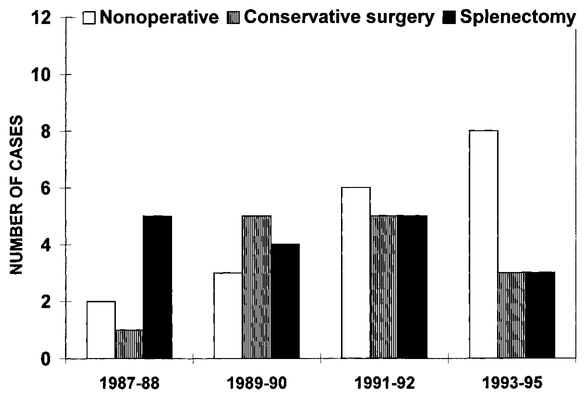

Fig. 1. The treatment policy in group C. The patients with conservative surgery were treated by splenic resection, haemostatic sutures, or with mesh

Table 1. Positive ultrasonography findings in three groups

Group	No. of patients	%
Group A ($n = 21$)		
In Morison's pouch	3	14
In Douglas's pouch	15	71
In perisplenic space	1	5
Group B ($n = 15$)		
In Morison's pouch	3	20
In Douglas's pouch	15	100
In perisplenic space	1	7
Group C ($n = 50$)		
In Morison's pouch	30	60
In Douglas's pouch	21	42
In perisplenic space	36	72

lenburg position. Contrast medium was either iopamidol (300 mg/ml) or iohexol (300 mg/ml). Ten to 15 min after performing pelvic X-ray, the abdominal US (Toshiba Cabasel, Tokyo, Japan) was performed using a 3.75-MHz transducer. The existence of free peritoneal fluid was assessed in Douglas's fossa, around the spleen and in Morison's pouch. The US finding was recorded as positive or negative in the three anatomical sites with no effort to quantify the amount of fluid when it was observed to be present. The urinary bladder was always full when performing US examination. All HSG and herniographies were performed by the same radiologist. The US investigator was blinded to the results of HSG and herniography.

To evaluate the potential of US in detection of larger volumes of free fluid, 50 consequent patients with acute splenic injury (group C, mean age 31 ± 20 years) were investigated. The patients were treated in Tampere University Hospital (tertiary trauma centre) from January 1987 until December 1995. The patient characteristics, radiological studies and operative findings were recorded. Real-time ultrasonography (5 MHz; Aloka, Tokyo, Japan) was performed within 120 min after patient's arrival to the emergency department. Patterns of splenic lesions, such as haemoperitoneum, heterogeneous parenchymal zones in the spleen, echogenic, sonotransparent and subcapsular hematomas [16, 17], were recorded to confirm splenic injury. In addition to routine organ views, the US examination consisted of the evaluation of left subphrenic space around the spleen, Morison's pouch (the peritoneal fold bounded by the liver, right kidney and transverse mesocolon) and the pelvis for evidence of free intraperitoneal fluid [1, 5, 6, 18]. Computed tomography was performed in only 5 patients (10 %). The diagnosis in surgically treated cases ($n = 31$) was based on the operating surgeon's macroscopic evaluation. In the conservatively treated cases ($n = 19$) the diagnosis was based on the clinical features (abdominal trauma and symptoms in the left flank) and positive US or CT findings. Laparotomy was performed by emergency surgeons' choice depending on the patient's haemodynamic status and US findings. The time delay from US study to laparotomy was between 30 min and 48 h depending on clinical status of the patient.

Results

Ultrasound was positive in group A (10 ml of fluid) in 15 patients in Douglas's fossa, in 3 in Morison's pouch and in 1 patient around the spleen (Table 1). Ultrasound was negative in 6 (29 %) of the HSGs in every three anatomical spaces. In group B (50 ml of fluid) US detected free fluid in 15 patients in the retrovesical space, in 3 in Morison's pouch and in 1 patient around the spleen.

In group C the mean volume of intraperitoneal blood found at the beginning of laparotomy was 1400 ± 1000 ml (range 200–4500 ml). The total measured bleeding at the end of operation was 2400 ± 1700 ml. Ultrasonography showed free fluid in every patient at least in one of the studied intraperitoneal spaces (Table 1). Fluid was most often detected around the spleen (72 %) and in Morison's pouch (60 %; Table 1).

Discussion

The anatomical spaces or sumps which are first filled by intraperitoneal fluid have been previously characterized in the studies of the spread of intraperitoneal infection (for review see [19]). Our study indicates that current US scanners can detect volumes as small as 10–50 ml of free fluid in the human abdominal cavity, but only near the site of trauma or injection. In the upright position with pigs, as little as 10 ml of fluid was visualized by US around the urinary bladder [12]. In the supine position, 20 ml were detected around the bladder and 30 ml around the liver [12]. Our experimental study showed that the lower pelvis is the most suitable anatomical location to find free fluid in humans. Small volumes of fluid (5–50 ml) did not distribute easily into the upper abdomen. One has to remember, however, that water-soluble contrast medium may distribute easier in the abdominal cavity than clotting blood.

The main purpose of US examination in trauma is first to detect free fluid in the peritoneal cavity supporting the diagnosis of haemoperitoneum, and after that to answer if the amount of fluid is enough to warrant a conclusive laparotomy [20, 21]. The anatomical areas best suited for US examination are the epigastrium and the pelvis because of the "acoustic windows" created by liver, spleen, kidneys and the filled urinary bladder [6]. Our results establish the spectrum of fluid collections in splenic trauma and their relative frequency in various abdominal compartments. We admit that the exact measurement of fluid/blood in splenic trauma patients is difficult in clinical situations due to time- and operator-dependent variables. The inclusion of such patients (group C) in our study was deemed necessary, however, to test the clinical utility of US. Detection of haemoperitoneum is as important as detection of the splenic parenchymal injury itself [17]. In one US study with splenic trauma haemoperitoneum was detected in 86 % and a direct splenic lesion in 66 % of children [22]. Previous CT studies in splenic trauma have indicated the patterns of fluid accumulation in the pelvis (65 %), left subphrenic space (48 %) and Morison's pouch (17 %) [18]. These figures are consistent with our findings. The fact that localized accumulations of blood can occur in the upper abdomen without necessarily reaching the pelvis has been observed previously [17].

The importance of splenic conservation in trauma is presently recognized in avoidance of postsplenectomy sepsis and other immunological defects [23]. This was also seen in our patients with a shift to a more conservative treatment policy over time (Fig. 1). Although our US data did not directly influence patient management, the obvious reason for this shift to more conservative treatment policy is the rapid development of imaging modalities at the emergency departments, which allows more accurate diagnosis of traumatized patients. Ultrasound seems to predict well the need for laparotomy, because the false-positive US studies resulting in unnecessary operations are below 5 % [6, 10]. Our study shows that Morison's pouch, Douglas's pouch and perisplenic space are the most likely intra-abdominal spaces to find small volumes of free fluid. The minimum quantity of fluid needed to be detected by current transabdominal US scanners is between 10 and 50 ml. These findings support the role of US as a primary imaging modality in blunt abdominal trauma.

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