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Ultrasound-assisted paracentesis performed by emergency physicians vs the traditional technique: a prospective, randomized study

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Abstract

Study objective: To determine if emergency center ultrasound (ECUS) can be of value to emergency physicians in the evaluation of possible ascites and accompanying decisions to perform emergent paracentesis.

Methods: During a 7-month period, patients suspected of having ascites and potentially requiring paracentesis were prospectively entered into a randomized study in an urban public hospital emergency center (>140 000 annual visits). Patients were randomized to receive paracentesis using the traditional or the bedside ECUS-assisted technique. Indications for paracentesis included known liver disease and obvious ascites as well as suspected ascites or suspected subacute bacterial peritonitis. Participating physicians had received a minimum of 1 hour of formal didactic ultrasound training that included gallbladder, renal, vascular, and bladder studies as well as the focused abdominal sonography for trauma examination for trauma and the detection of ascites. A portable Terason 2000 laptop ultrasound machine with a 5-MHz probe was used to scan the patients. Data collected included the patients' characteristics, estimation of ascitic fluid volume, number of attempts made to obtain fluid, speed of paracentesis, and the operator's overall evaluation of the ECUS-assisted technique, if used.

Results: Of 100 enrolled patients, 56 received the ECUS-assisted technique. Of 42 patients with ascites, 40 (95%) were successfully aspirated and 14 (25%) did not receive paracentesis because no ascites or insignificant amount of ascites was visualized. One patient was noted to have a large cystic mass in the left lower quadrant and another patient had a ventral hernia. Of the 44 patients randomized to the traditional technique, 27 (61%) were successfully aspirated. In 17 (39%) of these patients, fluid could not be obtained using traditional methods. Of these 17 failed attempts by traditional methods, 15 patients received ECUS in a "break" from the study protocol. Ascitic fluid was obtained in 13 of these 15 patients; of the 2 remaining patients, 1 did not have enough fluid to be sampled and the other had no fluid visualized.

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Conclusion: Ninety-five percent ($P = .0003$) of the patients who were randomized in the ECUS group and in whom a needle paracentesis was performed had ascitic fluid successfully obtained, as compared with the traditional method group.

1. Introduction

The evolving role of ultrasound (US) as a bedside tool to facilitate more timely emergency diagnoses and to improve the speed and success rate of certain invasive procedures is being increasingly recognized by physicians who practice emergency medicine. For example, the contribution of the focused abdominal sonography for trauma examination to better enable the rapid diagnosis of hemoperitoneum in patients with blunt trauma is now well established [1-7]. Likewise, the use of US has also been demonstrated in a study of US-facilitated central line placement and is used more and more for bedside diagnosis of ectopic pregnancy, pericardial effusion, hemothorax, and pneumothorax [8-13].

In patients presenting for new-onset ascites, increasing girth with known ascites, or fever with ascites, emergency physicians may be called upon to perform an emergent paracentesis to properly evaluate ascitic fluid to make a diagnosis. Often, a US-guided paracentesis is needed. Therefore, this study was conducted to determine if US would improve the success rate, time to completion, and number of attempts and decrease the rates of complications in emergent paracenteses when performed by emergency physicians with varying levels of experience.

2. Material and methods

The study was conducted in an urban public university teaching hospital emergency department (ED) that sees more than 140 000 patients per year. The ED is staffed primarily by emergency medicine and internal medicine residents as well as interns from various other services. Emergency medicine faculty supervise the ED 24 hours a day, 7 days a week. The study was a prospective, randomized investigation to assess the usefulness of US in paracenteses performed on ED patients. The study was approved by the institutional review board for clinical trials of the University of Texas Southwestern Medical Center. Verbal consent was obtained after the protocol was explained to the patients. The study enrolled a convenience sample of 100 patients who presented to the ED requiring a paracentesis over a 7-month period from July 2002 to February 2003. After the clinical decision to perform paracentesis was made, the patients were randomized by a coin toss. A toss resulting in "heads" placed a patient in US group. "Tails" placed a patient in the traditional technique group.

The study included adult (≥18 years old) patients who presented to the ED with an indication for a paracentesis. The indications included new-onset ascites, known ascites and increased abdominal girth, and ascites with abdominal pain or fever. The study excluded patients younger than 18 years and pregnant women. At the time of patient encounter, the physician who was to perform the procedure tossed a coin and recorded the result of the coin toss. If the result was heads, the US machine was brought to the bedside and used to localize the fluid collection. The real-time emergency center ultrasound (ECUS)–assisted technique for paracentesis was performed using a Terason 2000 laptop with an adjustable 3- to 5-mHz probe (Teratech, Houston, Tex). After the coin toss, the physician-sonographer would then make a mark on the patient's abdomen at the appropriate site and proceed with traditional procedure preparations or leave the US probe on the patient as he or she performed the procedure under direct guidance. If used for continuous direct visualization during the procedure, a sterile field was maintained by covering the probe with a sterile glove. Once ascitic fluid was aspirated, the Seldinger technique was used to place a catheter and drain the fluid.

The data gathering tool asked the provider-sonographer for patient demographics, physician characteristics (post-graduate level, department of origin [ie, internal medicine or emergency medicine]), assessment of anticipated difficulty, estimated amount of fluid present, time to fluid back after initial skin puncture, and number of passes of the needle required before fluid successfully obtained. If ECUS assistance was used, the operator was also asked whether he or she felt that US guidance facilitated the procedure (ie, increased efficiency, increased knowledge of anatomy, or decreased complications) (Table 1). A patient was considered a "difficult stick" if, on physical examination, the patient appeared to have little fluid, was markedly obese, or was for other reasons not demonstrating obvious physical signs of ascites. "Coagulopathic" was defined as an INR of more than 2.0. Fluid amount was considered "a lot" or described as "tense" if estimated to be greater than 1 L. Time was defined as less than 1 minute, 1 minute, or more than 1 minute.

The resident physicians did not receive training specific on this procedure; however, all the emergency physicians who performed the procedure using the US did receive a 1-hour didactic course. The 1-hour course included identification of routine abdominal US imaging. Most of the emergency medicine residents had also undergone practical training on performing abdominal

Table 1 Data included for 100 randomized patients who underwent emergent paracentesis during the 7-month study period

	ECUS Group	Traditional Group
User level	n = 54	n = 42
PGY1 [n (%)]	11 (20)	14 (33)
PGY2 [n (%)]	28 (52)	12 (29)
PGY3 [n (%)]	10 (19)	16 (38)
Faculty [n (%)]	3 (5)	0
Other [n (%)]	2 (4)	0
User department	n = 53	n = 43
Emergency medicine [n (%)]	43 (81)	27 (63)
Other [n (%)]	11 (20)	16 (37)
Patient age	n = 49	n = 37
Mean age (y)	49.4	50.41
Patient sex	n = 55	n = 38
Men [n (%)]	41 (75)	29 (76)
Women [n (%)]	14 (25)	9 (23)
Indication	n = 56	n = 38
Ascites [n (%)]	32 (57)	29 (76)
Suspected ascites [n (%)]	24 (43)	9 (23)
Other [n (%)]	1 (25)	0
IV drug abuser	n = 55	n = 34
Yes [n (%)]	13 (24)	10 (29)
No [n (%)]	42 (76)	24 (71)
Difficult stick	n = 45	n = 30
Yes [n (%)]	7 (16)	1 (3)
No [n (%)]	38 (84)	29 (97)
Coagulopathic	n = 53	n = 35
Yes [n (%)]	13 (25)	7 (20)
No [n (%)]	40 (75)	28 (80)
Fluid seen on US	n = 54	N/A
Yes [n (%)]	43 (80)	
No [n (%)]	11 (20)	
Amount estimated by PE or US	n = 54	n = 28
A lot [n (%)]	31 (57)	25 (89)
A little [n (%)]	16 (30)	3 (11)
None seen [n (%)]	7 (13)	
Number of passes	n = 42	n = 38
1 [n (%)]	29 (69)	27 (71)
2 [n (%)]	6 (14)	5 (13)
3 or more [n (%)]	7 (17)	6 (16)
Time to access	n = 40	n = 30
Less than 1 min [n (%)]	26 (65)	21 (70)
1 min [n (%)]	6 (15)	2 (7)
More than 1 min [n (%)]	8 (20)	7 (23)
Fluid obtained	n = 56	n = 44
Yes [n (%)]	40 (71)	27 (61)
No [n (%)]	16 (29)	17 (39)
User evaluation	n = 53	
US-avoided complications [n (%)]	45 (85)	N/A
US-increased efficiency [n (%)]	38 (72)	
US-enhanced knowledge of anatomy [n (%)]	42 (79)	

US in the trauma setting (focused abdominal sonography for trauma) examination.

A prospective, randomized, convenience sample of 100 patients was obtained. Fifteen patients initially randomized to the traditional technique group later received an ECUS paracentesis outside the protocol. Their results are also presented herein.

Descriptive statistics were obtained for the total sample and by group (Table 1). Frequencies and percentages are presented for categorical variables and means and standard deviations are presented for continuous measures. Comparisons of the traditional technique group to the ECUS group were made for each of the demographic variables to determine the comparability of the 2 groups. Comparisons of the other variables were done to determine if univariate differences occurred. Categorical variables were tested using either the Fisher's exact test for 2 × 2 contingency tables or the modified Fisher's exact test for 2 × 3 tables. The comparison of 2 proportions was done by the methods shown by Zar [14].

3. Results

Of the 100 patients enrolled in the study, 56 (56%) received the ECUS-assisted paracentesis. Of the 56 patients (25%) on whom US was used, 14 did not undergo the procedure because of the results of the US. In 12 of these 14 patients, too little or no fluid was seen on ECUS. Another 2 patients had other significant pathologies, which the US detected. One patient had a ventral hernia and the other had a large cystic mass. Both of these findings were confirmed by computerized tomography scans of the abdomen. Of the remaining 42 patients in whom fluid was visualized and determined to be adequate to aspirate, 40 had successful drainages (95% success rate; $P = .0003$). Only 2 patients had visible fluid that the physician was unable to aspirate (4.9%). One of these patients was a very obese woman in whom the needle could not pass the pannus. In 3 of the 56 (5.5%) patients, the US changed the location that the physician would have performed the aspiration on by showing a loculated fluid collection. Forty-four patients were randomized to receive the traditional paracentesis technique. Twenty-seven of these patients had successful drainages (61% success rate). Fifteen patients who were initially randomized to receive the traditional paracentesis received an ECUS-assisted paracentesis subsequent to the failure of the traditional technique (breaking from the protocol). Data were collected on the traditional and US attempts in these patients. The ECUS revealed no fluid in 2 of these 15 patients, making the paracentesis unnecessary. The other 13 patients were successfully aspirated using the ECUS-assisted technique. (Fig. 1) Fifty-three of the emergency physicians evaluated the ECUS technique and reported an ease in detection and collection of ascites, commenting that the ECUS-assisted technique was especially helpful in determining cases of absent or subtle ascites. The use of US showed no statistical difference in

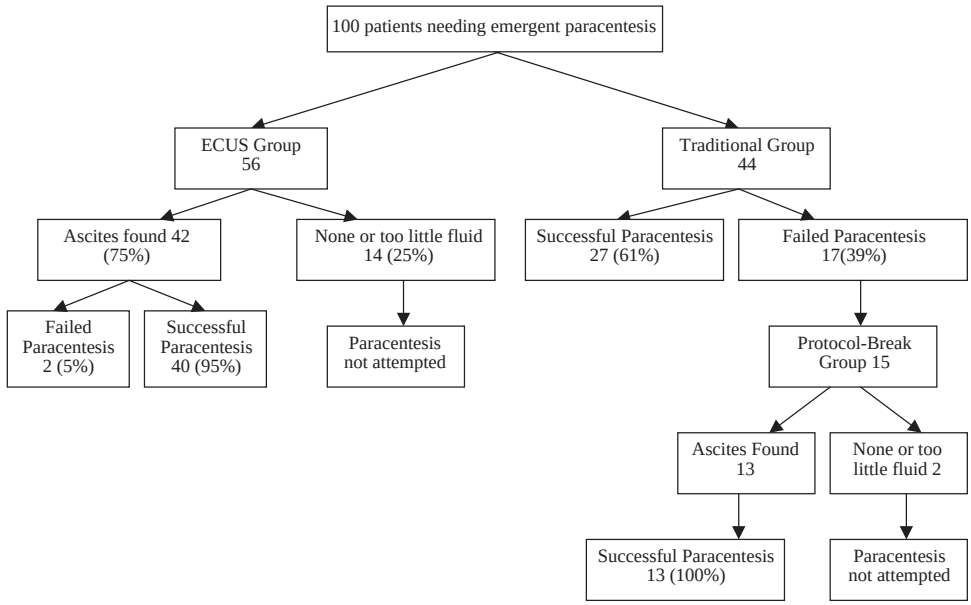

Fig. 1 Flowchart for the 100 randomized patients who underwent emergent paracentesis during the 7-month study period. The data include the patients randomized to the ECUS paracentesis group and the traditional paracentesis group.

the time to completion, success rate, number of attempts, or rate of complications (Table 1).

4. Discussion

Paracentesis is often indicated in the ED for patients with ascites and pain or fever, increasing abdominal girth and secondary dyspnea or discomfort, suspected malignant ascites, or new-onset ascites. In a busy academic center, residents and interns are primarily responsible for performing these procedures. Because of their lack of experience, they tend to needlessly puncture many patients several times. Many patients may not even have ascites or may have too little fluid to aspirate. In such situations, patients are exposed to unnecessary risk of complications, which include bowel perforation, bleeding, and iatrogenic infections. A formal abdominal US is often ordered after many unsuccessful attempts. The patient must then incur greater time in the ED.

The use of US for this procedure led to some unexpected results. The investigators had hypothesized that using the US would decrease the time and increase the ease of the procedure. Although this did occur in several individual cases, 25% of patients completely avoided the paracentesis altogether because no fluid or too little fluid was found by the ECUS examination.

Only 13 patients of the 100 enrolled were considered as difficult sticks by the provider-ultrasonographer and only 1 of these did not have an ECUS paracentesis. However, the 15 patients who had the ECUS-assisted paracentesis after the traditional method failed (breaking from randomization protocol) could also be considered difficult sticks if we were to retrospectively define the group. All the patients in this break-from-protocol group in whom fluid was seen on ECUS had a successful paracentesis (100%). This suggests that ECUS-assisted paracentesis is more likely to be used in patients whom the provider feels are difficult sticks or in those who fail the traditional paracentesis method. More importantly, in this study, 2 patients had other significant pathologies (tumor, hernia) that were mistaken for ascites by physical examination. In these cases, performance of a traditional paracentesis could have been detrimental.

This study has several limitations including the lack of a gold standard. The patients did not have a formal US to confirm our findings; therefore, it is not absolutely known whether the bedside ECUS fails to detect some cases of mild ascites. Further studies will help to confirm the true sensitivity and specificity of the ECUS. The patient with a cystic mass and the patient with a ventral hernia did however have a computerized tomography scan to confirm their findings. Although we did not follow up on our patients to ensure that our ED management was correct, we were not notified of any unforeseen outcome.

Another limitation of the study is that the randomization was not strictly followed. Only one patient considered a difficult stick underwent the traditional technique, suggesting that many residents used the ECUS method, breaking from study protocol. This occurred if the provider anticipated difficulty (despite not meeting criteria to include in this group) via the traditional technique or after having failed to obtain fluid via the landmark technique (ie, break in protocol).

Because of the statistically significant success rate in the ECUS paracentesis group (95%) vs the traditional technique group (65%) ($P = .0003$), this study supports the need for more ECUS use when performing an emergent paracentesis, especially when difficulty is anticipated or when examina-

tion findings are equivocal. Ultrasound guidance not only facilitates the performance of the procedure but, more importantly, also avoids unnecessary invasive procedures that may harm a patient.

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