Emergency Department Right Upper Quadrant Ultrasound Is Associated with a Reduced Time to Diagnosis and Treatment of Ruptured Ectopic Pregnancies

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Abstract. **Objective:** To determine whether the time to diagnosis and treatment of patients with ruptured ectopic pregnancy is significantly less for patients who had emergency department (ED) right upper quadrant (RUQ) ultrasound (US) compared with those who had US in the radiology department. **Methods:** The authors conducted a retrospective review of eligible patients presenting to an urban ED between January 1990 and December 1998. Patients were included in the study if they were seen in the ED, had a discharge diagnosis of ruptured ectopic pregnancy, were brought immediately to the operating room after a definitive diagnosis of ectopic pregnancy rupture was made, and had more than 400 mL of intraperitoneal blood found at the time of surgery. The ED, hospital, radiology, and operative records were reviewed to determine presenting vital signs, intraperitoneal blood loss, time to diagnosis, time to treatment, and type of US performed. **Results:** There were 37 patients enrolled; 16 received ED RUQ US (group I) and 21 had a formal US in radiology (group II). The ages, pulses, systolic blood pressures, and volumes of hemoperitoneum were similar between the two groups. The average time to diagnosis from ED arrival was 58 minutes for group I (SD = 57; 95% CI = 28 to 87) and 197 minutes for group II (SD = 82; 95% CI = 162 to 232) ($p \leq 0.0001$). The average time to operative treatment was 111 minutes (group I) (SD = 86; 95% CI = 69 to 153) and 322 minutes (group II) (SD = 107; 95% CI = 270 to 364) ($p \leq 0.0001$), respectively. **Conclusions:** Patients with ruptured ectopic pregnancy, who were selected to have RUQ US performed in the ED by emergency physicians, had an average decrease in time to diagnosis of two and a quarter hours, and an average decrease in time to treatment of three and a half hours, compared with those having a formal pelvic US in the radiology department. Further prospective investigation is needed to determine whether ED RUQ US can safely expedite care of patients with suspected ectopic pregnancy. **Key words:** emergency; ectopic pregnancy; ultrasound; diagnosis; rupture; hemoperitoneum. ACADEMIC EMERGENCY MEDICINE 2001; 8:331–336

RUPTURED ectopic pregnancy is a common medical problem seen in the emergency department (ED). It now accounts for 13% of pregnancy-related deaths and is the most common cause of maternal mortality in the first trimester.[1,2] Goldner and colleagues reported a death rate of 38/100,000 women with ruptured ectopics.[2] Historically, a formal ultrasound (US) or culdocentesis was usually required before patients with ruptured ectopic pregnancies were taken to the operating room (OR) for definitive treatment. Patients with suspected ectopic pregnancies may occasionally spend an hour or more in an unmonitored environment (i.e., radiology suite) while waiting for a formal US to confirm the diagnosis. After obtaining the formal US, there may be further delays to treatment if the US is not read or reported in a timely fashion.

Immediate goal-directed ED US by emergency physicians has been used to quickly diagnose and treat many time-sensitive, life-threatening conditions. Plummer et al. showed an improved outcome in patients with penetrating cardiac injury using ED US to diagnose hemopericardium.[3] Durham described how immediate ED US saves time in management of ruptured ectopic pregnancy, cardiac tamponade, and leaking abdominal aneurysms.[4] These studies clearly demonstrated that the emer-

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gency physician can perform a goal-directed US within minutes of the patient's arrival, directly improving patient care.

Emergency department transvaginal US (TVUS) can decrease length of stay in the ED for women in the first trimester of pregnancy with vaginal bleeding or abdominal pain.[5–7] However, due to the expense of transvaginal probes and interdepartmental credentialing issues, not all EDs have TVUS available. Transabdominal pelvic and RUQ USs are more readily available in the ED and may be useful in the diagnosis of ectopic pregnancy. In clinical situations where an ectopic pregnancy is highly suspected and an empty uterus is seen on transabdominal pelvic US, echogenic fluid in Morison's pouch suggests a ruptured ectopic pregnancy with hemorrhage.

Prior studies have shown that a RUQ US showing fluid in Morison's pouch indicates that there is between 400 and 700 mL of free fluid in the abdomen.[8,9] In this study, a positive urine pregnancy test with an empty uterus on transabdominal pelvic US and fluid in Morison's pouch are considered strong evidence for a ruptured ectopic pregnancy with significant (>400 mL of blood found at surgery) hemoperitoneum. These patients are taken directly to the OR without other confirmatory studies. To the best of our knowledge, this is the first study using limited ED RUQ Morison's pouch US to diagnose ruptured ectopic pregnancies. A MEDLINE search of all publications from 1950 to July 2000 associated with ectopic pregnancy and ultrasound found no other studies specifically using RUQ US to diagnose ruptured ectopic pregnancy.

Through a retrospective review of medical records of ectopic pregnancy cases, our study sought to determine whether limited bedside ED RUQ US by emergency physicians could potentially decrease the time to diagnosis and treatment of patients with ruptured ectopic pregnancies with significant hemoperitoneum. Our primary outcome measures were time from ED triage to time to diagnosis and time of operative intervention.

METHODS

Study Design. This was a retrospective chart review of patients who had ectopic pregnancy presenting to an ED between January 1990 and December 1998. The study was given expedited institutional review board approval and was considered exempt from informed consent.

Study Setting and Population. This study was conducted at a tertiary urban county hospital ED with an average annual census during the study period of 85,000 patients. Patients were eligible for the study if they had been admitted through the ED and had an ectopic pregnancy with more than 400 mL of hemoperitoneum found at the time of surgery. Because RUQ US will consistently be positive only if there is roughly 400 to 700 mL of hemoperitoneum, patients were excluded if less than 400 mL was found at the time of surgery.[8,9] Patients were also excluded if neither an ED US nor a formal radiology US was performed.

Study Protocol. Patients were identified from two sources. 1) The hospital database of discharge diagnoses was searched from January 1990 to December 1998, and those with ectopic pregnancy were cross-matched with those admitted through the ED. 2) The ED critical case and ED computerized tracking system (EmSTAT, Cyberplus Corporation, Austin, TX) databases were searched from April 1995 to December 1998 (these databases were not available prior to April 1995). All charts were reviewed by one of two researchers and data were collected on standardized data sheets. The interrater reliability of the data abstractors was determined, with a kappa of 0.90. The ED, hospital, radiology, and operative records were reviewed to determine presenting vital signs, presence of pain or tenderness, presenting beta–human chorionic gonadotropin (β-hCG), volume of hemoperitoneum at the time of surgery, time to diagnosis, time to treatment, and type of sonography performed. Time to diagnosis was defined as the time from presentation to the ED to the time of the formal US suggesting ectopic pregnancy, or the time of finding fluid in Morison's pouch by ED US. Time to treatment was defined as the time from ED presentation to initiation of anesthesia.

The ED USs were performed by emergency medicine (EM) faculty or senior EM residents directly supervised by the EM faculty. Prior to the time of this study, the EM faculty physicians involved had been using US since 1986 for the diagnosis of hemoperitoneum in trauma patients using the Morison's pouch view. In addition, the staff composition in our department was very consistent over the study period. All EM faculty were trained by the same US instructor (DP). Approximately 400 USs are performed each month on noncritical patients in our ED, of which 40% are abdominal views that image Morison's pouch (5 USs/day). Additionally each month, 125 ED USs of Morison's pouch are done on critical medical, trauma, or pediatric patients (4 USs/day) (personal communication, Dave Plummer, November 2000). Of the USs performed, approximately 60% are done by the senior EM residents and 40% by the EM faculty alone. The residents receive an annual didactic course involving a ten-hour lecture component as well as hands-on training in the focused abdom-

inal sonography for trauma (FAST) exam and various aspects of the cardiac US exam using multiple models. This course is conducted in a format that is consistent and recommended by the US subsection of the Society for Academic Emergency Medicine. Emergency department US is performed transabdominally either using an HP Sonos 100 (Hewlett-Packard, Palo Alto, CA) or an Aloka 1450 (Wallingford, CT) using a transducer frequency of 2.5–3.5 MHz. Formal USs were performed using both transabdominal and transvaginal views with transducer frequency between 3.5 and 7.5 MHz. As in trauma patients, a diagnostic ED RUQ US was defined as fluid seen in Morison's pouch.

Data Analysis. The patients were divided into two groups, those who had a positive Morison's pouch by ED US (group I) and those who did not have an ED US and instead had a formal US (group II). The Microsoft Excel program (Redmond, WA) was used to analyze descriptive statistics with 95% confidence intervals and comparison of the means using Student's t-test. A p-value of <0.05 was considered significant.

RESULTS

Over the nine-year period, 51 ED patients with a discharge diagnosis of ruptured ectopic pregnancy, with at least 400 mL of hemoperitoneum at the time of surgery, were identified. Sixteen patients had an ED Morison's pouch US performed by emergency physicians (group I), and 21 patients had a formal pelvic US done by radiology (group II). Fourteen patients were excluded from the study: 12 had no ED RUQ US or formal US during the ED visit, one patient refused to go to the OR after the diagnosis was made despite a positive Morison's pouch ED US until she went into shock, and one patient in the formal US group was admitted and observed by the obstetrics/gynecology service despite peritoneal signs in the ED (Table 1).

Table 2 illustrates the study parameters of pa-

TABLE 1. Characteristics of the Excluded Patients (Total = 14)

Age (Years)	Time to Diagnosis (Minutes)	Time to Treatment (Minutes)	Milliliters of Blood	Systolic Blood Pressure (mm Hg)	Initial Heart Rate (Beats/Min)	Reason for Exclusion*
19	130	220	1,700	81	80	Had positive Morison's pouch US in ED, but requested formal US and refused surgery until she went into shock
28		125	1,000	112	88	Previous US 10 days prior to date of ED visit showed ectopic pregnancy, straight to OR
20		45	1,700	80	112	Clinical shock, rigid abdomen, pale, diaphoretic, straight to OR
37		107	1,500	120	88	Clinical shock, rigid abdomen, pale, diaphoretic, straight to OR
24	25	47	1,500	114	96	Clinical shock, ED US showed empty uterus and fluid in pouch of Douglas, straight to OR
35		117	1,100	114	76	Clinical shock, rigid abdomen, diaphoretic, distended; ED US showed no IUP; no RUQ US or formal US, straight to OR
34		602	1,500	108	85	Previous US showed ectopic pregnancy, methotrexate treatment times two, guarding with rebound, straight to OR
27		170	1,500	96	96	Previous US 6 days prior showed no IUP, clinical shock, tender, straight to OR
33		120	550	132	96	Previous US one day before showed no IUP, tender and guarding, straight to OR
26		165	1,000	110	104	Culdocentesis was positive, tender and guarding, straight to OR
29		255	2,000	106	80	Culdocentesis was positive, tender and guarding, straight to OR
22		300	500	107	72	Culdocentesis was positive, in clinical shock, straight to OR
27	150	1,740	800	120	80	Patient admitted and observed after formal US, despite a tender abdomen with rebound and guarding in ED, time more than 2 SD outside mean
22		310	2,000	110	725	Clinical shock, diaphoresis, nausea, straight to OR

*US = ultrasonography; ED = emergency department; OR = operating room; IUP = intrauterine pregnancy; RUQ = right upper quadrant; SD = standard deviation.

TABLE 2. Characteristics of Patients Who Received Emergency Department (ED) Morison's Pouch Ultrasonography (US) (Group I) and Those Who Received Formal US (Group II)

	Group I ED US (n = 16)				Group II Formal US (n = 21)				
Category	Average	Median	Range	95% CI	Average	Median	Range	95% CI	p-value
Age (years)	29.4	27	18 to 40	25.8 to 33.0	29.6	29	20 to 40	27.4 to 31.9	0.45
Systolic blood pressure (mm Hg)	97	97	74 to 132	90 to 105	105	106	62 to 138	98 to 113	0.07
Heart rate (beats/min)	88	85	64 to 130	80 to 96	91	88	58 to 156	81 to 101	0.34
Milliliters of hemoperitoneum	1,039	1,000	400 to 1,625	847 to 1,230	947	800	400 to 2,000	738 to 1,156	0.27
Initial hemoglobin (g/dL)	11.2	11.6	8.0 to 12.2	10.6 to 11.7	11.1	11.6	4.4 to 13.2	10.2 to 12.0	0.46
Lowest hemoglobin (g/dL)	6.7	6.6	4.9 to 7.4	6.4 to 7.0	7.1	7.0	3.3 to 11.1	6.2 to 8.0	0.19
Units of blood transfused	1.1	1	0 to 3	0.6 to 1.7	1.4	2	0 to 4	0.8 to 2.0	0.28
Days in hospital	3.5	3	2 to 6	2.9 to 4.1	3.1	3	1 to 6	2.5 to 3.7	0.17
Time to diagnosis (minutes)	58*	41	1 to 185	30 to 87	197*	185	64 to 325	162 to 232	<0.0001
Time to treatment (minutes)	111*	73	13 to 313	67 to 153	322*	330	135 to 588	276 to 368	<0.0001

*Indicates statistical significance.

tients in group I and group II. The groups were similar in most parameters. However, there was a statistically significant difference in both time to diagnosis (58 minutes vs 197 minutes) ($p < 0.0001$) and time to treatment (111 minutes vs 322 minutes) ($p < 0.0001$).

Of the 51 patients found to have a ruptured ectopic pregnancy with significant hemoperitoneum (group I and group II and excluded patients), many received only urine pregnancy tests. In the 30 patients with β-hCG result documented, six of 30 (20%) had a level less than 1,500 mIU/mL, as shown in Table 3. Tachycardia (heart rate ≥100 beats/min; 11 of 50, 22%), and hypotension (systolic blood pressure <100 mm Hg; 17 of 50, 34%) were present in a minority of patients. Only six of 50 (12%) presented with both tachycardia and hypotension. All patients in both groups had abdominal pain or tenderness.

DISCUSSION

This study suggests that ED RUQ US performed by emergency physicians to detect ruptured ectopic pregnancy with significant hemoperitoneum can decrease the time to diagnosis and treatment. A RUQ Morison's pouch US may yield a diagnosis without the delays inherent in sending a potentially unstable patient to an unmonitored radiology department. The avoidance of delay is particularly important when patients are critically ill or when TVUS is not immediately available.

Multiple studies have shown that TVUS cannot accurately predict rupture. Frates et al. reviewed 132 patients, and found that a large amount of intraperitoneal fluid was the best predictor of rupture, but 37% of their patients with large amounts of fluid had intact tubes at laparoscopy. Finding a mass in the adnexa was also not predictive of rupture.[10] Falcone et al. studied 236 patients with ectopic pregnancy; 36.3% of the patients were ruptured at laparoscopy. They found that rupture cannot be predicted on the basis of any known risk factor, US findings, or serum hCG levels.[11] Sickler et al., on the other hand, reviewed 125 patients, concluding that intraabdominal echogenic fluid is predictive of rupture.[12] A study of 12 patients with echogenic fluid argues that only a large amount of echogenic fluid was predictive of rupture.[13] Furthermore Krantz et al. showed that the morbidity of ectopic pregnancy can be reduced by early diagnosis and conservative treatment.[14]

The difficulty in predicting rupture based on free fluid seen via TVUS is largely due to the fact that TVUS detects as little as 8 mL of fluid.[15] Because TVUS is so sensitive at picking up free fluid, the finding of fluid on TVUS is a nonspecific finding, which may be physiologic or from ovarian cyst rupture. Alternatively, it takes around 400 mL of fluid to show fluid in Morison's pouch, which would be more likely due to significant hemorrhage.[8,9] While the RUQ US has a decreased sensitivity for small hemorrhage, a positive finding is much more specific for significant hemoperitoneum. This makes it a rapid and noninvasive screen for patients who need immediate surgery.

Vital sign aberrations are widely considered as markers for patients who are bleeding internally. Our study suggests that there are limitations with the use of vital signs for detection of patients with

intraabdominal bleeding from ectopic pregnacies. Only six of the 50 patients (12%) in all groups (groups I and II and excluded patients) experienced both tachycardia and hypotension. We speculate this is because the patients are young and can tolerate a significant loss of blood before showing abnormal vital signs. However, these observations must be viewed cautiously because of the small sample size.

We also noted that 20% of the patients with a hemoperitoneum secondary to ruptured ectopic pregnancy had a β-hCG level less than the "discriminatory zone" of 1,500 mIU/mL.[16] Until recently, our radiology department often objected to the ordering of a pelvic US when the β-hCG was less than 1,500 mIU/mL. This study suggests that pelvic USs should be considered in patients with suspected ectopic pregnancies even when the β-hCG is below the "discriminatory zone" of 1,000 to 2,000 mIU/mL.[17–19]

TABLE 3. β-hCG Levels (mIU/mL) in Patients with Ruptured Ectopic Pregnancy with Significant Hemoperitoneum (Total = 30)

Group I ED US	Group II Formal US	Excluded Patients
1,246*	12,820	6,289
3,204	911*	11,700
12,127	23,750	62,900
45,815	83*	5,783
28,930	6,836	5,900
14,240	10,000	939*
2,823	288*	9,393
	30,850	
	21,180	
	11,000	
	18,360	
	18,900	
	1,100*	
	2,370	
	10,000	
	2,431	

Total numbers do not equal total numbers of patients in each group, because many patients received only a urine pregnancy test. β-hCG = beta–human chorionic gonadotropin; ED = emergency department; US = ultrasonography.
*Patients' β-hCG levels below the "discriminatory zone."

LIMITATIONS AND FUTURE QUESTIONS

The most important limitation of the study is one of potential selection bias. While we did our best to demonstrate the similarities between the two groups, there is no way to retrospectively assure that there wasn't something that distinguished those who were selected to receive ED RUQ U/S from those that went to radiology for a formal U/S. It is possible that those who received an ED U/S were simply "sicker looking" and would have gone to the OR quicker regardless of the type of U/S performed. Also, those physicians who were more aggressive about performing ED RUQ US might have been able to disposition patients more effectively.

Another important limitation of our study was that we did not check the sensitivity or specificity of the ED RUQ Morison's pouch US. In our early use of US technology, only positive US findings were reported in our medical chart. Therefore, had we attempted to determine sensitivity, it would have been falsely elevated. We know that Morison's pouch is insensitive for hemoperitoneum with less than 400 ml of fluid.[8,9] None of the ED US group had less than 400 mL hemoperitoneum at the time of surgery. Because our patient search included only patients diagnosed with ruptured ectopic pregnancy, we have no way of being certain that there were no false-positive ED RUQ USs.

Due to the small number of patients in our study, we were unable to show a decrease in morbidity or mortality in patients receiving ED RUQ US and subsequent early surgical intervention. Since the mortality associated with ectopic pregnancy is 3.8 deaths/10,000 events, we would not expect to show a statistical difference in mortality given our small sample size. Larger prospective randomized studies would help support our data. At our institution it would be difficult to do a randomized prospective study because it is now our standard of care to examine Morison's pouch by ED US in any pregnant female with severe abdominal pain, hypotension, or tachycardia. If the patient is pregnant and has a positive Morison's pouch US view, the patient goes directly to the OR without the delay of a formal US. Cooperation with the obstetrics and gynecology department on this issue is essential if these results are to be repeated elsewhere.

CONCLUSIONS

Emergency department US of Morison's pouch by emergency physicians was associated with a significant reduction in time to diagnosis of large intraabdominal hemoperitoneum and operative intervention in patients with ruptured ectopic pregnancies. Further prospective randomized study is needed to show that ED RUQ US can safely speed time to disposition and treatment of patients with suspected ectopic pregnancy.

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Poems and short stories must have a title and body. Two hard copies and one electronic copy should accompany each submission. A cover letter should identify the submission as *Reflections*. Photographs should have a title and may have a caption of no more than 50 words. All submissions must be accompanied by a signed copyright release and author disclosure form.

Contributors must provide the names, highest academic degrees, addresses, e-mail addresses, and phone/fax numbers of all contributors (including photographer). Acknowledgment of manuscript and photograph acceptance will be made in writing to the contributor.

If a photograph is submitted for consideration, the most original image available (slide, negative, or photograph) and two 5 × 7-inch black-and-white prints should be sent. The original image(s) will be returned if requested. Each print and slide should be labeled with the last names of the contributors and an arrow indicating the top of the image.

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