Portable Ultrasonography in Small Emergency Departments: A Systematic Review of the Guidelines and Clinical-Effectiveness
Until April 2006, the Canadian Agency for Drugs and Technologies in Health (CADTH) was known as the Canadian Coordinating Office for Health Technology Assessment (CCOHTA).


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Portable Ultrasonography in Small Emergency Departments: A Systematic Review of the Guidelines and Clinical-Effectiveness

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March 2009

1 PATH (Programs for Assessment of Technology in Health) Research Institute, McMaster University, Hamilton, Ontario.
Health technology assessment (HTA) agencies face the challenge of providing quality assessments of medical technologies in a timely manner to support decision making. Ideally, all important deliberations would be supported by comprehensive HTA reports, but the urgency of some decisions often requires a more immediate response.

The Health Technology Inquiry Service (HTIS) provides Canadian health care decision makers with HTA information, based on the best available evidence, in a quick and efficient manner. Inquiries related to the assessment of health care technologies (drugs, devices, diagnostic tests, and surgical procedures) are accepted by the service. Information provided by the HTIS is tailored to meet the needs of decision makers, taking into account the urgency, importance, and potential impact of the request.

Consultations with the requestor of this HTIS assessment indicated that a review of the literature would be beneficial. The research question and selection criteria were developed in consultation with the requestor. The literature search was carried out by an information specialist using a standardized search strategy. The review of evidence was conducted by one internal HTIS reviewer. The draft report was internally reviewed and externally peer-reviewed by two or more peer reviewers. All comments were reviewed internally to ensure that they were addressed appropriately.
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### ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>AAA</td>
<td>abdominal aortic aneurysm</td>
</tr>
<tr>
<td>ACEP</td>
<td>American College of Emergency Physicians</td>
</tr>
<tr>
<td>AIUM</td>
<td>American Institute of Ultrasound in Medicine</td>
</tr>
<tr>
<td>BMI</td>
<td>body mass index</td>
</tr>
<tr>
<td>CAEP</td>
<td>Canadian Association of Emergency Physicians</td>
</tr>
<tr>
<td>CEUS</td>
<td>Canadian Emergency Ultrasound Society</td>
</tr>
<tr>
<td>CI</td>
<td>confidence interval</td>
</tr>
<tr>
<td>CPG</td>
<td>clinical practice guideline</td>
</tr>
<tr>
<td>CT</td>
<td>computed tomography</td>
</tr>
<tr>
<td>CVC</td>
<td>central venous catheterization</td>
</tr>
<tr>
<td>DPL</td>
<td>diagnostic peritoneal lavage</td>
</tr>
<tr>
<td>DVT</td>
<td>deep vein thrombosis</td>
</tr>
<tr>
<td>ED</td>
<td>emergency department</td>
</tr>
<tr>
<td>EP</td>
<td>emergency physician</td>
</tr>
<tr>
<td>FAST</td>
<td>Focused Assessment with Sonography for Trauma</td>
</tr>
<tr>
<td>HTA</td>
<td>health technology assessment</td>
</tr>
<tr>
<td>IPFF</td>
<td>intraperitoneal free fluid</td>
</tr>
<tr>
<td>LP</td>
<td>lumbar puncture</td>
</tr>
<tr>
<td>RCT</td>
<td>randomized controlled trial</td>
</tr>
<tr>
<td>US</td>
<td>ultrasonography or ultrasound</td>
</tr>
<tr>
<td>USL</td>
<td>ultrasonography or ultrasound for use in lumbar puncture</td>
</tr>
</tbody>
</table>
EXECUTIVE SUMMARY

Ultrasonography (US), as a diagnostic tool in the emergency department (ED), gained popularity in the 1990s with the development of the Focused Assessment with Sonography for Trauma (FAST) examination. In most American trauma centres, FAST examination has replaced diagnostic peritoneal lavage (DPL) as the preferred method of initial evaluation of the injured patient. In a 2001 policy statement, the American College of Emergency Physicians (ACEP) considered the following as primary indications for emergency US: abdominal aortic aneurysm (AAA), ectopic pregnancy, thoracoabdominal trauma, pericardial effusion, determination of cardiac activity, biliary disease, renal tract disease, and procedure guidance.

A large proportion of the trials that constitute the body of evidence for US is not methodologically rigorous. The trials have small sample sizes, no reference standard for comparison (other than observation), no randomization of patients into intervention and control arms, and no blinding of interpreters. The earlier trials did not take place in an ED setting, and the US interpreters were not emergency physicians (EPs). Therefore, there is much uncertainty as to whether US is a value-added diagnostic tool to be used by EPs, especially in a small ED. The present review was undertaken to determine if there is now higher-quality evidence to determine whether US conducted by non-radiologists in an ED is an effective diagnostic tool in small EDs.

**Research questions**

1. What is the clinical-effectiveness of portable ultrasound used in smaller emergency departments?
2. What are the guidelines for use of portable ultrasound (including training requirements) in smaller emergency departments?

**Methods**

Search strategies were developed for the following databases: EMBASE (1980 to 2008 week 46) and MEDLINE (1950 to November week 1 2008) using the OVID search system (November 19, 2008). CINAHL was searched through the EBSCO interface. (November 26, 2008). Parallel searches were developed for MEDLINE In-Process and Other Non-Indexed Citations, and the Cochrane Library. Results include articles published between 2004 and November 2008, and are limited to English language publications only. Filters were applied to limit the retrieval to health technology assessments (HTAs), systematic reviews, meta-analyses, randomized controlled trials (RCTs), controlled clinical trials, and guidelines. Bibliographies of relevant papers were hand-checked.

MEDLINE subject headings included Emergency Service, Hospital; Emergency Physician; and Ultrasonography.

The Google search engine was used, and the websites of regulatory bodies and HTA and related agencies were searched. Specialized databases such as those of the University of York Centre for Reviews and Dissemination were also searched.

**Summary of findings**

The search identified zero HTAs, two meta-analysis/systematic reviews, nine RCTs, and two controlled trials. Of these trials, only one RCT and one controlled trial were conducted in small EDs. Both trials examined US guidance for venous access. Sensitivity and specificity estimates for the FAST protocol for detecting intraperitoneal free fluid (IPFF) varied from 0.80 to 0.90 and 0.96 to 1.00 respectively. The estimates varied depending upon the exact FAST protocol used (IPFF alone versus IPFF and imaging of solid organs), specialty of the interpreter (EP, surgeon, radiologist, radiology technician), methodological rigor of the study (appropriate use of reference standard and blinded US interpreters), and patient body mass index (BMI). US was also used to detect AAA, proximal deep vein thrombosis (DVT), and ectopic pregnancy with high sensitivity and specificity. The diagnostic accuracy estimates for the detection of blunt trauma and DVT were
similar between EP interpreters and radiology interpreters.

US also increased the success rates in procedure guidance such as central venous cannulation and urethral catheterization; as well it decreased the complication rate. Physician confidence in diagnosing pelvic pain in non-pregnant women was increased when an endovaginal US probe was used. US also afforded physicians the ability to compile significantly shorter and more accurate lists of the possible causes of non-traumatic undifferentiated hypotension.

Limitations

This review was limited to guidelines, HTAs, systematic reviews, meta-analyses, RCTs, and controlled clinical trials that were published in the last five years. The search was also limited to the English language, which may have excluded pertinent studies published in other languages. There were only two trials identified that were conducted in small EDs. Since limited information was identified on the use of US in small EDs, studies in larger EDs were included. All of the identified trials dealt with a variety of clinical scenarios, patient populations, and US protocols. Therefore, pooling of test estimates was deemed inappropriate and no meta-analysis was performed.

Conclusions

There is direct evidence from the literature to conclude that US is an effective tool in small EDs for guidance with procedures (central venous catheterization). The conclusion that US performed by EPs to answer focused questions to guide the clinical management of ED patients is a valuable tool for diagnosing trauma, DVT, ectopic pregnancy, and abdominal pain is based upon indirect evidence from research conducted in large urban hospital EDs. Also, diagnostic estimates obtained when EPs perform the US are comparable to those obtained when the US was performed by a radiologist.

There are many groups that offer US training programs for non-radiologists. Guidances have been published describing credentialing criteria and guidelines for establishing emergency medicine US protocols. In small community EDs where the prevalence or clinical probability of disease is low, continuing education, training, and re-training with US has been identified as critical. At the present time there is no guidance for the maintenance of competence in this area from the Royal College of Radiologists, ACEP, or the Canadian Emergency Ultrasound Society (CEUS).

There are many emerging uses for EP-performed US in EDs, as stated in ACEP’s Emergency Ultrasound Imaging Criteria Compendium. There are no data in the literature to support or refute these uses from a clinical standpoint. The literature dealing with US in the detection of blunt trauma and DVT report similar accuracy estimates between EPs and radiologists. Literature also reports that EPs can be trained to perform bedside US and interpret images with confidence. Therefore, it is not unrealistic that EPs can demonstrate proficiency with new emerging US uses.
Title: Portable Ultrasonography in Small Emergency Departments: A Systematic Review of the Guidelines and Clinical-Effectiveness

Date: March 2009

1 CONTEXT AND POLICY ISSUES

Kendall et al.\(^1\) published a history of emergency and critical care ultrasonography (US) in 2007. The first US instrument was introduced in the early 1950s, and it was not until the 1960s that such units became available for limited, primarily experimental use. Along with the technological improvements that were occurring throughout the 1980s and 1990s, growth in clinical applications was also being documented around the world.

Research conducted to evaluate the utility of US in trauma patients culminated in the development of the Focused Assessment with Sonography for Trauma (FAST) examination. In most American trauma centers, the FAST examination has replaced diagnostic peritoneal lavage (DPL) as the preferred method of initial evaluation. The term FAST was first coined by Rozycki et al.\(^2\) in 1996, and it involves the basic four-view examination that has become the foundation of the FAST examination.\(^5\)

Results of studies evaluating emergency US have been published across a wide spectrum of clinical conditions. These include (but are not limited to): diagnosis of blunt trauma;\(^3-7\) ectopic pregnancy;\(^8,9\) and abdominal pain;\(^10\) determination of prandial status;\(^11\) guidance for vascular access;\(^12\) management of cellulitis;\(^13\) and soft tissue infections.\(^14\) In a 2001 policy statement,\(^15\) the American College of Emergency Physicians (ACEP) considered the following as primary indications for use of emergency US: abdominal aortic aneurysm (AAA), ectopic pregnancy, thoraco-abdominal trauma, pericardial effusion, determination of cardiac activity, biliary disease, renal tract disease, and guidance for performing procedures.

A recent Cochrane review\(^5\) attempted to determine whether diagnostic algorithms using US in the emergency department (ED) reduced the mortality and morbidity of patients with suspected blunt abdominal trauma and improved functional and health-related outcomes. Their search (January 1966 to January 2008) only identified four randomized trials, and the authors had to conclude that the evidence from the trials (focusing on patient-centered outcomes) did not provide sufficient evidence to inform policy on the use of US-based clinical pathways in the initial diagnostic investigation of patients with blunt abdominal trauma.

Griffin and Pullinger\(^16\) also conducted a review of FAST and DPL. Six high-quality trials were identified, and they had similar conclusions to the Cochrane review.\(^5\) They suggested that FAST may support a decision to proceed to laparotomy without the need to undergo DPL, but it cannot be used to safely rule out the need for further investigation.

In a review of US guidance for central venous catheterization (CVC),\(^17\) two randomized controlled trials (RCTs) involving ED patients and five RCTs involving non-ED patients were identified. All seven trials reported significant benefits of US guidance in comparison with CVC placement by the landmark technique. The benefits included decreased failure rates, an increased rate of success at the first attempt, and decreased reports of complications.

A large proportion of the trials that make up the body of evidence for US is not methodologically rigorous. Some trials have small sample sizes;\(^18,19\) others use no reference standard for comparison (other than observation);\(^20-22\) no randomization of patients into intervention and control arms;\(^23-25\) and no blinding of interpreters.\(^26\) The earlier trials did not take place in an ED setting and the US interpreters were not emergency physicians (EPs). Therefore, there is uncertainty as to whether US is a value-added diagnostic tool to be used by EPs, especially in a small EDs. This review was undertaken to determine if there is now stronger evidence to evaluate whether US conducted by
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non-radiologists in an ED is an effective diagnostic tool.

Because smaller EDs may give ED specialists less exposure to diagnosis, and may also lead to increased error from smaller prior probabilities of disease based on lower clinical prevalence, there is considerable uncertainty about the use of portable US in smaller EDs. Therefore, this review was undertaken to assess the use of portable US in smaller EDs.

2 RESEARCH QUESTIONS

1. What is the clinical-effectiveness of portable ultrasound used in smaller emergency departments?
2. What are the guidelines for use of portable ultrasound (including training requirements) in smaller emergency departments?

3 METHODS

Search strategies were developed for the following databases: EMBASE (1980 to 2008 week 46) and MEDLINE (1950 to November week 1 2008) using the OVID search system (November 19, 2008). CINAHL was searched through the EBSCO interface. (November 26, 2008). Parallel searches were developed for MEDLINE In-Process and Other Non-Indexed Citations, and the Cochrane Library. English-language limits were applied and publication date limits were applied from January 2004 to November 2008. Filters were applied to limit the retrieval to guidelines, health technology assessments (HTAs), systematic reviews, meta-analyses, RCTs, and controlled clinical trials.

For this report an HTA is defined as a report that includes an evaluation of clinical- and cost-effectiveness, budget impact, and ethical and psychosocial concerns. Only meta-analyses based on systematic reviews were identified for the analysis.

MEDLINE subject headings included Emergency Service, Hospital, Emergency Physician, and Ultrasonography.

The Google search engine was used, along with searching the websites of regulatory bodies, and HTA and related agencies. Specialized databases such as those of the University of York Centre for Reviews and Dissemination were also searched. These searches were supplemented by searching the bibliographies of selected papers as well as the abstracts from conferences including the Canadian Association of Emergency Physicians (CAEP), the ACEP, the Society for Academic Emergency Medicine, and the American Academy of Emergency Medicine. Efforts were made to access unpublished studies by searching the websites of the commercial developers of ultrasound equipment.

Literature screening was performed in two stages: screening of the retrieved citations based on title and abstract only, and full text reviews of the citations identified as being potentially relevant. Two reviewers (KG, KK) independently screened titles and abstracts (if available) for relevancy (see Appendix 1 for level 1 screening criteria). To be included in level 2 screening the citations had to be reports about studies conducted in EDs (or trauma or outpost centres). The early literature that reviewed the accuracy and effectiveness of US included these settings; therefore, we also included them in our search. If either reviewer was uncertain about relevance, the citation was passed through to the next level for full-text screening. Two reviewers (KG, KK) independently examined the full-text reports of the potentially relevant records, applying more stringent eligibility criteria that had been developed a priori (Appendix 2). Any discrepancies were resolved by discussion and consensus. To be accepted for inclusion in this review the study had to use a comparator and the US had to be conducted and/or interpreted by an EP. The original research question was focused on small EDs, with the caveat that if limited numbers of studies were identified then studies set in large EDs would also be included. The data were extracted for all the primary studies identified using a standardized extraction form (Appendix 3).
4 SUMMARY OF FINDINGS FOR RESEARCH QUESTION #1:

The search identified zero HTAs, two meta-analyses/systematic reviews, nine RCTs, and two controlled trials. When these publications were reviewed to determine the size of the ED, it was noted that only one RCT and one controlled trial were conducted in small EDs. The definition of a small ED was arbitrary, originally set to less than or equal to an annual census of 30,000. The study by Leung et al.\(^27\) is conducted in an ED with an annual census of 36,000, which we believe is more reflective of a small ED. The two trials, conducted in small EDs, are discussed first, followed by a synthesis of the remaining publications.

4.1 Randomized Controlled Trial

4.1.1 Central Venous Catheterization

A prospective RCT from Australia reported by Leung et al.\(^27\) dealing with US-guided CVC, was identified. The ED had an annual census of 36,000. The trial randomized 130 patients to catheterization using US guidance or the traditional landmark technique, with failures (after three attempts) in the traditional group allowed to crossover to the US-guided group. All EPs participated in a two-hour training session on US-guided CVC.

There was a significant difference in the catheterization success rates between the two groups. The success rate using US guidance was 93.9% compared with 78.5% using the traditional landmark technique, resulting in a mean difference of 15.4% [95% confidence interval (CI) 13.8% to 27.0%; \(P = 0.009\)]. Twelve patients in the landmark group crossed over to the US group, and 11(92%) underwent successful catheterization.

The investigators also observed a significantly lower complication rate in the US group (4.6%) compared with the landmark group (16.9%), reporting a mean difference of 12.3% (95% CI 1.9% to 22.8%). US-guided CVC increased the success rate and decreased the complication rate compared with the traditional landmark method. Complications in the landmark group were: seven hematomas, four carotid artery punctures, and one pneumothoraces; the US group had two hematomas and one carotid artery puncture.

4.2 Controlled Trial

4.2.1 Peripheral Intravenous Access

Costantino et al.\(^28\) conducted a prospective, non-blinded, systematically allocated study comparing US-guided peripheral intravenous access with a traditional landmark and palpation approach. Patients presenting to the ED on an odd numbered date were placed in the US group, while those presenting on even numbered dates were placed in the traditional (control) group. The EDs were located in two urban, tertiary-care, American hospitals with an annual combined census of 60,000 patients. EPs performed peripheral intravenous access after three unsuccessful placement attempts performed by a nurse. If the physician had three unsuccessful attempts, patients were allowed to be “rescued” with US-guided peripheral intravenous access.

Emergency medicine residents and attending physicians were all familiar with US. Residency training included a three-week rotation in the ED, carrying out emergency US with a minimum of 15 hours of didactic lectures and 100 emergency US scans performed. Before the study, all residents and attending physicians took part in a one-hour didactic session on US-guided peripheral intravenous access and CVC.

Sixty patients were enrolled, 39 on odd days and 21 on even days. Table 1 displays summary measures of the outcomes observed in the intervention and control groups.
Table 1: Outcome Measures

<table>
<thead>
<tr>
<th>Outcome</th>
<th>US group (n = 39)</th>
<th>Control group (n = 21)</th>
<th>Difference (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Success Rate</td>
<td>97.0%</td>
<td>33.0%</td>
<td>64.0% (39.0% to 71.0%)</td>
</tr>
<tr>
<td>Median Time ± SD for First Percutaneous Puncture</td>
<td>4.0 ± 5.6 minutes</td>
<td>15.0 ± 11.8 minutes</td>
<td>11.0 minutes (8.2 to 19.4)</td>
</tr>
<tr>
<td>Number of Punctures</td>
<td>1.7 ± 0.7</td>
<td>3.7 ± 2</td>
<td>2.0 (1.27 to 2.82)</td>
</tr>
</tbody>
</table>

CI = confidence interval; SD = standard deviation; US = ultrasonography. All differences were statistically significant.

Among the 14 failures in the control group, three went straight to successful CVC. The other 11 entered the “rescue” path with successful peripheral intravenous access (these are not included in the US group results).

Authors concluded that US-guided peripheral intravenous access was superior to traditional landmark and palpitation approaches in achieving successful cannulation, decreasing the number of percutaneous punctures, and decreasing the time spent performing the procedure. Selection bias may have been a factor in this study, and thus the significant differences reported here must be viewed with caution.

There was no mechanism to check whether all eligible patients were enrolled, which may have biased the results, creating a greater difference in the success rates between the US and traditional groups.

4.3 Systematic Reviews and Meta-Analyses (not small emergency departments)

Two systematic reviews/meta-analyses that involved EP-performed US were identified. The first report reviewed the evidence for US in the diagnosis of trauma, AAA, and ectopic pregnancy; and the second report reviewed US for the assessment of deep vein thrombosis (DVT).

4.3.1 Trauma, Abdominal Aortic Aneurysm, and Ectopic Pregnancy

In 2006, Chen et al. published a systematic review of portable US devices in EDs in response to a health technology inquiry received by the Canadian Coordinating Office for Health Technology Assessment. The objective of the systematic review was to determine, based upon the available evidence, the effectiveness of non-radiologists’ use of portable US, and to review guidelines for the use of portable US. Full reports (or abstracts and conference proceedings that provided details about study design and outcome measures) of prospective and retrospective cohort studies, case-control studies, and RCTs published between 1995 and 2005 were included. Case reports were excluded. The review focused on patients seen in an ED with suspected abdominal trauma, AAA, or ectopic pregnancy. Computed tomography (CT) scans, DPL, or formal US scans by radiologists were the comparators for EPs performing US. Statistical pooling was performed only with studies that had a prospective study design and reported the actual number of true positives, true negatives, false positives, and false negatives.

Forty-nine relevant reports were identified, which included 29 reports (five comparative design, 24 case series) addressing the clinical-effectiveness of US in a total of 7,074 patients, six training guidelines, nine training programs, two clinical practice guidelines (CPGs), and three systematic reviews. The size of the EDs
where the trials took place was not reported. The
most frequently reported outcome measures in
the studies were diagnostic sensitivity and
specificity. Sensitivity and specificity estimates,
along with the positive predictive value and the
negative predictive value for detecting
intraperitoneal free fluid (IPFF), AAA, and
ectopic pregnancy are listed in Table 2. The
authors pooled the data from four prospective
trials that reported the actual numbers for true
positives, true negatives, false positives, and
false negatives to determine the positive
predictive value and negative predictive value
estimates.

False-negative and false-positive rates were all
from published case series. False-negative rates
were highest in abdominal trauma, varying from
0.10 to 0.25. Rates varied from 0.01 to 0.18 for
ectopic pregnancy. False-positive rates for
abdominal trauma and ectopic pregnancy were
0 to 0.04 and 0 to 0.02 respectively.

Unnecessary surgery rates in patients with false-
positive ED US examinations were as high as
50% and as low as 2.44%. One study in this
review31 reported that 75% of the false-negative
cases needed surgical repair of the abdominal
trauma, and one patient with a false-negative
result died. Reasons for false-negative results
have been attributed to the inability of US to be
used to detect small amounts of IPFF, early
(small) gestational sac, and operator
inexperience.29

Holmes et al.32 conducted a meta-analysis of US
in pediatric blunt trauma patients, but only two
of the included studies used EPs as the US
interpreter. The remainder of the studies used
either radiologists or surgeons as the US
interpreters. For comparison, the pooled
estimates from Holmes et al.32 are displayed
with the pooled estimates from Chen et al.29 in
Table 3. The sensitivity and specificity estimates
are comparable between the three specialties of
the US interpreters. The positive likelihood ratio
estimates were all large, with Chen et al.
reporting estimates that were greater than
Holmes et al.’s estimates. The negative
likelihood ratios reported from both systematic
reviews and meta-analyses are similar for EPs
and radiologists.

Two CPGs identified by Chen et al. suggested
that FAST was useful as an initial screening tool
when used by surgeons for patients with blunt
abdominal trauma. Both CPGs used a systematic
review to support the consensus
recommendations; one CPG used five studies,
the other used four studies. Findings reported in
the three systematic reviews identified in the
original search are inconsistent with the
recommendations of the two CPGs. One large
review (n = 30 studies) concluded that, in terms
of clinically suspected abdominal trauma,
another effective assessment (i.e., CT scan)
should be performed regardless of the initial
sonographic findings. A second review, by the
same authors, concluded that there is insufficient
evidence from RCTs to justify the promotion of
US-based clinical pathways in diagnosing
patients with suspected blunt abdominal trauma.

Chen et al. concluded that there was enough
evidence from studies of blunt abdominal
trauma, AAA, and ectopic pregnancy to suggest
that ED US performed by non-radiologists is an
effective tool for improving diagnostic certainty
in these three disease groups. The US diagnostic
estimates achieved by EPs were similar to those
achieved by radiologists reported in a separate
systematic review/meta-analysis. The positive
likelihood ratios exceeded 10, which indicates
that a positive test result can provide convincing
evidence of the presence of the trauma, ectopic
pregnancy, or AAA. The negative likelihood
ratios for ectopic pregnancy and AAA, but not
trauma, can be interpreted with confidence to
rule out the disease. The authors stated that
emergency US for abdominal trauma is not a
replacement for diagnosing with reference
standards.
### Table 2: Estimates for US by Diagnosis (adapted from Chen et al.²⁹)

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Number of Studies*</th>
<th>Sensitivity (range reported across studies)</th>
<th>Specificity (range reported across studies)</th>
<th>Pooled PPV Mean (95% CI)</th>
<th>Pooled NPV Mean (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPFF</td>
<td>18</td>
<td>0.80 to 0.90</td>
<td>0.96 to 1.00</td>
<td>0.94 (0.91 to 0.96)</td>
<td>0.97 (0.97 to 0.98)</td>
</tr>
<tr>
<td>AAA</td>
<td>1</td>
<td>1.00</td>
<td>NR</td>
<td>0.83 (0.77 to 0.88)</td>
<td>0.96 (0.92 to 0.98)</td>
</tr>
<tr>
<td>Ectopic Pregnancy</td>
<td>7</td>
<td>0.82 to 1.00</td>
<td>0.88 to 1.00</td>
<td>0.70 (0.63 to 0.77)</td>
<td>0.98 (0.96 to 0.99)</td>
</tr>
</tbody>
</table>

*Number of studies for sensitivity and specificity estimates only
AAA = abdominal aortic aneurysm; CI = confidence interval; IPFF = intraperitoneal free fluid; NPV = negative predictive value; PPV = positive predictive value; NR = not reported; US = ultrasonography or ultrasound.

### Table 3: US Diagnostic Estimates for Investigating Blunt Trauma, by Specialty of Interpreter (adapted from Chen et al.²⁹ and Holmes et al.³²)

<table>
<thead>
<tr>
<th>Estimate</th>
<th>EPs Range Reported Across Studies (Chen et al.²⁹)</th>
<th>Mixed Specialties* (Holmes et al.³²)</th>
<th>Radiologists (Holmes et al.³²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>0.80 to 0.90</td>
<td>0.81</td>
<td>0.82</td>
</tr>
<tr>
<td>Specificity</td>
<td>0.96 to 1.00</td>
<td>0.95</td>
<td>0.97</td>
</tr>
<tr>
<td>Positive LR</td>
<td>66.17</td>
<td>22.9</td>
<td>24.5</td>
</tr>
<tr>
<td>Negative LR</td>
<td>0.2</td>
<td>0.2</td>
<td>0.18</td>
</tr>
</tbody>
</table>

EP = emergency physician; LR = likelihood ratio. Mixed specialties include EPs, surgeons, radiologists, and radiology technicians.

#### 4.3.2 Deep Vein Thrombosis

Burnside et al.³⁰ conducted a systematic review and meta-analysis of EP-performed US for detection of lower extremity DVT. The authors searched two databases (MEDLINE and EMBASE), and additionally hand-searched two journals (Academic Emergency Medicine and Annals of Emergency Medicine) for relevant articles published between January 1994 and July 2007. The included studies reported on a prospective sample of predominately outpatients (> 50%). The diagnostic test was US on one or both legs performed by an EP, and the reference standard was a second US performed by an US technician with images interpreted by a radiologist or vascular physician sonographer. Using the sensitivity and specificity of each study and a random effects model, pooled sensitivity and specificity, and associated 95% CIs were calculated.

The search identified six studies, with a total patient sample of 936. The authors graded the quality of the included studies based on adequate blinding. Grade A was assigned to prospective studies in which the EP US performer was blinded to the reference standard. When blinding measures were not explicitly stated or not performed, the study was assigned grade B. Four studies had a quality grade of A, and the remaining two had a quality grade of B. All studies had at least one potential methodological limitation, and 67% had three potential limitations. Some of these limitations included an inconsistent reference standard, insufficient description of selection criteria, index test results not being specifically stated as blinded to the performer of the reference test, and potential for disease progression bias. The pooled sensitivity and specificity were estimated to be 0.95 (95% CI 0.87 to 0.99) and 0.96 (95% CI 0.87 to 0.99) respectively. There was significant heterogeneity among the results. The reported US test...
estimates are based upon only six studies that have their own methodological limitations including selection bias that may overestimate the actual sensitivity. The authors concluded that EP-performed US has excellent specificity and sensitivity.

Goodacre et al.33 conducted a systematic review and meta-analysis of the use of US for the detection of DVT, but the US interpreters were not EPs. As seen in Table 4, the US diagnostic estimates achieved by EPs are greater than those achieved by radiologists, as reported by Goodacre et al. This difference may reflect developing technology; radiologists may be using technology of an older generation compared with the technology used in the six trials reviewed by Burnside.30

4.3.3 Limitations and Generalizability of Systematic Reviews and Meta-Analyses

The two systematic reviews and meta-analyses reported here limited their search to the English language; therefore, some pertinent studies may have been missed. The methodological quality (appropriate use of reference standard and blinded US interpreters) of some of the included studies was not high. This may limit the ability to extract data accurately for statistical pooling; resulting in overestimated pooled sensitivity and specificity values. A systematic review and meta-analysis not described here because there were no primary studies involving EPs included in the review, conducted analyses to explore the source of heterogeneity. The authors found that methodological rigor (based upon QUADAS35 and STARD36 scales) had a major effect on the accuracy of sensitivity and specificity estimates. The reported overall pooled sensitivity and specificity estimates of US to detect abdominal injury (organ, free fluid, or both) were estimated to be 0.79 (95% CI 0.75 to 0.83) and 0.99 (95% CI 0.990 to 0.994) respectively. When the estimates were adjusted for the methodological drawbacks of the original studies through a multivariate regression analysis, the pooled sensitivity was only 0.65. Also, pooling the data from trials that use multiple reference standards versus using a single standard also increases the sensitivity estimate.34

The lack of detail in describing patient enrolment limits the ability for comparisons with other clinical populations (i.e., rural versus urban, men versus women, outpatients versus inpatients etc.). Not reporting the sizes of the EDs also limits the generalizability of the results because it is unclear as to what size of ED the results apply. All the literature reviewed for this systematic review and meta-analysis were of studies conducted in metropolitan hospitals; therefore, the results may not be generalizable to small and/or rural hospitals.

<table>
<thead>
<tr>
<th>Table 4: US Diagnostic Pooled Estimates for Identifying DVT, by Specialty of Interpreter (adapted from Burnside30 and Goodacre33)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimate</td>
</tr>
<tr>
<td>Sensitivity (95% CI)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Specificity (95% CI)</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

CI = confidence interval; DVT = deep vein thrombosis; EP = emergency physician; US = ultrasonography or ultrasound.
4.4 Randomized Controlled Trials (not small emergency departments)

There were eight primary studies identified involving EPs performing US in an ED for the detection of a variety of medical conditions. This included two studies using US for the detection of DVT\(^{21,37}\) that were included in a previously described systematic review and meta-analysis,\(^{30}\) and therefore these are not summarized in detail here. The remaining six articles are described qualitatively, and are grouped according to clinical indication.

4.4.1 Trauma

Melniker et al.\(^{38}\) conducted a trial to assess the effects of FAST on the time to definite care of patients with suspected torso trauma. There were 111 patients randomized to the intervention arm (standard care plus FAST) and 106 patients in the control arm (standard care). The participating EPs underwent training using a curriculum consistent with the ACEP and a trained sonographer instructor. Patients in the intervention arm requiring operative care were transferred to operative care in 64% less time than non-FAST patients [57 minutes, (median 60, interquartile range(IQR)) 41,70 versus 166 minutes (median 157, IQR 90,78) respectively]. No patients with a negative FAST test went to operative care. FAST patients had an odds ratio of 0.16 (95% CI: 0.07 to 0.32) compared with the control patients to undergo a CT scan.

The EPs were not blinded in this study, only 41% of patients screened were randomized, and a 17% dropout rate after enrollment was noted. Also, only 55% of the study population had torso trauma among their final diagnoses despite the initial suspicions based upon the history, symptomatology, and physical examination findings. Even with these limitations, the authors concluded that protocols including FAST examinations significantly decrease time to operative care in patients with suspected torso trauma.

Nazeer et al.\(^{39}\) conducted an RCT that evaluated whether US would improve the success rate, time to completion and number of attempts until successful completion of emergent paracentesis, and decrease the rates of complications. Paracentesis is a surgical procedure performed for the investigation of ascites or complications thereof, and would follow a positive FAST scan for IPFF. The paracenteses were performed by EPs with varying levels of experience. This American trial was conducted in a large urban hospital ED, and eligible patients were randomized to either US-guided or traditionally guided paracentesis. A convenience sample of 100 patients was enrolled (56 US and 44 traditional) and all EPs received a one hour didactic course, which included the identification of abdominal structures routinely seen with US imaging.

Of the 56 patients in the US group, 25% did not undergo paracentesis because little or no fluid was identified during US, or other abnormalities were identified. Of those who underwent the procedure 40 (95%) had successful drainages compared with only 27 (61%) in the traditional group (\(P = 0.0003\)). The initial location of fluid was changed in three (5.5%) patients after US. Fifteen failures in the traditional group crossed-over to the US-guided paracentesis, and 13 patients (87%) underwent successful drainage. No fluid was detected in the other two patients. The authors concluded that US guidance not only facilitates the performance of paracentesis, but it also helps to avoid unnecessary invasive procedures that may harm a patient.

4.4.2 Deep Vein Thrombosis

One prospective RCT\(^{40}\) from the United States dealing with US-guided CVC was identified. The annual census of the ED was not reported. The trial randomized 235 patients to cannulation using US guidance (static or dynamic) or the traditional landmark technique, with failures (after three attempts) in the traditional group allowed to crossover to US-guided group. All EPs participated in a one-hour training session on US-guided CVC.
The unadjusted success rates were 98%, 82%, and 64% for the dynamic, static, and landmark groups respectively. A logistic regression resulted in an odds ratio (95% CI) compared with the landmark group of 3.0 (1.3 to 7.0) for group static, and 53.5 (6.6 to 440.0) for the dynamic group. Non-significant differences in the complication rates between the three groups; 3% for both US groups versus 13% for the landmark group were reported. The authors concluded that US guidance was superior to the traditional landmark technique for CVC.

### 4.4.3 Pain

Tayal et al.\(^41\) conducted an RCT of 30 patients that compared endovaginal sonographic bimanual examination with the traditional digital bimanual examination in non-pregnant women presenting to the ED with pelvic pain. This prospective trial took place in a large American ED. Eligible patients had to be older than 18 years of age and not pregnant. Patient size has been cited as a factor for the poor performance of the digital bimanual examination; therefore, before examination, patients were placed in one of three body mass index (BMI) classes: normal, overweight, or obese. All patients underwent both examinations, and the order of the examinations was randomized. Each exam was performed by a different EP who had extensive experience (> 1,000 exams) in an emergency setting, and who had undergone intensive training on the use of the endovaginal probe and had demonstrated proficiency with its use. Each EP recorded their confidence with their findings for the 11 clinical aspects of the examination, and the EPs were blinded to each others’ results. The clinical aspects were: cervical position, uterine size, uterine position, uterine alignment, uterine tenderness, ovarian size, ovarian tenderness, cervical motion tenderness, cervical os opening, rectovaginal tenderness, and presence of an adnexal mass.

Overall, the mean physician confidence scores for the sonographic bimanual examination were significantly higher compared with the digital bimanual examination (1,000 versus 790, \(P < 0.0001\)). There were only three clinical aspects, (cervical motion tenderness, cervical os opening, and rectovaginal tenderness) that did not show a significant difference in physician confidence between the two forms of examination. Physician confidence in the digital bimanual examination was significantly lower as the patient BMI increased for the criteria of uterine size (\(P < 0.01\)), uterine alignment (\(P = 0.03\)), uterine tenderness (\(P = 0.01\)), ovarian size (\(P < 0.01\)), and ovarian tenderness (\(P = 0.01\)). There were no significant changes in confidence in the sonographic bimanual examination with any of the examination criteria as the patient BMI increased. Authors concluded that the sonographic bimanual examination provided a consistently high confidence rate (> 90%) for all aspects of the examination in each BMI class and that US has a supplementary role in the evaluation of a patient who is also obese.

### 4.4.4 Lumbar Puncture

Nomura et al.\(^42\) conducted a prospective blinded RCT of lumbar puncture (LP) using US (USL) or traditional palpitation for locating the L4-5 or L3-4 interspinous space. The study took place in a large teaching institution ED (92,000 patients annually). Forty-six patients were enrolled, 22 were randomized to the palpitation group, and 24 to the USL group. After patients were enrolled, the physician investigator located the area for LP with US and placed a mark indicating where the puncture should take place using ultraviolet ink only visible with black light. The EP (blinded to the USL mark) placed the palpitation mark (which differed in shape from the USL mark) with ultraviolet ink after locating the space through palpitations. Both the EP and patients were blinded as to which mark was used for the LP.

The USL technique resulted in higher LP success rates compared with palpitation, with a relative risk of 1.32 (95% CI 1.01 to 1.72). There was one of 22 LP failures in the USL group compared with six of 22 in the palpitation group. Traumatic LP was 1.04 times less likely with USL versus palpitation (95% CI 0.83 to 1.31). The authors concluded that US for static marking of the interspinous space is a useful adjunct for LP in the ED and that the physician’s
perceived difficulty performing the procedure is reduced. They also stated that the identification of landmarks using US is easily taught by brief instruction with a short period of practical experience.

### 4.4.5 Undifferentiated Hypotension

Jones et al.\(^4\) conducted a blinded RCT in a large American ED (census > 100,000) to determine whether an EP performed, goal-directed US protocol would significantly narrow the number of potential viable diagnoses of patients with non-traumatic, symptomatic, undifferentiated hypotension. All EPs were accredited through the hospital with a minimum of 100 non-cardiac and 25 cardiac US scans. The third-year residents did a one month rotation during their first year of residency and routinely performed non-cardiac US under the supervision of accredited physicians. All ED attending physicians and residents were given an additional course (didactic and laboratory) teaching, goal-directed echocardiography. All eligible patients with signs and symptoms of shock were randomized to immediate US (within 15 minutes) with standard care or delayed US (after 15 minutes) with standard care. Patients immediately received standard emergent interventions followed by US before 15 minutes or after 15 minutes. All physicians completed prospective data sheets listing the potential diagnoses at 15 minutes and at 30 minutes.

A total of 88 patients were randomized to the immediate US group, and 96 patients were randomized to the delayed US group. As seen in Table 5, the proportion of potential diagnoses is significantly higher in the delayed US group compared with the immediate US group at 15 minutes.

The correct diagnoses for all patients were determined through a blinded chart review. The proportion of correct diagnoses in the immediate US group at 15 minutes was 80% (95% CI 70% to 87%) versus 50% (95% CI 40% to 60%) in the delayed US group, a significant difference of 30% (95% CI 16% to 42%). The authors concluded that the addition of the US protocol to standard care afforded physicians the ability to compile a significantly shorter and more accurate list of possible causes of non-traumatic undifferentiated hypotension.

### 4.5 Controlled Trials (not small emergency departments)

#### 4.5.1 Urethral Catheterization

Chen et al.\(^4\) conducted a prospective controlled trial of urethral catheterization in children younger than two years of age who presented to an American ED. The size of the ED was not reported. For three months, 136 consecutive eligible patients underwent catheterization, and the amount of urine obtained during the first attempt was recorded (observation phase). Successful catheterization was defined as obtaining ≥ 2 mL of urine. During the next three months, 112 consecutive patients were enrolled when one of two pediatric EPs were available to perform bladder US (intervention phase). The amount of urine present in the bladder was estimated using a standardized formula. If ≥ 3 mL of urine were seen with US, catheterization was conducted. If < 3 mL were present, US was repeated at 30 minute intervals until a sufficient volume of urine was identified.

The intervention phase success rate was significantly greater than the observation phase success rate (96% versus 72%, P <0.001). During the observation phase, 14 (10%) patients had no urine present during the first attempt at catheterization and 23 (17%) patients had sufficient urine for culture only. In the 27 intervention patients that did not have sufficient urine initially, subsequent US revealed sufficient urine within 90 minutes. The authors concluded that rapid bedside US of the bladder performed by a pediatric EP led to increased success rates of urethral catheterization.
### Table 5: Number of Potential Physician Diagnoses at Two Time Points

<table>
<thead>
<tr>
<th>Time (minutes)</th>
<th>Immediate US</th>
<th>Delayed US</th>
<th>Mean difference (95% CI)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>4</td>
<td>9</td>
<td>5 (4 to 6)</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>30</td>
<td>4</td>
<td>3</td>
<td>NR</td>
<td>0.4463</td>
</tr>
</tbody>
</table>

CI = confidence interval; P = probability; US = ultrasound; NR = not reported.

#### 4.6 Discussion

The original objective of this review was to determine the clinical-effectiveness of US in small EDs. From the studies that took place in small EDs, US guidance for procedures is superior to the standard landmark techniques, allowing the patient to avoid unnecessary operative care for trauma (i.e., DPL or paracentesis), repeated invasive testing (catheterization, especially in children), and repeated attempts for cannulation. This ultimately increases patient safety in the ED.

Conclusions about the accuracy of the FAST scans and US scans for the detection of DVTs are inferred from studies within large EDs. Sensitivity and specificity estimates for the FAST protocol for detecting IPFF are high and varied from 0.880 to 0.90 and from 0.96 to 1.00 respectively. The estimates varied depending upon the exact FAST protocol used (IPFF alone versus IPFF and solid organ, three views versus four views), specialty of the interpreter, methodological rigor of the study, and patient BMI. These estimates are comparable with estimates reported when the US interpreter is a radiologist. The diagnostic accuracy estimates of using US for the detection of DVT are also similar between EP and radiology interpreters. The sensitivity and specificity estimates, as well as successful DVT detection rates are high.

The literature suggested that a positive FAST examination accurately identifies if trauma, AAA, or ectopic pregnancy is present, but a negative FAST cannot rule these out. In an hemodynamically unstable patient, a positive FAST examination would justify immediate transfer to the operating suite. In a stable patient, the positive FAST examination may be followed by a CT scan to grade the severity of the injury. A negative FAST in a hemodynamically stable patient still leaves diagnostic uncertainty. Since a known limitation of FAST is its inability to detect small amounts of fluid (or small gestation sacs), and US is easy and rapid to perform, then US may be repeated in the stable patient. Studies assessing repeated US scans are limited, but the one study that did utilize repeated US examinations (every 30 minutes) reported the presence of adequate urine within 90 minutes of presentation in the ED. Repeating the US procedure when the first FAST scan is negative is also recommended by Holmes et al. and Stengel et al.

#### 5 SUMMARY OF FINDINGS FOR RESEARCH QUESTION #2

##### 5.1 Guidance for Use of Emergency Ultrasound

The literature search, along with a scan of relevant websites, and the bibliographies of relevant papers identified six medical bodies publishing a total of seven US guidance and related documents. The American Board of Emergency Medicine published the updated Model of Clinical Practice of Emergency Medicine, which defines the scope of emergency medicine. The original model was introduced in 2003. The model is the result of a collaborative effort of six emergency medicine bodies governing the practice of emergency medicine, and is based on empirical data and the advice of several expert panels. The model describes three dimensions of clinical practice: physician tasks, patient acuity, and a matrix of physician tasks and patient acuity. Under physician tasks the
model specifies that bedside US is one of the many procedures and skills for EPs that is essential to the practice of emergency medicine.

The CAEP\textsuperscript{46} published a position statement in 2006 that replaces the 1999 position statement. It is unclear how the CAEP guidelines were developed. CAEP recommends that EDs should have access to targeted US 24-hours per day, seven days per week and suggests that immediate access to bedside US enhances patient care and safety by expediting illness management and avoiding transfer outside of the ED for diagnostic procedures. They also recommend that targeted US training should be incorporated into emergency medicine residency programs, training guidelines be developed, and continuing medical education in ED US is strongly encouraged. The position statement outlines documentation procedures and recommends the implementation of a quality improvement program.

The CAEP offers a course entitled Emergency Department Targeted Ultrasound. It is a nine-hour introductory course that teaches all the essential skills for US. This evidence-based course offers didactic and hands-on training in US physics, image generation and interpretation, US psychomotor skills, and indications for and limitations of ED targeted US. More information about upcoming courses is available at this link:\ http://www.caep.ca/template.asp?id=8B793B0F46CE4083AB4E775BE6D6A412

The Canadian Emergency Ultrasound Society (CEUS) has published indications for ED US\textsuperscript{47} and recommended standards,\textsuperscript{48} but they do not state how they were developed. The indications for US state “emergency US …is a HIGHLY LIMITED use of ultrasound in potentially life-threatening situations when there is no time to involve radiological colleagues.”\textsuperscript{47} Indications include pericardial tamponade and cardiac standstill, intraperitoneal hemorrhage in trauma, ruptured AAA, and ruptured ectopic pregnancy. The CEUS also recommends that US should be used whenever possible to guide the placement of central venous catheters. They recommend that physicians attain the status of independent practitioner (IP) before being allowed to perform ED US without supervision. To become an IP the physician must take an introductory course and then complete 50 scans of each of the relevant areas (heart, aorta, abdomen, and pelvis). After the scans, candidates must successfully pass written, visual, and practical exams.\textsuperscript{48}

The CEUS offers a course entitled The Essentials of Emergency Department Ultrasound. More information about this day-long course is available at this link: \ http://www.ceus.ca/003-courses/003.docs/2005/WELCOME.EDE.pdf

ACEP has recently published updated guidelines\textsuperscript{49} on the use of US and the guideline development process was not reported. The ACEP defines emergency US as “…a goal-directed focused ultrasound examination that answers brief and important clinical questions…” The ACEP considers emergency US within the scope of practice for the bedside diagnostic evaluation of emergency medical conditions and diagnoses, as well as resuscitation of critically ill, acutely ill, or injured patients, for guidance in difficult or high-risk procedures, monitoring of certain pathologic states, and as an adjunct to therapy.

ACEP recommends training pathways, one residency-based and the other practice based. The practice-based pathway is for physicians who have completed their residency training without emergency US. The training should include a 16 hour to 24 hour introductory course (residency pathway specifies a minimum of 20 hours during the three-year residency). The course should cover the core applications of US followed by practical hands-on sessions. ACEP provides the outline for an introductory course. At least 25 documented and reviewed cases should be obtained in each of the core applications. For general emergency US competency, 150 to 250 emergency US examinations are required.

The ACEP has published the Emergency Ultrasound Imaging Criteria Compendium,\textsuperscript{50} which provides detail on the specifications for the performance and interpretation of emergency
US, pitfalls and limitations, documentation, equipment specifications, and quality control. The imaging criteria listed in the compendium are for the aorta, biliary, echocardiography, pelvic, renal, trauma, venous thrombosis, and other US-guided procedures. ACEP has also published The Emergency Ultrasound Fellowship Guidelines, a consensus document developed to assist departments and individuals seeking post-residency training in emergency US.\textsuperscript{51} The guidelines recommend that emergency US fellows should have, on average, at least five scanning shift equivalents per month. During a scanning shift, the fellow spends the entire length of a typical clinical shift scanning patients in the ED, supervised by the fellowship director. Among the minimum criteria for graduation, the fellow must perform a minimum of 800 US examinations.

In 2007, the American Institute of Ultrasound in Medicine (AIUM) and the ACEP jointly developed a practice guideline for the FAST examination.\textsuperscript{52} These guidelines cover indications and contraindications, detailed specifications for individual examinations, equipment specifications, responsibilities of the physician, and documentation. Both the AIUM and the ACEP recommend that policies and procedures be developed in accordance with standards they have developed relating to training and credentials, quality control and improvement, infection control, and patient education. There is no statement regarding how the guidelines were developed. AIUM recommends training and credentialing based on guidelines from the physicians’ specialty society, or from the AIUM or ACEP.

In 2000, The American Medical Association affirmed that US is within the scope of practice of appropriately trained physicians and supported reimbursement for US that is performed in the ED and other settings.\textsuperscript{53} The Royal College of Radiologists\textsuperscript{54} has provided detailed requirements for the performance of focused emergency US by medical non-radiologists. There is no statement regarding how the guidelines were developed. Some of the notable recommendations include:

### Level 1 Training
- Approximately five supervised US examinations performed per week in either the ED or radiology department.
- Approximately 50 examinations should be undertaken, with an assessment based on competencies.
- Examinations should focus on the core clinical indications of trauma, AAA, or vascular access.

### Level 2 Training
- At least one year of experience at Level 1 with an average of three to five scans per week.
- A further 150 to 200 examinations in order to encompass most of the listed conditions and procedures.
- Supervision by someone with at least two years experience at Level 2.

The Royal College of Radiologists also outlines competencies to be acquired and provides for the maintenance of skills for all training levels.

The Accreditation Council for Graduate Medical Education\textsuperscript{55} provides emergency medicine guidelines that include bedside US among their recommended core competencies. There is no statement regarding how the guidelines were developed. The program director and the faculty have the primary responsibility for the determination of procedural competency in US. Hence, a specific number of required US procedures is not specified.

Chen et al.\textsuperscript{29} conducted a systematic literature search for articles describing the use of portable US devices by non-radiologists and non-radiology technologists, and located six guidelines describing training and credentialing requirements published between 1994 and 2005. They reported that the minimum number of US scans recommended varied from 50 to 500, while the minimum number of accurate scans varied from 15 to 25. Chen et al. reported evidence of misdiagnosis with US that is associated with inexperience and corresponding improvements in the performance of non-radiologist physicians who undergo didactic and
practical training. Most researchers in the 11 primary studies identified by Chen et al. reported previous training experience of eight to 12 hours of didactic sessions, and 15 to 50 hours of unsupervised portable US scans. Most studies required a certain portion of positive scans to demonstrate proficiency at interpreting US images.

5.2 Discussion

The utilization of emergency US is recommended by all of the guidance producers identified by this review and each body outlines policies and procedures related to emergency US, including recommended indications, equipment specifications, quality control, and documentation.

There is general consensus among available guidance that suggests that US should be performed by EPs who are adequately trained in its use. Training consists of courses followed by supervised hands-on experience. The number of required ED US examinations to gain competency varied from 50 scans to 800 scans. Maintenance of US competency is not addressed by the Royal College of Radiologists, ACEP, and CEUS. One study did suggest that the ultrasonography skills of EPs at academic medical centres where emergency medicine US research is being conducted may exceed the capabilities of most EPs in community practice. There is no evidence to confirm or refute this statement.

6 LIMITATIONS

This review was limited to guidelines, HTAs, systematic reviews and meta-analyses, RCTs, and controlled clinical trials published in the last five years. The search was also limited to the English language, which may have excluded pertinent studies published in other languages. The identified trials dealt with a variety of clinical scenarios, patient populations, and US protocols. Pooling of test estimates was deemed inappropriate given the observed heterogeneity of studies.

7 CONCLUSIONS AND IMPLICATIONS FOR DECISION OR POLICY MAKING

There is direct evidence from the literature to conclude that US is an effective tool in small EDs for guidance with procedures (i.e., CVC and catheterization). The conclusion that US performed by EPs to answer focused questions to guide the clinical management of ED patients is a valuable tool for the diagnosing trauma, DVT, ectopic pregnancy, and abdominal pain is based upon indirect evidence from research conducted in large urban hospital EDs. Diagnostic estimates obtained when EPs perform the US are comparable with those obtained when the US was performed by a radiologist.

There are many groups that offer US training programs for non-radiologists. Guidances have been published describing credentialing criteria and guidelines for establishing emergency medicine US protocols. In small community EDs where the prevalence or clinical probability of disease is low, continuing education, training, and re-training with US has been identified as critical. At the present time there is no guidance for the maintenance of competence from the Royal College of Radiologists, ACEP, or CEUS.

There are many emerging uses for EP-performed US in EDs, as stated in ACEP’s Emergency Ultrasound Imaging Criteria Compendium. There are no data in the literature to support or refute these uses from a clinical standpoint. The literature that deals with US in the detection of blunt trauma and DVT reports similar accuracy estimates between EPs and radiologists. In the literature it is also reported that EPs can be trained to perform bedside US and to interpret images with confidence. Therefore, it is not unrealistic that EPs can demonstrate proficiency with the new emerging US uses.
REFERENCES


APPENDIX 1: Portable Ultrasound Level 1 Screening (Title and Abstract)

1. Does this article report the use of a portable ultrasound as a diagnostic/screening technique
   a. In an emergency room
   b. Trauma site
   c. Outpost centre

2. Does this article report results of training of non-radiologists (Emergency medicine doctors, residents, clerks etc.)

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
<th>Maybe</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If Yes or Maybe to any sub-point (a to c) in Q1 Include
If Yes or Maybe to Q2 Include
If No to all sub-points in Q1 and Q2 Exclude
## APPENDIX 2: Portable Ultrasound Level 2 Screening

Ref ID: __________   Author and Year: ________________________________

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1. Reports about emergency physicians performing the ultrasound diagnostics?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q2. Is the setting an emergency room</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do they report the annual number of visits to determine if it is a “small” emergency room (≤ 30,000 visits)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q3. Is the setting a trauma centre or remote centre</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q4. Is there a comparator group</td>
<td></td>
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<tr>
<td>Q5. Are outcomes reported</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q6. Is this a review</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q7. Is this a guideline, or recommendations for use, or for training requirements</td>
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If Q1 and (Q2 or Q3) is Yes and Q4 and Q5 are Yes Include
If Q6 or Q7 are the only yes Include
All others Exclude
## APPENDIX 3: Data Extraction Form

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<th>Citation</th>
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<th>Population (inclusion and exclusion criteria)</th>
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