Utilization of ultrasound in medical inpatients in Malawi

Hannah E. Brindlea,*, Theresa J. Allainb, Sam Kampondenic, Noel Kayangeb, Brian Faraghera, Imelda Batesa and Elizabeth Joekesa

aLiverpool School of Tropical Medicine, Pembroke Place, Liverpool L3 5QA, UK; bCollege of Medicine, Private Bag 360, Blantyre 3, Malawi; cQueen Elizabeth Central Hospital, Chichiri, Blantyre, Malawi

*Corresponding author: Present address: Institute of Infection and Global Health, The Ronald Ross Building, 8 West Derby Street, Liverpool L69 7BE, UK. Tel: +44 151 706 4381; E-mail: hannah.brindle@liverpool.ac.uk

Received 3 April 2012; revised 31 August 2012; accepted 20 September 2012

Background: Ultrasound utilization studies in the developing world are important to support appropriate use.

Methods: A prospective, cross-sectional study in the medical wards at Queen Elizabeth Central Hospital, Blantyre, Malawi, was performed which aimed to assess referrals, reports and usefulness of scans to develop local recommendations. The primary outcome of a ‘useful scan’ was based on scan results and utilization of the report. Indication, quality of requests and reports, and operator were documented. Recommendations for request and report writing were developed.

Results: During 28 April–1 June 2011, 96 scans were analysed of which 66 (69%) were useful. Scans were not useful when the report was non-diagnostic, not documented or not acted upon. Seventy-eight scans (82%) were requested without prior laboratory investigations. A working diagnosis of a pericardial effusion was significantly associated with a useful scan (p = 0.01) as was a medical history of HIV (p ≤ 0.001). The quality of requests and reports in terms of clinical information was moderate or poor in 73% and 33% of cases respectively. Scans by clinicians were at greater odds (OR = 4.0, p = 0.01) of being useful compared with those by radiology technicians.

Conclusion: Despite the majority of ultrasound scans being useful, underutilization and non-useful scans were common, indicating the need to identify appropriate indications and develop relevant guidance and training.

Keywords: Ultrasound, Abdominal, Echocardiogram, Utilization, Malawi, Africa

Introduction

Ultrasound is increasingly used in limited-resource settings for the diagnosis of medical conditions. The relatively low cost, safety profile and portability make it an attractive option.1,2 However, inappropriate requests and poor quality reporting may add to workload and cost in an already overstretched health system.3 Within medical wards, abdominal and cardiac ultrasounds are the most common types of scan. However, the indications for, and interpretation of these differ from those in more highly resourced settings. For example, tuberculous pericarditis accounts for the majority of pericardial effusions4 and the detection of ascites and mesenteric masses have a high positive predictive value for the diagnosis of abdominal TB in high burden populations.5 Ideally, the appropriate use of ultrasound should reflect these differences in pathology.

Effective utilization of diagnostic imaging depends on appropriate requesting and reporting of the scans and use of the results in patient management. Previous studies, using change in patient management as an indicator of the usefulness of the scan, have found rates of 30–86%. On the basis of this the authors advocate the wider use of ultrasound.6

There is a lack of guidelines in the developing world for the appropriate use of diagnostic imaging studies, or standards for expected service delivery. The WHO in their call for guidance has acknowledged this problem.7 To develop such guidelines a larger evidence base is needed to identify appropriate indications for ultrasound in various low-income and middle-income settings.

Malawi is a country with a high prevalence of HIV and TB and an emerging epidemic of non-communicable diseases.8,9 There are few healthcare staff and diagnostic resources. Queen Elizabeth Central Hospital in Blantyre, is the largest hospital in the country. Ultrasound is performed by clinicians, without formal certified training; a private radiologist (SK) who does a small number of scans; and unsupervised radiology technicians.

This prospective study aimed to evaluate the utilization of abdominal ultrasound and echocardiography in medical inpatients in an operational low-resource setting. Referral practices, quality of requests and reports and utilization of the scan results were evaluated. The results were used to identify factors resulting in a useful scan and areas where improvements could be made.

© Royal Society of Tropical Medicine and Hygiene 2013. All rights reserved. For Permissions, please email: journals.permissions@oup.com.
Materials and methods

Study setting

The study was performed at the Queen Elizabeth Central Hospital, Blantyre, Malawi, a secondary level hospital for the population of Blantyre (approximately one million), and tertiary referral centre for the Southern Region (population of approximately six million). A Philips HD3 Ultrasound System (Royal Philips Electronics, Amsterdam, The Netherlands) was used by the radiologist (SK), or one of the radiology technicians or medical doctors (including TJA), within the department of radiology, to perform abdominal ultrasounds and echocardiograms. Doctors also performed bedside echocardiograms, using a SonoSite 180 Plus (Bothell, WA, USA). The patients were not required to pay for their scan.

Study design

A prospective, descriptive and quantitative cross-sectional study was conducted in the public medical inpatient wards over a period of 5 weeks from 28 April to 1 June 2011. Patients aged ≥19 years for whom an echocardiogram or abdominal ultrasound scan was part of the management plan were recruited. Those unable to give informed consent (e.g. had impaired consciousness or hearing and visual loss) were excluded from the study.

The radiographers and medical staff were informed that the study would be performed. However, specific details of the study were not explained to avoid a Hawthorne Effect. The principal investigator (HB), who did not request or perform ultrasounds, obtained consent from all patients to avoid recruitment bias. Consent forms and patient information sheets were translated into the local language and a translator was used in the case of illiterate patients. No financial incentives were provided for the patients or the staff.

Data collection

The files of every inpatient in the medical wards were reviewed at least three times per week to determine whether a scan had been requested. Clinicians wrote request forms for departmental scans and patients were allocated a time for the scan or attended the department on a ‘drop-in’ basis if it was thought to be more urgent. Results were documented in the patient notes or on the reverse of the request form. Demographic data, clinical data, the working diagnosis (including how this was arrived at), staff category who performed the scan and the utilization of the results were collected from copies of the request forms or the medical files. The principle investigator collected all the data.

The quality of the request forms and reports was evaluated using a proforma with criteria based on a study in Spain which aimed to evaluate ultrasound requesting practices, and on reporting criteria from UK and American guidelines (Supplementary Appendix 1).

Outcomes

The primary outcome was the usefulness of the scan. ‘Useful’ was defined as ‘confirming a diagnosis, a useful negative, recommending appropriate further investigation or action on management, or supporting patient monitoring or treatment’ as based on a previous study in Malawi. A consensus expert opinion (from radiologists SK and EJ) was obtained in equivocal cases. The treating doctor, who in some cases may have performed the ultrasound, made the management decisions and the patients were followed until discharge from hospital, death or completion of the study.

Following preliminary data analysis, meetings took place with the medical and radiology staff (including both those who requested and those who performed the scans) to incorporate their feedback. Local recommendations for requests and reports were drafted for common conditions with stakeholders TJA (head of the department of medicine), SK (consultant radiologist) and NK (consultant clinician).

Sample size and data analysis

The power of the study was based on the proportion of patients in whom a scan was ‘useful’. Using Win Episcope 2.0 software, assuming that 50% of scans were useful, a sample of 250 patients would estimate the proportion with a precision (95% CI) of ±6.2% (i.e. 43.8–56.2%). Double data entry was performed and a random selection of 10% of cases was compared for inconsistences. Using PASW Statistics 18 (SPSS Inc., Chicago, IL, USA) proportions were calculated. Fisher’s exact test was used to compare categorical variables against the primary outcome (the usefulness of the scan). A p value ≤0.05 was considered significant.

Results

A total of 117 patients consented to participate, 156 scans were requested and 96 scans were analysed (Figure 1). Ultrasound was considered useful in 66 (69%) of analysed scans.

Figure 1. Study profile showing the eligibility of participants and number of scans analysed for medical inpatients at Queen Elizabeth Central Hospital, Blantyre, Malawi.
Demographics
Of the 96 scans analysed, 51 (53%) were for patients aged <40 years and 45 (56%) were for women. Most patients were non-smokers (78%, n = 75) and did not drink alcohol (73%, n = 70). The most common diagnoses on past medical history included HIV infection (47%, n = 45) and TB (20%, n = 19) (Table 1).

Usefulness of ultrasound related to patient demographics and past medical history
Scan usefulness related to demographics and past medical history is shown in Table 1. Those with a past medical history of HIV were significantly more likely to have a useful scan (p ≤ 0.001).

Usefulness of ultrasound related to scan type and operator
Of the total number of scans analysed, 52 (54%) were abdominal, 36 (38%) were echocardiograms performed in the radiology department and 8 (8%) were bedside echocardiograms. There was no significant difference between the type of ultrasound and whether the scan was useful or not (p = 0.40).

The type and number of scans performed by different staff categories are shown in Figure 2. There was a significantly higher odds of a useful ultrasound if it was performed by a radiologist or clinician (OR = 4.0, 95% CI 1.5–10.4; p = 0.01). Abdominal ultrasounds were only performed in the radiology department and not at the bedside.

Usefulness of ultrasound related to diagnoses
The decision to request an ultrasound was based on the patient history or clinical findings in 95 (99%) of cases. In 18 patients (19%) the request was also based on laboratory results and in 34 patients (35%) on previous radiological investigations.

Table 2 summarizes the working diagnoses prior to ultrasound and the usefulness of the scan. Those patients with a working diagnosis of pericardial effusion were significantly more likely to have a useful ultrasound scan than not (p = 0.01).

Usefulness of ultrasound related to quality of requests and reports
Figures 3 and 4 show the quality of the requests and reports in terms of clinical and non-clinical information. The quality of the requests, in terms of the clinical information, scored moderately or poorly in 73% (n = 53) with inadequate completion of history and clinical findings in 53% (n = 39) and inadequate completion of reason for request in 48% (n = 35). The quality in terms of technical information (adequate or inadequate completion of name, date), scored moderately in all cases. The quality of the reports in terms of the clinical information was good in 67% of cases (n = 62) and good in terms of technical information in 12% (n = 11).

The difference between the odds of having a useful ultrasound scan if a good quality request was written, compared with a

Table 1. Correlation between patient demographics and useful ultrasound scan for medical inpatients at Queen Elizabeth Central Hospital, Blantyre, Malawi

<table>
<thead>
<tr>
<th>Demographics</th>
<th>Ultrasound useful (n = 66)</th>
<th>Total (n = 96)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19–29</td>
<td>14 (70)</td>
<td>20</td>
<td>NS</td>
</tr>
<tr>
<td>30–39</td>
<td>23 (74)</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>40–49</td>
<td>12 (67)</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>≥50</td>
<td>17 (63)</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>32 (76)</td>
<td>42</td>
<td>NS</td>
</tr>
<tr>
<td>Female</td>
<td>34 (63)</td>
<td>54</td>
<td></td>
</tr>
<tr>
<td>Smoking status</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-smoker</td>
<td>51 (68)</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>Current smoker</td>
<td>3 (43)</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Ex-smoker</td>
<td>7 (100)</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Missing</td>
<td>5 (71)</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Alcohol use</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>46 (66)</td>
<td>70</td>
<td>NS</td>
</tr>
<tr>
<td>Yes</td>
<td>5 (63)</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Previous</td>
<td>13 (87)</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Missing</td>
<td>2 (67)</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Past medical history</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HIV</td>
<td>39 (87)</td>
<td>45</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>TB</td>
<td>15 (79)</td>
<td>19</td>
<td>NS</td>
</tr>
<tr>
<td>Diabetes</td>
<td>2 (50)</td>
<td>4</td>
<td>NS</td>
</tr>
<tr>
<td>Hypertension</td>
<td>4 (57)</td>
<td>7</td>
<td>NS</td>
</tr>
<tr>
<td>Other</td>
<td>19 (66)</td>
<td>29</td>
<td>NS</td>
</tr>
</tbody>
</table>

NS: not significant.
moderate or poor quality request was not significant (OR = 0.5, 95% CI 0.2–1.5; p = 0.28). Similarly, the difference between the odds of having a useful ultrasound with a good quality report, compared with a moderate or poor quality report was not significant (OR = 2.0, 95% CI 0.8–5.1; p = 0.16). The difference between the quality of reports and staff category also did not reach significance (OR = 1.2, 95% CI 0.5–3.2; p = 0.80).

Changes in patient management
A change in patient management occurred following 57% (n = 55) of scans. Figure 5 outlines the changes in management with an initiation of treatment accounting for 55% (n = 30) of these. Some patients had more than one change in their management. For those scans that were not deemed to be useful, there was an absence of documentation in the medical file that the report had been read in 16 cases (53%).

Stakeholder group discussions
The clinicians considered ultrasound to be a useful diagnostic tool. However, several commented that the reliability of the reports may depend on who had performed the scan. Some would therefore refer more urgent or serious cases to clinicians rather than to radiographers. The absence of a clear answer to the question on the

<table>
<thead>
<tr>
<th>Working diagnosis</th>
<th>Ultrasound useful (n = 66) n (%)</th>
<th>Total (n = 96) n</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pericardial effusion</td>
<td>17 (94)</td>
<td>18</td>
<td>0.01</td>
</tr>
<tr>
<td>Abdominal TB</td>
<td>18 (64)</td>
<td>28</td>
<td>NS</td>
</tr>
<tr>
<td>Abdominal malignancy</td>
<td>6 (75)</td>
<td>8</td>
<td>NS</td>
</tr>
<tr>
<td>Cardiac failure</td>
<td>20 (65)</td>
<td>31</td>
<td>NS</td>
</tr>
<tr>
<td>Hepatic impairment</td>
<td>15 (56)</td>
<td>27</td>
<td>NS</td>
</tr>
<tr>
<td>Renal impairment</td>
<td>8 (62)</td>
<td>13</td>
<td>NS</td>
</tr>
<tr>
<td>Other</td>
<td>31 (67)</td>
<td>46</td>
<td>NS</td>
</tr>
</tbody>
</table>

NS: not significant.
HIV is frequently associated with pericardial TB\(^4,5\) and those with a diagnosis of HIV or working diagnosis of pericardial effusion were significantly more likely to have a useful scan. Heller et al. (2010)\(^1\) developed a protocol for rapid ultrasound assessment for HIV/TB (FASH [Focused Assessment with Sonography for HIV/TB]) in South Africa. The protocol is based on the FAST (Focused Assessment with Sonography in Trauma) scans used in emergency medicine. FASH findings include the identification of pericardial and pleural effusions and ascites among others.\(^1\) Our finding that ultrasound is significantly more useful in those with HIV and those with suspected pericardial effusions supports the further validation of such a protocol. Statistical significance for usefulness was not reached for any of the other diagnoses (Table 2).

Unfortunately, the influence of request and report quality on the usefulness of the scan also did not reach significance. The smaller sample size, compared with original calculations, is likely to explain this. The complex logistics of this study in this setting led to the smaller sample size and larger studies will be needed to address usefulness of other common indications and to readdress the influence of request and report quality.

Scans performed by a clinician or radiologist were significantly more likely to be useful compared with those performed by a radiology technician. It is likely that the greater clinical experience of doctors allowed for a more focused and therefore potentially useful scan. Particularly in the presence of an incomplete request, technicians cannot rely on clinical judgement to the same degree and may have therefore been less accurate in reporting outcomes and answering the question posed. Also, arguably, those patients who were more unwell and therefore were preferentially referred to a clinician for their scan, may have had advanced underlying pathology which may have been easier to detect. These aspects may not have been reflected in our grading criteria, resulting in a non-significant difference between the quality of reports and staff category.

In studies by Heller et al. (2010)\(^1\) in South Africa and Shah et al. (2009)\(^6\) in Rwanda, additional training in ultrasonography was provided for clinicians by the study investigators. This resulted in changes in patient management of 47% and 43% respectively. Focused training programmes for clinicians in Malawi and similar settings may optimize the utilization of ultrasound. Radiography technicians in this study highlighted their need for additional training and formal supervision.

A review by LaGrone et al. (2012)\(^7\) of ultrasound training opportunities in low-income and middle-income countries reports that, despite few programmes meeting WHO criteria for training, the accuracy of trainees from shorter programmes can be good. This supports further research into shorter, focused training modules. However, strict quality control measures are required to avoid misuse and errors.\(^1\)

Our study showed that 57% of scans resulted in a change in patient management. This was higher than in many of the other studies.\(^6,15,16\) Although the type of ultrasound was not reached for any of the other diagnoses,\(^4,5\) changes in patient management were comparable and included initiation of treatment or referral to another specialty, differences in percentages resulting in a change in management may be attributed to a wider range of indications included in these studies. In addition, our definition of usefulness included scans which confirmed a diagnosis, but did not necessarily result in a change in management.

The influence of quality of request and report writing

Less than one-third of request forms were of ‘good’ quality with regard to the clinical information. However, there was no significant difference between the quality of clinical information on the request or report and the usefulness of the scan. This suggests that staff have been using their clinical acumen to compensate for limitations in information provided, rather than rely on the requests and reports per se. Despite this, it remains important to improve the quality of request and report writing. Following this study, local recommendations for referral, as well as guidelines for reporting of the most common indications were implemented.

Strengths and limitations

The decisions made by the principal investigator regarding the usefulness of the scan were partly subjective. Despite the application of standardized proformas, judgements had to be made based on information that was recorded in files only. This may not have accurately reflected the thoughts of the referring clinician. In addition, it would have been best to ask doctors to state their anticipated management without ultrasound, as per Speets et al. (2006).\(^1\) A degree of unavoidable bias may have occurred when the treating doctors performed the ultrasound themselves or when coauthors were involved in requesting and reporting ultrasound. Additionally, an expert second operator did not repeat scans and misinterpretation might have influenced the perceived usefulness. The final limitation was the small sample size, as we were unable to recruit the calculated sample size of 250 due to time limitations.

A number of previous ultrasound studies in the developing world include scans performed by visiting experts or by local doctors who had received extra training prior to the research.\(^6,15,16\) A strength of this study lies in the assessment of the utilization of ultrasound in...
daily routine practice, without external expertise or funding, in a setting where formal training is limited. It provides insight into the indications for which ultrasound is currently used and includes assessment of the request and report quality as well as local stakeholder feedback. This gives supporting evidence for the development of recommendations and training relevant to local practice and pathology.

This study supports the important role of ultrasound as a first-line diagnostic tool in low-resource settings. However, inappropriate utilization and underutilization should be recognized and addressed. Improved training in ultrasonography in Malawi is required and focused training, directed at locally relevant and evidence-based indications, may support optimal utilization. In addition, larger outcome-based studies, identifying indications that are most and least effective in various low and middle-income settings are needed, to provide a more robust evidence base for the use of ultrasound and to inform the development of local and international guidelines.

Conclusion

Ultrasound is a useful diagnostic tool in a low-resource setting in Africa, particularly in those who are HIV positive. However, there is scope for improvement. Scans which are not useful have implications for cost and staffing. Evidence-based, locally relevant referral guidelines and focused training for common conditions such as abdominal TB and pericardial effusions should be developed as a priority.

Supplementary data

Supplementary data are available at Transactions Online (http://trstmh.oxfordjournals.org/).

Authors’ contributions: EJ and SK proposed the study; HEB, EJ, IB and TJA designed the study in collaboration with NK and SK; HEB collected and analysed the data; BF contributed towards the statistical analysis; HEB, EJ, IB and SK designed the manuscript. All authors revised, read and approved the final version. HEB is guarantor of the paper.

Funding: This work was supported by the Research and Development Fund, Radiology Department, Royal Liverpool University Hospital, Pembroke Place, Liverpool L7 8XP, UK. Funding was provided for the PI.

Competing interests: None declared.

Ethical approval: This study was approved by the Liverpool School of Tropical Medicine, Ethics Committee, Liverpool, UK [approval no. 11.01 LT] and the College of Medicine Research and Ethics Committee, Blantyre, Malawi [approval no. F2/11/1024].

References