Point of use ultrasound by general surgeons: Review of the literature and suggestions for future practice

Andrew D. Beggs, Paul R.S. Thomas*

Department of Surgery, Epsom & St Helier Hospital NHS Trust, Green Wrythe Lane, Carshalton SM5 1AA, UK

OBJECTIVE: To carry out a review of the literature on bedside ultrasound as performed by surgeons.

Methods: Searching was carried out through Ovid Medline 1950 to current; the Ovid EMBASE 1980 to current; Cochrane Database of Systematic Reviews, PubMed and Google Scholar. Studies were eligible if they were any type of study relating to ultrasound scanning performed by surgeons or non-radiologists, using portable equipment and assessed as relevant by two reviewers. A narrative synthesis of the eligible studies was presented.

Results: There was moderately good evidence for the routine use of ultrasound by surgeons at the bedside for Gallbladder, Thyroid, Parathyroid, DVT scanning and trauma scanning. There was weaker evidence for aortic, hernia, breast, arterial and venous scanning.

Conclusions: Evidence exists for the routine use of certain types of bedside ultrasound in surgical practice, especially in hepatobiliary and head and neck scanning. Further study is needed to determine its utility in vascular, hernia and breast ultrasound.

1. Introduction

Diagnostic ultrasound has been in use in medicine for the past 60 years, with the earliest examples by gynaecologists relating to the use of industrial ultrasound to differentiate abdominal masses. Since then, the use of ultrasound in diagnosis has expanded exponentially, with a range of technologies and devices allowing non-invasive examination of the body without the use of ionising radiation.

Ultrasound imaging has been primarily the province of radiologists and radiographers, with a few exceptions, mainly in the field of women’s health and in gastroenterology/coloproctology. However, the availability of low cost, ultra-portable ultrasound machines allowing diagnostic quality images to be obtained at the bedside has stimulated the development of bedside ultrasound by non-radiologists.

The use of diagnostic ultrasound as a tool for surgeons has been promoted in the USA by the American College of Surgeons. Their statement on Ultrasound Education (ST-31) laid out a program of education, credentialing and outlined training programmes for surgeons. They also suggested a programme of continuing medical education for the maintenance of competence in ultrasonography.

The uptake of bedside ultrasonography in the UK has been less enthusiastic, due to perceived issues with training, competence and medico-legal issues. The Royal College of Radiologists has issued guidelines for the training in the medical and surgical specialties in ultrasound. However, due to the issues discussed above, there has been patchy uptake of bedside ultrasonography in the UK. The College of Emergency Medicine and the Royal College of Obstetrics and Gynaecology have embraced diagnostic ultrasound, with curricula, educational programmes and credentialing available for trainees in these specialties.

The uptake in the surgical specialties has been poor; however bedside ultrasound has been of interest to surgeons for over 20 years. An early study by Williams et al. in 1994 examined the role of ultrasound by training two surgical registrars at St Mary’s Hospital, London for half a day in ultrasound technique. In a series of 205 scans, they found that their findings correlated with that of a formal departmental scan in 86% of the 139 patients subsequently scanned, and that 138/203 patients had their management changed by data available from the scan. Ultrasound has become increasingly popular as a tool available to surgeons at the bedside, rather than restricted to radiology departments.
A recent review by Moore and Copeland in the NEJM suggested that bedside ultrasound could become as ubiquitous as the stethoscope, especially as several US medical schools are now issuing their medical students with portable US machines to be used at the bedside. The potential also exists for this technology & training to be deployed to remote or rural environments, further enhancing care.

In summary, bedside ultrasonography has the potential to further enhance care provided by surgeons in both the acute and clinic setting. We aimed to review the current literature regarding bedside ultrasound by surgeons to ascertain the levels of evidence for current practice and future research. We aimed to do this by carrying out a narrative review of the available evidence on surgical bedside ultrasound. We also aimed to make recommendations regarding further training in ultrasound.

2. Methods

A review of the available literature was carried out using the Ovid Medline 1950 to current; the Ovid EMBASE 1980 to current; Cochrane Database of Systematic Reviews, PubMed and Google Scholar. As no MESH search terms existed for bedside ultrasonography, a combined free text search for “ultrasound” and “surgeon” was performed. From this search the results were filtered by the other key words “gallbladder”, “aorta” “hernia”, “thyroid”, “parathyroid”, “vascular”, “appendix” and “trauma”. These key words were chosen because of their relevance to surgical practice. The search was carried out in January 2012.

All papers identified were screened and had their bibliography searched manually by the two authors to identify further papers of interest as well as following links to papers that cited that paper in PubMed & Google Scholar. Studies were included that met the criteria above and were in the English language. Studies were excluded if they were not in English, as no funding existed to enable translation of their manuscripts. We also specifically excluded endoscopic and endoanal ultrasound scanning as these modalities have already been discussed in numerous other studies. Data from studies was captured into a Microsoft Excel spread sheet. As this was a narrative study, no specific variables were captured; rather the results and outcomes of each study were recorded. Risk of bias was assessed by examining the methodology of each study. The level of evidence and quality of the study was assessed using the Centre for Evidence Based Medicine, University of Oxford criteria.11

3. Results

In total, 4122 studies were found (see Fig. 1), of which 4046 were discarded for non-relevance. Of the remaining 76 studies which were retrieved for more detailed evaluation, 54 were discarded for non-relevance, leaving 23 studies. Further study of the bibliographies of these studies revealed 32 studies that were relevant (Supplementary Table 1). Agreement between authors for studies was 100%.

4. Gallbladder

Right upper quadrant pain is a frequent presenting complaint in surgical on-calls, and it has become increasingly common for patients to have laparoscopic cholecystectomy whilst an inpatient, the so-called “hot” gallbladders. Identification and differentiation of biliary pathology by surgeons would allow triage into groups requiring urgent surgery, those with dilated common bile ducts needing stone clearance prior to emergency treatment or those that can be managed as an outpatient. Assessment of the gallbladder by the surgeon has been performed for approximately 10 years. One of the first studies by Kell et al.12 carried out sonographic examination of 53 patients presenting with signs and/or symptoms of hepatobiliary pathology. They found that surgeon performed ultrasound, retrospectively compared to radiologist performed ultrasound had a sensitivity of 95.2% and specificity of 100% in detecting gallstones as well
as significantly decreasing the time to scan. Gallagher et al. compared measurements of gallbladder dimensions between a surgeon and a radiologist, also retrospectively finding that both groups could achieve similar levels of accuracy. Ross et al. carried out a systematic review of all prospective studies examining the role of ultrasound carried out by emergency physicians to diagnose cholelithiasis. There were 8 studies identified for the review, with 710 subjects in total. Poole analysis of these studies demonstrated a sensitivity of 89.9% (95% CI 86.4–92.5%) and specificity of 88.0% (95% CI 83.7–91.4%) in detecting cholelithiasis as compared to department performed US. Several of the included studies also accurately detected the presence of CBD dilatation. They concluded that clinician performed ultrasound was reliable in both ruling out gallstones as a cause of RUQ pain and also allowing appropriate triage to either inpatient or outpatient management. Good evidence therefore exists for the routine use of bedside ultrasound in the detection of biliary pathology.

5. Aorta

With the roll out of screening for abdominal aortic aneurysm within the UK, the need for clinicians capable of bedside ultrasonography of aortic aneurysms has increased greatly.

Blosi carried out an office based study of 45 patients who underwent screening scanning by a primary care physician who were then scanned by a radiologist. Blosi found that absolute mean difference between the two aortic scans was 0.2 cm (95% CI 0.15–0.25 cm) with a correlation of R = 0.81 compared to formal scan. Blosi also found that scanning the patient took typically around 4 min in total (mean scanning time 212 s, 95% CI 194–230 s). Dijos et al. carried out a comparison of 204 patients who had their aorta scanned with conventional arterial duplex performed by an expert and a bedside ultrasound machine (the VSCAN) performed by a non-expert. They found that there was strong correlation between aortic diameters as scanned by the two machines (R = 0.98, 95% CI 0.97–0.99, p < 0.0001) with 100% agreement for diagnosis of AAA. In total 18/204 patients were found to have asymptomatic AAA.

In the emergency setting, Moore et al. carried out opportunistic scans of “at risk for AAA” patients presenting to emergency departments. They scanned 179 patients, with a total of 12 AAAs discovered, finding that the average discrepancy between physician performed US and departmentally performed US was 3.9 mm. Hoffman et al. found that performance at measuring aortic size varied significantly with experience level, and they determined that up to 25 supervised scans may be required to attain competence. Tayal et al. investigated a cohort of 125 patients presenting to the emergency room with suspected AAA who were imaged by bedside ultrasound. Of these, 29 had AAA detected on bedside US, of which 27 were subsequently found to have AAA. In conclusion, detection and accurate measurement of AAA at the bedside is feasible and has good evidence for its use.

6. Hernia

There is little evidence regarding the role of ultrasound performed by surgeons in the diagnosis of hernias of any type. This is particularly useful in patients presenting with symptoms suggestive of a hernia (i.e. groin pain) but no obvious lump at the groin. Lilly and Arregui carried out surgeon performed ultrasound examination followed by open groin exploration of 65 patients suspected to have an inguinal hernia by reported symptoms. Ultrasound was accurate in determining the type of hernia (direct vs. indirect) with an 85% success rate, with an overall accuracy by surgeons of 92% in finding a hernia, even in patients with no palpable bulge. Clearly, hernia ultrasound has the potential to be high useful for surgical practice, however a well-designed trial needs to be carried out.

7. Thyroid

There is extensive evidence regarding the use of surgeon performed ultrasound in thyroid disease. Diagnostic thyroid ultrasound is important in the outpatient setting to differentiate benign pathology from malignant, triage of patients, and surveillance for benign lesions. Solorzano et al. described the use of surgeon performed ultrasound in 2003 for a variety of settings including for FNA guidance and for lymph node excision. In an outpatient setting, Goldfarb et al. found in a retrospective review of 624 patients who underwent surgeon performed ultrasound & fine needle aspiration for solitary thyroid nodules that using a specific statistical model devised by themselves their false negative rate for calling benign thyroid disease was 1.5%, i.e. benign disease could be reliably differentiated from malignant disease within the outpatient setting using bedside US. Mazzaglia carried out surgeon performed ultrasounds on all patients referred to his thyroid outpatient clinic, 261 in total. He found that surgeon performed ultrasound altered the diagnostic or operative management in 46/261 (17.6%) of patients. Of these patients, 23 patients did not need a FNA as the cyst had regressed, 9 were found to have Hashimoto’s disease, 12 had non-palpable lymph nodes that were biopsied and 3 were positive for metastatic thyroid cancer. Further research needs to be carried out regarding the use of surgeon performed ultrasound in thyroid disease; however the current evidence is reasonably strong that it is of benefit.

8. Parathyroid

Minimally invasive parathyroidectomy (MIP) has gained considerable popularity in recent years. The majority of patients presenting with primary hyperparathyroidism have elevated serum parathyroid hormone and serum calcium and need surgery to remove the abnormal gland. There is a need for a highly accurate imaging modality to localise the abnormal gland. 99mTc-SestaMIBI SPECT lacks the anatomical accuracy needed for MIP. Bedside ultrasound in the clinic, and peri-operatively, immediately prior to the incision is of use here. A number of recent studies have demonstrated the utility of surgeon performed ultrasound in localising abnormal glands prior to operation. Untch et al. examined the role of surgeon performed ultrasound in 516 patients undergoing parathyroidectomy finding that it accurately localised the adenoma in 342/392 (87%) patients scanned. A meta-analysis of cohort studies looking at ultrasound to localise parathyroid adenomas carried out by Cheung et al. found that it had a pooled sensitivity of 76.1% (95% CI 70.4–81.4%) in the localisation of parathyroid adenomas. A recent study by Deutmeyer et al. of 136 patients undergoing targeted parathyroidectomy based on surgeon performed ultrasound found that sensitivity and specificity in this group were 87% and 88% respectively but operative success rate was 99%. They suggested that the accuracy of surgeon performed ultrasound for localisation of parathyroid adenomas made the use of 99mTc-SestaMIBI SPECT unnecessary. The existing level of ultrasound is strong enough for surgeon performed ultrasound to be routinely carried out in the localisation of parathyroid adenomas.

9. Breast

Ultrasound as performed by breast surgeons as part of the initial work up, especially in “one stop” breast clinics, has been part of routine clinical care in the UK for over a decade.
carried out a prospective study whereby patients undergoing surgeon performed breast ultrasound were divided into two groups. The first group consisted of patients whose ultrasound was correlated with histology findings (i.e. the differentiation of benign from malignant disease) and the second group where ultrasound performed by the surgeon was correlated with ultrasound performed by a radiologist. In the first group, surgeon performed ultrasound had a sensitivity of 98.3% and specificity of 91.7%, demonstrating that surgeon performed ultrasound had high accuracy in differentiating benign from malignant disease. In the second group there was concordance in 96% of cases. Other studies have found that it is feasible to train junior surgeons in breast ultrasound in a reasonably short period of time, although evidence is poor in this respect. Currently, there is insufficient evidence of the utility of surgeon performed breast ultrasound. A high quality randomised trial needs to urgently carried out to demonstrate its effectiveness.

10. Peripheral arterial & venous duplex

Focused peripheral vascular ultrasound performed by surgeons is potentially very useful, especially in scenarios such as the acutely ischaemic leg where ascertainment of blood flow is needed. Other situations where it may be of use include detection of deep vein thrombosis and in assessment of varicosities prior to surgery to allow planning of the operation.

There is no current evidence regarding emergency arterial ultrasound, but there is evidence regarding the training of surgeons in arterial duplex. Elberg et al.29 carried out a blinded study of a novice vascular surgical trainee who carried out arterial duplex after receiving basic training in vascular duplex of the lower limbs (15 supervised examinations). They found that only 50 examinations of the above knee arterial tree and around 100 examinations of the below knee arterial tree were required to attain competence, well within the reach of a surgical trainee in a training programme. Elsharawy and Elzayat30 found that vascular surgeons in training were able to achieve an accuracy of 95% (k = 0.85) in 105 lower limb arterial duplex scans compared with digital subtraction angiography in determining the presence of arterial disease.

There is little available evidence on the accuracy of venous duplex performed by surgeons. Kordowicz et al.31 performed a prospective study of venous duplex for symptomatic varicose veins performed by a consultant vascular surgeon and a vascular technologist. Scan results were then assessed by randomisation of the reports into two categories which were then assessed blindly by two consultant vascular surgeons to decide on treatment. Good inter-rater agreement was seen between two ultrasonographers (k1 = 0.68 and k2 = 0.81) suggesting that the vascular surgeon had developed sufficient proficiency to carry out these kind of scans. The paucity of evidence for surgeon performed ultrasound in diagnosing arterial and venous pathologies means that a diagnostic study is needed to ascertain the utility of this.

For the diagnosis of deep vein thrombosis (DVT) at the bedside, the evidence is clearer with a systematic review by study is needed to ascertain the utility of this. The paucity of evidence for surgeon performed ultrasound in diagnosing arterial and venous pathology means that a diagnostic study is needed to ascertain the utility of this.

11. Trauma ultrasound

There is extensive evidence regarding the use of ultrasound in trauma situations. The Focused Assessment using Sonography for Trauma protocol (FAST) consists of views of the hepatorenal space, splenorenal space, aorta, Pouch of Douglas and subcostal echocardiography, and with the eFAST modification a transthoracic scan of the lung to look for occult pneumothorax.

FAST scanning has recently been seen as lacking diagnostic accuracy, mainly due to its misuse as a “rule-out” scan for the presence of intraperitoneal fluid rather than “rule-in” as it was originally designed to. Gaarder et al.33 demonstrated in a study of 104 trauma patients that even with a radiologist performing the scan, FAST could not reliably rule out free intra-abdominal fluid. Dolich et al.34 retrospectively reviewed the case notes of 2576 patients undergoing FAST scanning for blunt abdominal trauma. They found that FAST scanning had a sensitivity of 86%, a specificity of 98% and an accuracy of 97% for the detection of free intra-abdominal fluid. Natarajan et al.35 retrospectively reviewed their trauma database and followed up 2130 patients undergoing FAST scanning for trauma. They found that the sensitivity of FAST scanning was much lower, at 43% with a specificity of 99% and accuracy of 94.1%. They concluded that given its' low sensitivity, haemodynamically stable patients with blunt abdominal trauma and a negative FAST scan should undergo additional confirmatory imaging. These conclusions are supported by a meta-analysis of FAST in 2001 by Stengel et al.36 examining the role of FAST in 9047 patients across thirty trials. Stengel et al.37 carried out a later Cochrane review, finding that there was no definitive evidence for the routine use of FAST scanning in blunt abdominal trauma, but that it reduced the rate of CT scanning.

A recent meta-analysis was carried out by Quinn and Sinert38 of trials examining the sensitivity and specificity of FAST scanning in detecting free fluid in penetrating abdominal trauma. They found that FAST scanning had high specificity (94–100%) but low sensitivity of (28.1–100%) in the detection of free intra-abdominal fluid. They concluded that a negative FAST scan in penetrating trauma mandates further imaging to rule out free fluid.

In patients with suspected pneumothorax (i.e. due to a deceleration injury) “Enhanced” FAST (eFAST) scanning has been shown to be highly sensitive in a study by Nandipati et al.39 They examined the accuracy of eFAST in detecting pneumothorax in 204 sequential trauma patients. They found that eFAST was superior to chest radiography but inferior to CT scanning in detecting occult pneumothorax. Brook et al.40 found that eFAST was an excellent “rule-out” tool for large and moderately sized pneumothoraces.

At the moment the use of FAST scanning routinely in blunt and penetrating trauma is limited by lack of evidence of its benefit. However, it has been shown to reduce the subsequent CT scanning rate, which could be of benefit in reducing radiation dose. However in detection of pneumothorax in trauma, limited evidence exists that eFAST scanning is of benefit.

12. Appendicitis

Fox et al.41 examined the use of bedside ultrasound in the emergency department in the detection of appendicitis in patients presenting with a clinical suspicion of appendicitis. They found a sensitivity of 65% and specificity of 90%. A meta-analysis of available studies of radiologist performed US42 vs. CT scanning of acute appendicitis demonstrated that CT was superior to US scanning, with US less likely to visualise the appendix than CT, however US was reasonably sensitive at detecting ultrasound. Further study is needed to ascertain whether surgeons can reliably perform imaging of the appendix at the bedside.

13. Other potential uses of ultrasound for the surgeon

Surgeon performed ultrasound has several other potential uses. Surgeon performed, ultrasound guided, local anaesthetic blocks are
feasible with current equipment as not all anaesthetists currently may have relevant training in LA blocks. The transversus abdominis plane block has been demonstrated in multiple randomised controlled trials to provide good analgesia and reduce use of opioid analgesia in general surgical operations, especially when combined with ultrasound guidance.

Surgeon performed ultrasound may also be of use in interventional procedures. The current UK National Institute for Clinical Excellence TA49 guidelines for insertion of central venous catheters recommend the routine use of ultrasound to guide insertion, and this is backed up by high quality evidence in the form of the SOAP-3 blinded RCT. A study by Arul et al. examined the use of ultrasound in 500 Hickman line insertions in paediatric patients. They found that ultrasound guided insertion was safe, and although it was associated with a learning curve, it was feasible to be taught quickly to both surgeons and anaesthetists.

14. Conclusions

Bedside ultrasonography, performed by surgeons, has the potential to enhance the level of care given to patients as well as ensure more timely access to care. As can be seen from the literature, the evidence base for surgeon-performed ultrasound is highly variable, and dependent on the area studied. Even more surprising is that areas thought to be standard practice for surgeon performed ultrasound, such as breast ultrasound (i.e. for ultrasound guided biopsy) have little high quality evidence to justify their use. One of the limitations of our study is that it relies on the use of English language, indexed abstracts. Extension of this study with non-English language abstracts would be helpful, especially as bedside is popular in Western Europe. We are also limited by our search terms. Currently, there is no specific MeSH search term regarding bedside ultrasonography, and this could lead to studies that were missed.

The areas for which reasonably high quality evidence exists are gallbladder ultrasound, aortic ultrasound, trauma ultrasound, DVT ultrasound and parathyroid ultrasound. An example of this is trauma ultrasound, in the form of FAST scanning, which demonstrates how ultrasound techniques can be used by surgeons to improve patient care, and how changing evidence leads to change of guidelines regarding FAST. In this case, it is now known that FAST scanning has low diagnostic sensitivity and it is recommended that negative FAST scans in haemodynamically stable patients with blunt abdominal trauma under additional imaging, i.e. contrast enhanced CT.

However, there exist several serious sources of bias for each of these studies. A significant proportion of these studies were poorly designed, carried out retrospectively, and with a poor or non-existent study protocol. There was also no control for observer bias or selection bias. It is difficult to design these types of study to ensure appropriate blinding and lack of bias. Because of the lack of specific search terms for this type of study it is possible that studies have been missed from this systematic review. Therefore we suggest that high quality research studies be set up for all modalities of surgical bedside ultrasound to ascertain its accuracy and practicality.

A barrier to adoption of surgeon performed bedside ultrasound in both the UK and overseas has been the perceived medico-legal issues of non-radiologists performing routine ultrasound examinations. Non-medically qualified practitioners such as ultrasonographers and medically qualified non-radiologists, for example cardiologists or rheumatologists, have been performing routine ultrasound examinations for decades under a clear education and medico-legal framework. Given the obvious advantages and benefits of bedside ultrasound performed by surgeons, a clear framework and training curriculum must be established to ensure its successful implementation. In the UK, ultrasound training could begin as part of the Intercollegiate Surgical Curriculum Project (ISCP) in the 3rd postgraduate year (Core Training year 1) with defined levels of competency in various scans depending on the subspecialisation undertaken by the trainee.

In conclusion, there is an opportunity for surgeons to perform focused, high quality ultrasound at the bedside that has the potential to improve and quicken patient care. Further research is needed to clarify the issues associated with this, and more high quality evidence is needed but surgeon performed bedside ultrasound has the potential to become an important tool in the surgical armamentarium.

Ethical approval
Not required.

Funding
None.

Authors contributions
Study design: ADB, PRT.
Data collection: ADB.
Data analysis: PRT.
Manuscript: ADB, PRT.

Conflict of interest
None.

Appendix A. Supplementary data
Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.ijsu.2012.11.014.

References


