

# Ultrasound scanning of the acute abdomen by surgeons in training

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Ultrasound is widely used in the investigation of abdominal symptoms. Its increasing popularity may lead to pressure on radiological services, diagnostic delay and prolonged hospital stay. Immediate imaging performed by radiologists can contribute useful information in acute emergencies. This study assessed the accuracy and value of abdominal ultrasonography when carried out by admitting surgeons.

Three surgical registrars were first instructed for two half days by a consultant radiologist. Patients with acute symptoms were scanned at the time of initial presentation using an Aloka SSD-620 scanner with 3.5 and 5 MHz probes. A total of 205 scans was performed—124 of the upper and 81 of the lower abdomen. Immediate ultrasound provided information that contributed to the establishment or refutation of a diagnosis in 138 patients (67.3%), predominantly by confirming or excluding hepatobiliary disease, tubo-ovarian pathology or aortic aneurysms and in blunt abdominal trauma. The diagnosis was altered in a small proportion (7.8%). Scanning proved unhelpful in 62 patients and misleading in five. Findings concurred with those of a radiologist in 86% of the 139 patients subsequently scanned.

Abdominal ultrasound is a useful tool in the hands of surgeons dealing with emergencies and may occasionally provide vital information. If access to radiological facilities is delayed, ultrasound by the admitting surgeon could lead to improved patient management and cost savings.

Clinical assessment remains fundamental to the management of the acute abdomen. However, a number of methods of improving diagnostic acumen are available, one of which is immediate ultrasound examination of the abdomen (1–3). Ultrasonography contributes important information additional to that seen on a plain radiograph of the abdomen (4). The two modalities are to some extent complementary, in that ultrasound is particularly adept in scanning solid organs and detecting fluid collections, whereas X-ray films commonly focus on abnormal gas patterns. Some would now regard ultrasonography as essential to the management of abdominal emergencies (5). In addition to its everyday use in the diagnosis of gallstones and in gynaecological practice, ultrasound can image the acutely inflamed appendix, although this may require an expert ultrasonographer (6). The availability of ultrasound is very variable and patients often spend days in hospital waiting for their scans (7).

The aim of this study was to assess prospectively whether ultrasound is of value in the management of abdominal emergencies when performed by relatively non-expert surgical registrars at the time of initial presentation in the accident and emergency department.

## Patients and methods

Three general surgical registrars were each given two half days tuition in basic landmarks in abdominal ultrasound by a consultant radiologist. A series of patients with acute abdominal symptoms (including those resulting from trauma) referred by general practitioners and casualty officers were then examined. Before scanning, the admitting registrar endeavoured to make a clinical diagnosis on

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the basis of symptoms and signs, simple blood test results and plain chest and abdominal radiographs. He documented this, together with his determination at the time of what the course of investigation and treatment should be.

Patients were then scanned either in the accident and emergency department or occasionally on admission to a ward using a mobile, high-resolution ALOKA SSD 620<sup>®</sup> machine, with 3.5 and 5 MHz probes. Organs were scanned transversely and longitudinally, turning the patient and measuring distances as appropriate. Free fluid or blood was searched for, notably at the tip of the liver and the pouch of Douglas, and emphasis was placed on localising the most tender spot and determining its relationship to underlying structures. In the upper abdomen, liver, spleen, gallbladder, common bile duct, pancreas, diaphragm, and kidneys were examined and uterus and adnexal regions were scanned in the lower abdomen. By applying steady pressure in the right iliac fossa, abnormalities such as a distended thickened appendix were looked for when appropriate. Patients were rarely fasted and as they had been asked to provide a specimen of urine on arrival, it was unusual to scan through a distended bladder.

The results of immediate ultrasound were compared with the diagnosis at the time of discharge and scans were classified as useful if they provided important positive or negative information. Results were further grouped as follows: ultrasound supported the clinical diagnosis or decision-making process (included in this group were patients thought to have non-specific abdominal pain affecting the right upper quadrant in whom scanning excluded gallstones); ultrasound altered the working diagnosis or decision-making; ultrasound was unhelpful; or ultrasound was misleading. Additional incidental findings on ultrasound were noted. Whenever possible, the ultrasonographic results of the surgical registrars were compared with those of subsequent scans performed by radiologists.

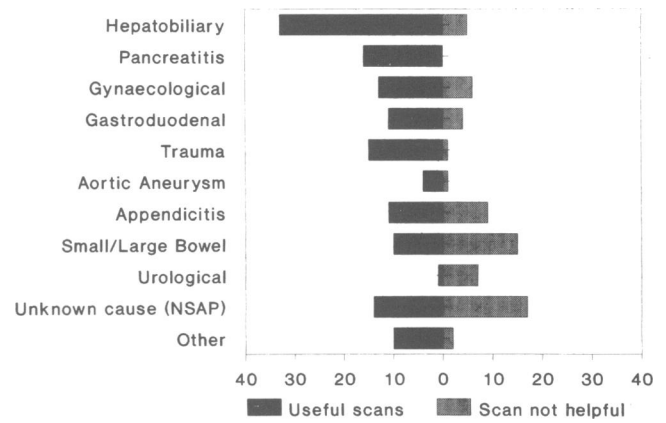


Figure 1. Usefulness of immediate abdominal ultrasound performed by surgical registrars.

### Results

During the 6-month study period, the surgical registrars scanned 205 patients; 124 scans were for upper abdominal pain (61 male, 63 female) and 81 scans were for lower abdominal symptoms (29 male, 52 female). Results were analysed by dividing the patients into a number of diagnostic groups (Fig. 1, Table I). Results of subsequent scans by radiologists were compared with those of the immediate scans in similar fashion (Table II).

#### Hepatobiliary

This group included patients with biliary colic (7), acute cholecystitis (7), obstructive jaundice (13), liver metastases (8) and hepatitis (1). Our surgical registrars correctly identified the main diagnosis in 33 of the 38 cases, including one 38-year-old patient with unsuspected liver metastases. In four immediate scans, they failed to recognise an obstructed bile duct, an inflamed gallbladder, a diffuse malignant infiltration of the liver and a

Table I. Results of immediate abdominal ultrasound performed by surgical registrars

Diagnostic group	Altered diagnosis	Diagnosis supported	Ultrasound not helpful	Ultrasound misleading	Incidental finding
Hepatobiliary	1	32	4	1	10
Pancreatitis	3	13	—	—	—
Gynaecological	7	6	6	—	1
Gastroduodenal	2	9	4	—	—
Trauma	—	15	1	—	—
'Aortic aneurysm'	—	4	1	—	2
Appendicitis	—	11	9	—	—
Small/large bowel condition	1	9	14	1	—
Urological	—	1	4	3	3
No diagnosis established (NSAP)	2	12	17	—	—
Other	—	10	2	—	—
<b>Total</b>	<b>16</b>	<b>122</b>	<b>62</b>	<b>5</b>	<b>16</b>

Table II. Comparison of results of subsequent ultrasound by radiologist with immediate surgical scan

Diagnostic group	Altered findings	Added information	Similar findings	Less accurate	Not performed
Hepatobiliary	3	9	24	1	1
Pancreatitis	—	—	16	—	—
Gynaecological	5	—	11	1	2
Gastroduodenal	—	—	11	—	4
Trauma	—	1	6	—	9
'Aortic aneurysm'	—	—	2	—	3
Appendicitis	—	—	4	3	13
Small/large bowel condition	1	1	10	1	12
Urological	3	—	4	—	1
No diagnosis established (NSAP)	—	—	12	1	18
Other	—	—	9	—	3
Total	12	11	109	7	66

perforated gallbladder. A gallbladder polyp was mistakenly thought to represent a stone. Our radiologists corrected three of the above failures and provided additional information in another nine patients relating to accurate measurement of bile duct diameter (2), malignant lymph node enlargement (2), identification of a stone within the bile duct (2), localisation of a carcinoma of the gallbladder and a pancreatic mass, and a diagnosis of malignant carcinoid based on the unusual echo pattern of liver metastases. They incorrectly attributed gallstones to adenomyosis of the gallbladder in one patient.

### Pancreatitis

Gallstones were correctly identified in four patients admitted with acute pancreatitis and excluded in eight patients. Two pancreatic pseudocysts (one suspected) were identified as well as pancreatic ascites due to pseudocyst rupture. A distended stomach due to gastric outlet obstruction was seen in a patient with chronic pancreatitis and persistent vomiting.

### Gynaecological

Immediate scanning identified six symptomatic ovarian cysts (five clinically unsuspected) but missed a further five (two unsuspected) detected by a radiologist. Of 11 ovarian cyst patients, nine were referred as possible appendicitis. One was thought to have a perforated appendix but immediate scanning detected blood between the liver and right kidney—further questioning then elicited a history suggestive of ovarian cyst rupture at the time of sexual intercourse. Immediate ultrasound also identified two unrecognised pregnancies (one with a dead 22-week fetus) and reinforced the decision to operate in two suspected ectopic pregnancies who had positive pregnancy tests. A pyosalpinx suspected on

immediate scanning but subsequently missed by a radiologist was confirmed at laparoscopy. Other gynaecological abnormalities detected included a carcinoma of the ovary with hydronephrosis and a bulky uterus associated with pain and vaginal bleeding.

### Gastroduodenal

The role of ultrasound in patients with peptic symptoms was mainly to exclude gallstones. In two patients, a clinical diagnosis of cholecystitis was altered when tenderness was ultrasonically localised to the first part of the duodenum. Of three patients with carcinoma of the stomach, one had an 8.9 cm mass and another a distended fluid-filled stomach due to gastric outlet obstruction. Pneumoperitoneum completely obscured the viscera in a patient with a perforated duodenal ulcer.

### Trauma

Immediate scanning was considered useful in all the patients who presented with blunt or penetrating trauma, with the exception of one patient who had extensive subcutaneous emphysema from a pneumothorax obscuring the upper abdomen to ultrasound. Three patients had an obvious haemoperitoneum, two the result of ruptured spleens and a third from a chest stab wound that had penetrated the diaphragm. No abnormality was seen in the remaining patients who remained stable on observation. A radiologist identified one small subcapsular renal haematoma not seen initially.

### 'Aortic aneurysm'

Previously undiagnosed aortic aneurysms were confirmed in three of four symptomatic patients and

excluded in a further case whose back pain and pulsatile mass was subsequently found to be due to lymphoma. We failed to confirm one palpable disrupting aneurysm in an obese immobile patient. One shocked patient was operated on immediately while the remainder underwent CT scans.

### Appendicitis

Abnormal findings corroborating a clinical diagnosis were apparent on immediate scanning in only 11 of 20 patients who had acute appendicitis (one of two perforated). They included thickened appendix (5), free fluid in the right iliac fossa (3), and appendix mass/abscess (3). Confident clinical diagnosis and prompt surgery prevented a subsequent scan by a radiologist in many cases, but their success rate was little better in those patients admitted during normal working hours or those who were first managed by observation. A further 27 patients were referred with possible appendicitis: seven of 12 gynaecological problems were recognised on immediate scanning, two patients had urinary tract infections, one a carcinoma of the caecum and no diagnosis was established in 12 (ie scans were helpful in 19 of the 35 patients with possible appendicitis in whom a specific diagnosis was established).

### Small/large bowel

Eight patients had colonic cancer. A caecal mass was unexpectedly found in a patient thought to have appendicitis. All five palpable colonic tumours were easily seen on ultrasound scanning, although the surgical and radiology registrars each missed luminal gas in one case, thereby incorrectly suggesting an extracolonic or ovarian origin. A huge fluid-filled caecum was noted in a patient with malignant large bowel obstruction. An impalpable sigmoid carcinoma could not be visualised. In seven patients with diverticulitis, no positive information whatsoever was obtained on immediate scanning, but a radiologist detected one small abscess. Fluid-filled actively peristalsing loops were seen in three out of four patients with small bowel obstruction and in a further patient with campylobacter enteritis. Ultrasound was unhelpful in pain resulting from large hernias (3), constipation (1) and mesenteric infarction (1).

### Urology

Urological problems were normally referred to a separate unit and our experience was very limited. Immediate scanning confirmed a suspected renal carcinoma. Our radiologists were required to diagnose two patients who had pain from renal calculi and pyelonephritis and they excluded an incorrect diagnosis of a lumbar collection in a third. A perinephric abscess was mistakenly thought to appear solid both on immediate and radiological scanning. Ultrasound was unhelpful in uncomplicated urinary tract infection.

### Non-specific abdominal pain

No firm diagnosis was established in 31 patients. Immediate scanning was considered helpful in excluding gallstones in 12 patients when abdominal pain involved the right upper quadrant—two were thought clinically to have biliary symptoms. Ultrasound was also considered helpful in excluding recurrent intussusception in a child and free fluid or any other obvious abnormality in an AIDS patient. Two normal appendices were removed; both these patients had unremarkable scans as were those of a further ten thought initially to have possible acute appendicitis. Because of the absence of positive findings in half our patients with obvious appendicitis, we were reluctant to exclude appendicitis on the basis of non-visualisation and these scans were therefore classified as unhelpful. A scan by a radiologist was reported as indicating acute appendicitis in one of these patients, but her clinical presentation and rapid recovery made this result unconvincing and operation was deferred.

### Other

The miscellaneous group included a mesenteric cyst and patients with ascites (3), collections (2), an abdominal wall abscess, a haematoma and a malignant pleural effusion. Collections were excluded in two patients readmitted after earlier abdominal surgery. Scanning was unhelpful in a patient who had basal pleurisy and another with necrotising fasciitis.

### Incidental findings

Incidental findings unrelated to the presenting problem included gallstones in ten patients, an ovarian cyst, two abdominal aortic aneurysms, two renal cysts and urinary retention.

### Discussion

In this study, surgical registrars achieved acceptable results in scanning emergency abdominal cases despite a lack of previous hands-on experience in this field of investigation. Immediate ultrasound generated information that was considered helpful to a varying degree in 138 (67.3%) of the 205 patients investigated. In most cases, this confirmed a working clinical diagnosis and proposed course of action, but in 16 (7.8%) the diagnosis was altered. Ultrasonographic findings were misleading in 5 (2.4%) patients, three of whom had urological problems. Results agreed with those of a radiologist in 109 (78.4%) of the 139 patients who went on to have a subsequent scan. Radiologists corrected initial error in 12 (8.6%) patients and provided relevant additional information in 11 (7.9%). The junior radiologists involved varied in experience and competence and their results proved less accurate than the surgical registrars in 7 (5.0%) cases.

In surgical hands, scanning proved useful primarily by increasing confidence in clinically determined diagnosis and decision-making, although findings occasionally prompted urgent action. Abdominal emergencies can be divided into three categories with respect to the use and timing of ultrasound scans.

In the first category, the results of ultrasonography are of immediate importance. This group includes potential traumatic intra-abdominal injury and haemorrhage (serial scans may be helpful for surveillance in this context), undiagnosed aortic aneurysms, intussusception, and patients with lower abdominal pain (particularly young women). These conditions comprise an important group of surgical emergencies and it is therefore entirely appropriate for surgical trainees to take up ultrasound. Ultrasonography provides a very rapid and simple means of assessing abdominal trauma and, with a little practice, our registrars became confident at looking for major injury. Haemoperitoneum, haematomas, and splenic/hepatic injuries can be detected non-invasively with little loss of time. Specificity in trauma is impressive, although it is important to stress that an apparently normal ultrasound scan should not in any way preclude the use of more sensitive investigations such as peritoneal lavage and CT, particularly in suspected hollow viscus perforation and pancreatic injuries (8). Penetrating chest trauma with possible cardiac tamponade is a further indication *par excellence* for instant imaging (9). With regard to abdominal aortic aneurysms, the intention in this study was sonographically to confirm the presence of an undiagnosed aneurysm and not necessarily to identify a leak. However, a large symptomatic aortic aneurysm, even if not definitely ruptured, is often an indication for prompt surgery. A crucial role of urgent ultrasound in patients with possible appendicitis is the diagnosis of other conditions to account for symptoms, notably those of gynaecological origin (3). Of our altered diagnoses, seven were in this category, arguably one of the important benefits of immediate ultrasound. Ultrasonographic detection of pregnancy is usually within the capacity of the novice (9), and our recognition of ovarian problems was reasonable under the circumstances. It is worth remembering that small follicular cysts (under 2 cm in diameter) are present normally and that per vaginal scanning, when the expertise is available, has advantages in this area. Scanning the appendix itself is not always straightforward and may be particularly operator dependent. Radiologists can attain accuracy rates of over 90% in this context (10–12), but this is not always the case and studies are sometimes selective or exclude inadequate scans (13–16). Perforation, severe guarding and obesity give rise to difficulties (13,15). Even in expert hands, failure to visualise an inflamed appendix does not exclude appendicitis (10), although the specificity of ultrasound in appendicitis can generally be relied on. Our immediate scans were positive in only 55% of patients with confirmed appendicitis and there were several occasions when we could find no ultrasonographic abnormality, even in the presence of convincing clinical evidence. Other surgeons have detected 80% of inflamed appen-

dices using ultrasound (17), indicating that we have room for improvement. With experience, mesenteric lymphadenopathy and ileocaecal thickening due to bacterial enteritis can also be detected (18). Patients with clinical signs of appendicitis but a negative ultrasound scan should proceed to laparoscopy (13,19) or directly to appendicectomy.

In a second category of conditions, ultrasound is an established first-line investigation, and a scan within 12 to 24 h is perfectly acceptable. Examples include biliary colic, cholecystitis, jaundice, pancreatitis, palpable abdominal masses, hydronephrosis, ascites, abscesses, cysts and collections. By partly excluding these abnormalities, urgent ultrasound also has a role in so-called non-specific abdominal pain. It is occasionally possible sonographically to localise tenderness from an ulcer to the first part of the duodenum, and a fluid-filled stomach may indicate gastric outlet obstruction. Ultrasound is an accepted part of urological practice and our poor performance in this field partly reflects a lack of experience, although others have also had problems in the emergency setting (1).

Ultrasound would appear to have relatively little to offer in a third group of conditions that includes intestinal obstruction and mesenteric ischaemia. Worthwhile information is only occasionally obtained in scanning patients with diverticular disease (3,4). While ultrasonographic changes may be detected in association with perforated peptic ulcer (20), management is usually guided by clinical status.

What are the advantages and disadvantages of surgeons performing their own ultrasound scans? Ultrasound is non-invasive and can instantly be available. Technological advances have led to increasingly compact and portable scanners that are readily taken to the bedside. Diagnostic acumen is very readily enhanced by taking up ultrasonography and the experience gained can then be extended into the developing field of intraoperative ultrasound. Whether or not immediate ultrasound affects clinical results and the efficient use of inpatient facilities and costs will depend on local circumstances. Our hospital has an urgent ultrasound service provided promptly by our radiologists, but others have reported a wait of three or more days for inpatient scans (7,21). In such circumstances, immediate scanning at the time of admission might expedite further investigation and treatment or alternatively allow earlier discharge home (7). Some of the morbidity and hospital stay associated with unnecessary appendicectomy might be avoided if a gynaecological cause for symptoms is identified (although reliable, laparoscopy entails general anaesthesia and is inevitably more costly than ultrasound). Timely scanning is clearly important if a policy of treatment involves early operation for cholecystitis or ERCP in pancreatitis. With limited practice, the detection of gallstones, measurement of gallbladder wall thickness and the so-called echographic Murphy's sign should be straightforward. Ultrasound occasionally turns up important incidental findings such as the presence of an aortic aneurysm, retention of urine, liver metastases and ascites.

Potential disadvantages include the circumstances

under which scans are performed, notably persisting background light in casualty and on wards, patients who are not fasted with empty bladders and unless incorporated into an organised teaching programme, a lack of training and supervision. While certain features such as nodular liver metastases and pancreatic pseudocysts can be detected with relatively little experience, others such as the identification of a stone at the lower end of the common bile duct (an area obscured by gas in the adjacent duodenum), the finer points of liver texture and echo pattern, the detection of malignant lymph nodes and accurate localisation of pancreatic masses require a much greater proficiency. Although efficiency is improved with practice and familiarity with the machine, scans are time-consuming and take between 20 and 30 min to perform (during which time, however, the clinician continually refines his earlier clinical assessment and develops his relationship with the patient). Initial expense will be a limiting factor (the scanner used in this study costs approximately £16 000 to purchase), although this might be expected to diminish with time.

In this study, all three surgical registrars adapted quickly and easily to ultrasonography as it is an active process and interpretation is based on a knowledge of anatomy, pathology, and the options for further investigation and treatment (2). Each became more confident during the course of the study, particularly over his first 20 to 30 scans. As occurs with clinical experience, progressively more weight could be placed on findings. However, action was rarely if ever based on the result of scanning alone, a policy that is sensible in this context. Scanning is useful in many emergency situations and should form a part of surgical training as already occurs in continental Europe and the USA (2). Rather than antagonising radiological colleagues, the incorporation of ultrasound into surgical practice should occur in a way that serves to increase collaboration. Radiologists continue to report on X-ray films viewed initially by clinicians and immediate scanning by a surgeon should not preclude a subsequent expert scan—indeed, this might be considered essential for education and quality control. Access to a skilled specialist ultrasound department will remain essential to a clinical surgical unit.

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## References

1 Simeone JF, Novelline RA, Ferrucci JT Jr *et al.* Comparison of sonography and plain films in the evaluation of the acute abdomen. *AJR* 1985; **144**: 49–52.

2 Griffiths C. Ultrasound and laparoscopy in surgery. *Br J Hosp Med* 1989; **42**: 173.

3 McGrath FP, Keeling F. The role of early sonography in the management of the acute abdomen. *Clin Radiol* 1991; **44**: 172–4.

4 Kuuliala IK, Niemi LK. Sonography as an adjunct to plain film in the evaluation of acute abdominal pain. *Ann Clin Res* 1987; **19**: 355–8.

5 Weiler S, Rohmer P, Coche G, Weill F. Ultrasound imaging in abdominal emergencies; results in a series of 179 cases. *J Radiol* 1986; **67**: 765–8.

6 Jones PF. Practicalities in the management of the acute abdomen. *Br J Surg* 1990; **77**: 365–7.

7 Parys BT, Barr H, Chantarasak ND, Eyes BE, Wu AVO. Use of ultrasound scan as a bedside diagnostic aid. *Br J Surg* 1987; **74**: 611–12.

8 Thal ER, Meyer DM. The evaluation of blunt abdominal trauma: computed tomography scan, lavage, or sonography. *Adv Surg* 1991; **24**: 201–28.

9 Jehle D, Davis E, Evans T *et al.* Emergency department sonography by emergency physicians. *Am J Emerg Med* 1989; **7**: 605–11.

10 Kang W-M, Lee C-H, Chou Y-H *et al.* A clinical evaluation of ultrasonography in the diagnosis of acute appendicitis. *Surgery* 1989; **105**: 154–9.

11 Sim KT, Picone S, Crade M, Sweeney JP. Ultrasound with graded compression in the evaluation of acute appendicitis. *J Natl Med Assoc* 1989; **81**: 954–7.

12 Schwerk WB, Wichtrup B, Rüschoff J, Rothmund M. Acute and perforated appendicitis: current experience with ultrasound-aided diagnosis. *World J Surg* 1990; **14**: 271–6.

13 Puylaert JBCM, Rutger PH, Lalisang RI *et al.* A prospective study of ultrasonography in the diagnosis of appendicitis. *N Engl J Med* 1987; **317**: 666–9.

14 Gai H. Acute abdominal pain. Actual surgical aspects of sonography. *Surg Endosc* 1988; **2**: 28–35.

15 Adams DH, Fine C, Brooks DC. High-resolution real-time ultrasonography: a new tool in the diagnosis of acute appendicitis. *Am J Surg* 1988; **155**: 93–7.

16 Fa EM, Cronan JJ. Compression ultrasonography as an aid in the differential diagnosis of appendicitis. *Surg Gynecol Obstet* 1989; **169**: 290–8.

17 Ziehlike A, Malewski U, Lindlar R *et al.* Ultrasonography in acute appendicitis. Option or obligation? *Chirurg* 1991; **62**: 743–9.

18 Puylaert JBCM, Vermeijden RJ, van der Werf SDJ, Doornbos L, Koumans RKJ. Incidence and sonographic diagnosis of bacterial ileocaecitis masquerading as appendicitis. *Lancet* 1989; **2**: 84–6.

19 Paterson-Brown S, Eckersley JRT, Sim AJW, Dudley HAF. Laparoscopy as an adjunct to decision making in the 'acute abdomen'. *Br J Surg* 1986; **73**: 1022–4.

20 Fuentes R, Sosa M, Martinez F, Rodriguez M. New ultrasonic finding in perforated ulcer. *Lancet* 1991; **337**: 733.

21 Walsh PF, Crawford D, Crossling FT, Sutherland GR, Negrette JJ, Shand J. The value of immediate ultrasound in acute abdominal conditions: a critical appraisal. *Clin Radiol* 1990; **42**: 47–9.

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