The use of ultrasound in the diagnosis of cystic lesions of the liver and upper abdomen and in the detection of ascites

C. F. McCarthy, P. N. T. Wells, F. G. M. Ross, and A. E. A. Read

From the Departments of Medicine, Medical Physics, and Radiodiagnosis, University of Bristol, United Bristol and Southmead Hospitals, Bristol

SUMMARY The use of ultrasonic A- and B-scans has been evaluated in the diagnosis of fluid-filled lesions in the liver and abdomen, and in the detection of intraperitoneal fluid. Six patients with polycystic livers or suspected polycystic livers, three with solitary cysts, four with liver abscesses, and three with miscellaneous intraabdominal cystic lesions were scanned. The lesions could be clearly distinguished from solid masses by either technique. The presence of as little as 300 to 800 ml of intraperitoneal fluid could be detected by either the A- or B-scan.

Several papers have appeared on the use of ultrasound in the diagnosis of liver disease (for example, Howry, 1965; Holmes, 1966; Schenkte and Renger, 1966; and McCarthy, Read, Ross, and Wells, 1967). They indicate shortcomings in its use for the detection of diffuse disease in the liver but when fluid-filled lesions are suspected it may be the method of choice. The ability to distinguish by means of ultrasound between fluid-filled and solid or gaseous structures has already proved useful in establishing the presence of small amounts of ascitic fluid, the diagnosis of which can be extremely difficult when physical examination alone is used. The technique has already been found to be valuable in several diagnostic problems, for example, in the differentiation of renal masses (see Goldberg, Ostrum, and Isard, 1968) but, apart from the report of Wang, Wang, Chang, Kao, Yu, and Chiang (1964), seems to have been little used in studies of the liver.

METHODS

Ultrasonic A- and B-scans were carried out as described previously (McCarthy et al, 1967; Wells, McCarthy, Ross, and Read, 1969). For the detection of ascitic fluid the patient lay on one side and the probe was held against the most dependent (lowest) part of the abdomen.

A probe of 2 cm diameter was used, operating at a frequency of 1.5 MHz. The swept gain rate was 1.8 dB cm⁻¹. The scans were generally made during respiratory inspiration, and the scanning time was about 10 seconds.

A pulse repetition frequency of 150 Hz was used, so that the two-dimensional B-scans each contained about 1,500 lines.

PATIENTS

The patients scanned and the clinical problems they presented are indicated in Tables I to IV.

The opportunity was taken to compare the clinical and ultrasonic detection of intraperitoneal fluid by introducing known amounts at the start of peritoneal dialysis or diagnostic pneumoperitoneum. Volumes of 300 to 800 ml of normal saline were introduced. The presence of shifting dullness was the clinical criterion for the detection of fluid. The comparison of clinical and ultrasonic assessments of the presence of fluid is shown in Table V.

SCAN APPEARANCES

The appearance of the A-scan and the B-scan which can be used to distinguish between a soft tissue structure and a cyst are illustrated in Figure A. These diagrams are for a normal liver and for an abnormal liver containing a solitary cyst; but the basis of the method is the same in other diagnostic situations. At low sensitivity the normal liver sends back no detectable echoes, but at high sensitivity many small echoes arise from within the liver. If the swept gain compensation is accurate these small echoes appear to be quite regularly distributed. However, if the A-scan line passes through a cyst the part of the scan corresponding to the cyst is relatively free from echoes, even at high sensitivity. This is because
### TABLE I
#### MULTIPLE CYSTS OR SUSPECTED MULTIPLE CYSTS

<table>
<thead>
<tr>
<th>Patient and Fig. No.</th>
<th>Sex and Age</th>
<th>Clinical Details</th>
<th>Clinical Problem</th>
<th>Solution to Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M 58</td>
<td>Abdominal pain; hepatomegaly 3 cm, firm and regular abdomen</td>
<td>Cause of hepatomegaly</td>
<td>Ultrasonic scan—multiple cysts</td>
</tr>
<tr>
<td>2</td>
<td>F 60</td>
<td>Known polycystic liver, Marked hepaticomegaly, hard and irregular</td>
<td>Liver felt like secondary deposits</td>
<td>Ultrasonic scan: multiple cysts</td>
</tr>
<tr>
<td>3</td>
<td>F 52</td>
<td>Abdominal pain. Liver enlarged 6 cm, firm and irregular</td>
<td>Cause of hepatomegaly</td>
<td>Ultrasonic scan: multiple cysts</td>
</tr>
<tr>
<td>4</td>
<td>F 42</td>
<td>Known polycystic kidneys. Uraemic liver, enlarged 2 cm, firm</td>
<td>Cause of hepatomegaly</td>
<td>Ultrasonic scan: multiple cysts</td>
</tr>
<tr>
<td>5</td>
<td>M 67</td>
<td>Haematemesis. Mass both sides upper abdomen. IVP: polycystic kidneys</td>
<td>Cause of haematemesis</td>
<td>Ultrasonic scan: multiple cysts</td>
</tr>
<tr>
<td>6</td>
<td>M 52</td>
<td>Haematemesis hepatosplenomegaly, IVP: polycystic kidneys</td>
<td>Cause of haematemesis</td>
<td>Ultrasonic scan: multiple cysts</td>
</tr>
</tbody>
</table>

### TABLE II
#### SOLITARY CYSTS

<table>
<thead>
<tr>
<th>Patient and Fig. No.</th>
<th>Sex and Age</th>
<th>Clinical Details</th>
<th>Clinical Problem</th>
<th>Solution to Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>M 72</td>
<td>Hard mass in epigastrium, moved with liver on respiration</td>
<td>Nature of mass</td>
<td>Ultrasonic scan: cyst, aspiration of cyst</td>
</tr>
<tr>
<td>8</td>
<td>F 60</td>
<td>Abdominal radiograph because of pain showed partly calcified mass in right upper abdomen.</td>
<td>Solid or cystic mass</td>
<td>It was thought likely that this was a calcified hydatid cyst.</td>
</tr>
<tr>
<td>9</td>
<td>F 77</td>
<td>Abdominal radiograph because of pain showed calcified mass in right upper abdomen.</td>
<td>Solid or cystic mass</td>
<td>Ultrasonic scan: cyst, exact nature of cyst not decided</td>
</tr>
</tbody>
</table>

### TABLE III
#### LIVER ABSCESS

<table>
<thead>
<tr>
<th>Patient and Fig. No.</th>
<th>Sex and Age</th>
<th>Clinical Details</th>
<th>Clinical Problem</th>
<th>Solution to Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>M 54</td>
<td>Abdominal pain and fever; liver slightly enlarged</td>
<td>Abscess or tumour</td>
<td>Ultrasonic scan: fluid-filled cavity drainage of abscess</td>
</tr>
<tr>
<td>11</td>
<td>M 61</td>
<td>Upper abdomen tender</td>
<td>Cause of fever</td>
<td>Ultrasonic scan: fluid-filled cavity, drainage of abscess</td>
</tr>
<tr>
<td>12</td>
<td>M 73</td>
<td>Fever; hepatomegaly; Bt 1,-1,000 pg</td>
<td>Cause of fever</td>
<td>Ultrasonic scan: suggestive of small cavities in liver. Temperature subsided with antibiotics and liver size became normal.</td>
</tr>
<tr>
<td>13</td>
<td>M 42</td>
<td>Abdominal pain, tender liver</td>
<td>Cause</td>
<td>Ultrasonic scan: fluid-filled cavities, pus aspirated from liver. Fever and hepatomegaly went on chloroquine.</td>
</tr>
</tbody>
</table>

### TABLE IV
#### MISCELLANEOUS

<table>
<thead>
<tr>
<th>Patient No. and Fig.</th>
<th>Sex and Age</th>
<th>Clinical Details</th>
<th>Clinical Problem</th>
<th>Solution to Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>F 30</td>
<td>Pregnant 29/40; mass right upper abdomen</td>
<td>Possibly liver tumour</td>
<td>Isotope scan: liver normal. Ultrasonic scan: large fluid-filled cavity. IVP: right hydrenephrosis</td>
</tr>
<tr>
<td>15</td>
<td>F 5</td>
<td>Fever and hard upper abdominal mass</td>
<td>Possibly liver or pancreatic tumour</td>
<td>Ultrasonic scan: cystic mass which disappeared after three months and was probably a pancreatic pseudo-cyst.</td>
</tr>
</tbody>
</table>
a solid mass of homogeneous tissue contains small acoustic discontinuities which are not so marked in a liquid.

The B-scan appearance of a cyst or abscess within the liver is of a relatively echo-free area surrounded by echo-producing surfaces. A superficially similar appearance may be seen in some patients with secondary tumour in the liver. In this situation an increase in the sensitivity of the ultrasonic system produces many echoes in the previously echo-free area, whereas a fluid-filled area does not develop so many echoes.

The physical basis of the technique is discussed in greater detail elsewhere (Wells, 1969). Thus, there is a tendency for echoes to appear to originate from within a cystic area when high sensitivity is used, due to reverberation and the increasing width of the ultrasonic beam. Ostrum, Goldberg, and Isard (1967) mention that they use a substantial degree of suppression to eliminate these signals from the display. However, in the A-scans presented here, suppression was kept to a minimum, because its use can lead to confusion between a cyst and, for example, a tumour. The threshold level of the B-scan display introduced
**FIG. 1.** Polycystic liver disease. The arrows indicate some of the many cysts.

**FIG. 2.** Polycystic liver disease. The arrows indicate some of the many cysts. (On this occasion the performance of the equipment was not entirely satisfactory.)

**FIG. 3.** Polycystic liver disease. The arrows indicate some of the many cysts.

**FIG. 4a.**

**FIG. 4b.**

**FIG. 4.** Polycystic liver disease. (a) A-scan: (b) two-dimensional B-scan. The arrows indicate some of the many cysts.

**FIG. 5.** Polycystic liver disease. The arrows indicate some of the many cysts.

**FIG. 6.** Congenital hepatic fibrosis. The scan gives no evidence of fluid-filled cavities within the liver.
FIG. 7. Solitary cysts. (a) A-scan; (b) two-dimensional B-scan. The arrows indicate the cyst. (c) Radiograph, with cyst demonstrated by Lipiodol.

FIG. 8. Probably a calcified hydatid cyst indicated by the arrow.

FIG. 9. Solitary cyst: (a) two-dimensional B-scan arrow indicating the cyst and (b) radiograph showing calcified mass.
FIG. 10. Liver abscess indicated by the arrow.

FIG. 11. Liver abscess in case 11: (a) two-dimensional B-scan, arrow indicating the abscess and (b) radiograph with abscess demonstrated by Lipiodol.

FIG. 12. Probably multiple liver abscess. (a) A-scan; (b) two-dimensional B-scan. The arrows indicate some of many cavities, presumably fluid-filled.

FIG. 13. Amoebic liver abscess. (a) A-scan; (b) two-dimensional B-scan. The arrows indicate some of many fluid-filled cavities.
FIG. 14a. FIG. 14b. FIG. 15a. FIG. 15b. FIG. 16. Arteriovenous anastomoses. The arrows indicate some of many fluid-filled cavities.

an additional degree of suppression in the two-dimensional scans, and this must be considered when interpreting the results.

The characteristic diagnostic appearances were obtained in all patients examined, and typical A- and B-scans are illustrated in Figures 1 to 16.

DETECTION OF INTRAPERITONEAL FLUID

The characteristic B-scan appearance of ascites is shown in Figure 17. From Table V it can be seen that quite small volumes of fluid could be detected both

<table>
<thead>
<tr>
<th>Volume (ml)</th>
<th>Detected Clinically</th>
<th>Ultrasonically</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>−</td>
<td>+</td>
</tr>
<tr>
<td>350</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>400</td>
<td>−</td>
<td>−</td>
</tr>
<tr>
<td>450</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>500</td>
<td>−</td>
<td>−</td>
</tr>
<tr>
<td>600</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>700</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>800</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

FIG. 17. Ascites. The arrow indicates the region containing fluid.
by clinical examination and ultrasound. However, in
two instances the ultrasonic method detected fluid
when it was not demonstrable clinically.

**DISCUSSION**

It is apparent from these results that ultrasound is
extremely valuable in deciding whether multiple cysts
are a cause of hepatic enlargement. In two of the
patients with multiple cysts in the liver, the clinical
impression when the liver was palpated was that it
was replaced by secondary tumour. Ultrasound
revealed multiple cysts in those patients in whom
there was not a gross degree of hepatomegaly. In
patient no. 6 with polycystic kidneys it was felt
unlikely that multiple cysts were present in the liver
because splenomegaly is unusual in patients with
multiple cysts in the liver. Ultrasound demonstrated
that cysts were not present, and congenital hepatic
fibrosis (the alternative cause of hepatomegaly in
patients with polycystic kidneys) was diagnosed.
This was confirmed by biopsy and later by necropsy.

Of the patients with solitary lesions in the liver,
the scan was most helpful in patient no. 7, where the
clinical diagnosis was a malignant tumour of the
liver. In patients nos. 8 and 9, the demonstration of a
cystic lesion was helpful as there was a slight possi-
bility that the lesion was a calcified tumour. It
seems most likely that these patients had old cal-
cified hydatid cysts.

The scan was of considerable value in making a
diagnosis of liver abscess in the four patients de-
scribed. In patient no. 11, the surgeon at laparotomy
doubted the diagnosis as the surface of the liver
looked normal but needling it produced pus.

The ultrasonic diagnosis of a fluid-filled lesion in
patient no. 14 enabled the surgeon to plan a nephrec-
tomy and avoid a diagnostic laparotomy. In patient
no. 15 an operation was avoided because of the
information from the ultrasonic scan. In patient no.
16 the most likely clinical diagnosis was cirrhosis,
with which the scan was not compatible, and opera-
tion confirmed the presence of an arteriovenous
malformation.

It is usually considered that clinical detection of
ascitic fluid is difficult unless 2 litres of fluid are
present (Sherlock, 1968). Undoubtedly the knowledge
that fluid has been put into the abdomen influences
the observer in eliciting the signs of ascites, and this
may account for the detection of shifting dullness
when as little as 300 ml was present (see Table V).
There is no doubt that an ultrasonic scan can
detect smaller amounts than 2 litres of fluid.

From the patients scanned it seems that an ultra-
sonic scan is helpful in the following clinical situa-
tions:

1. If a liver abscess is suspected it is important
that many ultrasonic scans are carried out, otherwise
the ultrasonic scan plane may not pass through the
abscess cavity. It is unlikely that scanning will
diagnose an abscess of less than 2 cm in diameter,
but most abscesses at the time of diagnosis are much
larger than this. Of the patients reported by Butler
and McCarthy (1969), the diameter of the smallest
abscess was 6 cm. Wang et al (1964) found that about
14% of abscesses were 3 cm or less in diameter. They
have extensive experience of the use of ultrasound
in the diagnosis of liver abscess; using an A scope they
successfully diagnosed about 97% of 218 patients
with abscess.

It is unlikely that an abscess will not be found if
the liver is scanned carefully. In five patients scanned
by us in whom liver abscess was suspected clinically,
the ultrasonic scan did not reveal appearances of
fluid and none was later shown to have an abscess.
An abscess can be accurately localized by ultrasound
and with knowledge of its exact site repeated aspira-
tion and instillation of an antibiotic may avoid the
need for formal surgery (McFadzean, Chang, and
Wong, 1953). Such localization may also help the
surgeon at operation as inspection of the liver may
not reveal the site of the lesion. Ultrasound will also
demonstrate the gradual closure of an abscess
cavity. Scintiscanning of the liver will show an area
of decreased uptake if an abscess is present but in
contrast to ultrasound will not indicate whether this
area of decreased uptake is due to a solid or cystic
lesion.

2. If hepatomegaly is present, the demonstration
of many cysts may reverse a clinical diagnosis of
liver secondaries for a more favourable one of poly-
cystic liver.

3. If there is a localized mass in the liver.

4. If hydatid disease of the liver is suspected.

5. If ascites is suspected. If doubt exists after
clinical examination of the abdomen whether or not
fluid is present an ultrasonic scan will usually decide
the diagnosis. A negative ultrasonic scan does not
exclude the possibility of the presence of small
amounts of fluid. If a small amount of fluid is present
it is helpful if the patient lies on one side and the
ultrasonic probe is held against the lowest, most
dependent part of the abdomen. The fluid will gravi-
tate towards this point and may then be detected.
Recently, four-quadrant aspiration of the abdomen
in patients with acute abdominal conditions has been
considered to be diagnostically helpful (Veith,
Webber, Karl, and Deysine, 1967). Small amounts
of fluid may be localized with the ultrasonic scan
and the need for multiple paracenteses may be
reduced.

The simple, relatively inexpensive A-scan equip-
ment is quite adequate to make the diagnosis although some practice is required in recognizing the appearance of fluid. It is helpful to compare the results of A-scanning with B-scanning until such practice is obtained.

We are grateful to Dr H. F. Freundlich, Head of the Department of Medical Physics, United Bristol Hospitals, who has always supported our work with his enthusiasm. We thank the physicians and surgeons of the United Bristol Hospitals and Southmead Hospital for referring their patients to us for scanning.

The work was financed by the Medical Research Council, the Department of Health and Social Security (Health), and the Board of Governors of the United Bristol Hospitals.

REFERENCES


The use of ultrasound in the diagnosis of cystic lesions of the liver and upper abdomen and in the detection of ascites

C. F. McCarthy, P. N. T. Wells, F. G. M. Ross and A. E. A. Read

*Gut* 1969 10: 904-912
doi: 10.1136/gut.10.11.904

Updated information and services can be found at:
http://gut.bmj.com/content/10/11/904

**Email alerting service**

*These include:*

Receive free email alerts when new articles cite this article. Sign up in the box at the top right corner of the online article.

**Notes**

To request permissions go to:
http://group.bmj.com/group/rights-licensing/permissions

To order reprints go to:
http://journals.bmj.com/cgi/reprintform

To subscribe to BMJ go to:
http://group.bmj.com/subscribe/