Introduction of real-time linear scan ultrasonography to clinical practice has revolutionized the diagnostic approach to hepatobiliary disorders. This modality allows the operator to scan the liver and biliary tract with a real-time effect, and obtain three dimensional images. One can follow vessels and ducts from one end to the other. The portal and hepatic venous systems are readily seen and distinguished. Real-time ultrasonography (US) using an electronically activated linear array transducer is becoming a stethoscope for the liver specialist, because a portable size real-time ultrasonograph is already available.

It is now established that real-time US is useful not only in the diagnosis of gallstones, dilatation of the biliary tract, and cystic lesions, but it can also assess liver parenchyma in various diffuse liver diseases. Thus, a wide range of diffuse liver diseases beside localized hepatic lesions can be evaluated by US. It can also make the diagnosis of portal hypertension\(^2\)\(^-\)\(^4\)

In our unit, the patient with a suspected hepatobiliary disorder is examined by US on the first day of hospital visit, and the next investigation that will possibly provide a definitive diagnosis, such as ERCP, PTC, X-ray CT, angiography, scintigraphy, etc., is scheduled. Using a specially designed transducer, a needle can be guided while the vessel, a duct, or a structure is being aimed and entered (US-guided puncture).\(^5\);\(^7\) US-guided puncture technique has improved the procedure for percutaneous transhepatic cholangiography\(^8\), biliary decompression, percutaneous transhepatic catheterization for portography\(^9\), and obliteration of bleeding varices. The following are the major diagnostic applications of real-time US.

**Biliary Tract Diseases**

Gallstone disease. Gallstones in the gallbladder greater than 6 mm invariably and those between 3 and 6 mm almost always display strong echoes and posterior acoustic shadowing.

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Figure 1 depicts typical acoustic shadows as related to the size and number of stones. It even provides indirect information regarding the chemical composition of the stones.
Table I gives the number of patients found to have cholelithiasis in a five year period at a large hospital in Japan during which time conventional cholecystography was gradually replaced by US examination as the routine investigation for suspected stone disease. There was a two-fold increase in the number of cases diagnosed.

Table 2.
COMPARISON OF DIAGNOSTIC CAPABILITY OF I.V. CHOLECYSTO-
CHOLANGIOGRAPHY AND ULTRASOUND
(ORAL CHOLECYSTOGRAPHY NEGATIVE CASES, N = 32)

<table>
<thead>
<tr>
<th>Method</th>
<th>Gallbladder stone</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Positive</td>
</tr>
<tr>
<td>Cholangiography</td>
<td>6 (13.8%)</td>
</tr>
<tr>
<td>Ultrasonography</td>
<td>28 (87.5%)</td>
</tr>
</tbody>
</table>

Table II compares capability of intravenous cholecystocholangiography and US in 32 patients in whom stones were suspected but oral cholecystography failed to make the diagnosis. In this study, US identified stones in 28, or 87.5% of them.

Obstructive /aundice. The sizes of various parts of the biliary tract as measured by US in Japanese
adults are given in Table III.

The normal diameters of the left and right hepatic ducts were 1.7 mm, and of the extrahepatic bile duct, 3.0-3.3 mm. These figures are somewhat smaller than those obtained by cholangiography. It is probably due to excess echoes from the wall reducing the diameter of the lumen. In obstructive jaundice, these figures are clearly increased, and such dilation is readily recognized by US. Differential diagnosis of obstructive jaundice and intrahepatic cholestasis was possible by US alone in 174 of 175 patients (99.4%) (Table IV).

The only failure in diagnosis occurred in a patient with hilar carcinoma which was infiltrating along the major intrahepatic bile ducts causing no visible dilatation of the biliary tract.

Although the scanning of the extrahepatic bile duct is often hampered by intestinal gas, repeated examination will yield information for the determination of whether the obstructing lesion is located proximally or distally. Often, but less frequently, the distal end of the obstructing lesion is discerned (Table V).
# Ultrasound Diagnosis of the Level of Obstruction (Real-Time Linear Scan)

<table>
<thead>
<tr>
<th>Level of Obstruction</th>
<th>No. of cases</th>
<th>Dx of level No.</th>
<th>Dx of level %</th>
<th>Dx of Obstruction end No.</th>
<th>Dx of Obstruction end %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hilar bile duct</td>
<td>41</td>
<td>41</td>
<td>100</td>
<td>40</td>
<td>97.6</td>
</tr>
<tr>
<td>Proximal duct</td>
<td>9</td>
<td>8</td>
<td>88.9</td>
<td>7</td>
<td>77.8</td>
</tr>
<tr>
<td>Distal duct</td>
<td>92</td>
<td>92</td>
<td>100</td>
<td>68</td>
<td>73.8</td>
</tr>
<tr>
<td>Total</td>
<td>142</td>
<td>141</td>
<td>99.3</td>
<td>115</td>
<td>81.0</td>
</tr>
</tbody>
</table>

![Diagram of bile duct levels]
Fig. 2. A dilated common bile duct containing a protruding echogenic object is apparent. B. Percutaneous transhepatic cholangiogram made through a drainage catheter inserted by the US-guided technique. Distal bile duct carcinoma obstructing the common bile duct is apparent (at arrow). It corresponds to the echogenic lesion in A.
Fig. 3 Hepatocellular carcinoma 2.5 cm in diameter, seen in a cirrhotic liver. Note the low echo periphery or rim of the mass suggesting the presence of a pseudocapsule.
Fig. 4 Hepatocellular carcinoma invading into the left portal vein branch (at arrow).
Figure 2 illustrates the US finding of a distal bile duct carcinoma and its cholangiogram. Intrahepatic stones. Intrahepatic stones or hepatolithiasis is a common disorder in the Far East\textsuperscript{10}, as contrasted by the Western countries where it is a rarity. In Hong Kong, recurrent pyogenic cholangitis secondary to intrahepatic stones is one of the major surgical problems. For the detection of intrahepatic
stones, US proves most diagnostic, particularly when it is combined with UG-guided PTC (Table VI).

<table>
<thead>
<tr>
<th>Procedure</th>
<th>No. of negative Dx</th>
<th>No. of suspected Dx</th>
<th>No. of definite Dx</th>
<th>All stones shown</th>
<th>Part of stones</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTC &amp; ERC</td>
<td>8 (26.7%)</td>
<td>7 (23.3%)</td>
<td>6 (20.0%)</td>
<td>9 (30.0%)</td>
<td></td>
</tr>
<tr>
<td>Ultrasonography</td>
<td>0</td>
<td>1 (3.3%)</td>
<td>2</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>PTC under US guidance</td>
<td>0</td>
<td>0</td>
<td>30</td>
<td>(100%)</td>
<td></td>
</tr>
</tbody>
</table>

U-guided PIC and biliary drainage. With the use of the puncture transducer\(^{5-7}\), an intrahepatic bile duct greater than 5mm can be aimed and entered with a very high success rate. Since puncture carried out while the vessels and ducts are being observed, inadvertent puncture of blood vessels can be avoided. Similarly, transhepatic biliary decompression and drainage in obstructive jaundice\(^{11,12}\) can be easily achieved with the use of US guidance system, avoiding damage to blood vessels, which is the major cause of severe complications (Table VII).

<table>
<thead>
<tr>
<th>Complication</th>
<th>X-ray control (n=181)</th>
<th>Ultrasound guidance (n=175)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biliary peritonitis</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Massive bleeding (abdominal)</td>
<td>1*</td>
<td>0</td>
</tr>
<tr>
<td>Massive bleeding (biliary)</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Pneumothorax</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Aggravated bacteremia</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

* Death due to puncture of hemangioma

**Liver Diseases**

Hepatic tumors. US is very sensitive in detecting space occupying lesions. However, due to lung air, examination of the anterior superior area of the right lobe is not always reliable. For more accurate examination of this particular area, other types of grey-scale scanner may be used. Small hepatocellular
carcinoma (HCC) is usually solitary, and has a hypoechoic interior or an anechoic rim around (Fig.3), in contrast to metastatic tumors which are frequently hypechoic or mixed hypo. and hypechoic, and multiple. Large hemangioma is invariably hypechoic, but some of the very small ones may not be distinguishable from small HCC. US examination carried out regularly at a set interval in patients with cirrhosis together with measurement of serum alpha-fetoprotein is an established practice in Japan for the early detection of HCC, and hundreds of cases of small HCC have been found. In advanced cases, the portal vein system should be carefully examined to determine whether a major portal branch has already been invaded (Fig.4). Such information is important when hepatic resection is contemplated.

Cysts and abscesses. Cysts, whether simple, hydatid, or otherwise, are seen as round anechoic lesions with exaggerated back echoes due to reduced attenuation. Whereas the shape of cysts is circular, that of an abscess is much more irregular, and the interior has more echoes. Abscess in its early phase of formation may look like a mass, but after liquefaction, the interior looks more like a cyst except for the shape. Ultrasound guided puncture and drainage is now an established procedure for the treatment of liver abscess. We have treated 21 consecutive cases of idiopathic liver abscess by puncture and/or drainage combined with systemic antibiotics without requiring operation.

Liver cirrhosis. The surface of a normal liver is smooth as seen by US, and a grossly nodular liver surface can easily be recognized. Obtunded angle of the liver edge is another important finding to suggest cirrhosis. Ascites which is also readily recognized by US, and signs of portal hypertension discussed below are highly suggestive of cirrhosis.

Portal hypertension. The size of the spleen can be semiquantitatively assessed by the left intercostal scan. Increased diameters of the portal trunk and major branches of the portal vein suggest portal hypertension. Large shunts involving the left renal vein are seen as a cystic lesion in front of the spleen. The umbilical portion of the left portal vein branch is perpendicular to the anterior plane of the body, and readily recognized by US; if a dilated paraumbilical vein is seen coursing anteriorly and inferiorly along the round ligament, it is a good indication of portal hypertension. The left gastric (coronary) vein which is the main feeding vein for esophageal varices, can also be discerned in the section where the splenic vein, left lobe of the liver and the lower esophagus are seen.

Fatty liver. Normal liver parenchyma and renal parenchyma have similar echo patterns. In advanced fatty liver, the liver exhibits much stronger echoes diffusely, and the difference from the renal parenchyma as a control is evident in a section in which both the liver and kidney are seen.

Vascular diseases. Thrombosis of the hepatic vein and membranous obstruction of the inferior vena cava (Budd-Chiari syndrome) can be diagnosed by US. For more definitive diagnosis, angiographic examination is required. In the eyes of the experienced hepatologist-sonographer, cavernous transformation of the portal vein in the hilar area, indirect evidence for portal obstruction, is seen as an irregular vascular structure.

Other diseases. In acute hepatitis, intrahepatic vascular structures show exaggerated walls. Advanced schistosomiasis demonstrates irregular echoes in the liver, and they may prove diagnostic in the endemic areas.

Summary

Real-time ultrasonography is imperative in the diagnosis of hepatobiliary diseases in modern medicine. It will prove diagnostic not only for gallstones, biliary obstruction and localized hepatic lesions, but also for some of the diffuse liver diseases such as cirrhosis. It must be done as a routine, as is the stethoscope used by the physician, in patients in whom hepatobiliary disease is suspected.

References