Three dimensional imaging is the next logical step in diagnostic ultrasound. However, clinical application of three-dimensional (3D) ultrasound has been limited. This preliminary study was performed as a trial of expanding the clinical applications of this modality. The purpose of this study is to determine the feasibility of 3D ultrasound with minimum transparent mode (3D US-MTM) in noninvasive imaging of the biliary system in the patients with obstructive jaundice.

**Techniques & Subjects**

**Specialized 3D Volume Transducer**
- Automatic freehand movement
- One sweep through nearly entire liver
- Predetermined angle: 40 - 70º
- Acquisition time: 3 - 6 seconds

**Planar Reconstruction**
- Lines with blue and yellow color: intersection planes
- Central dot: the center of rotation and the common point of intersection of these planes
- Rotating the image planes
- Infinite number of anatomic views

**Volume Rendering**
- Transparent minimum mode
  - Useful for rendering a fluid-soft-tissue interface
  - Displays minimum gray values in the ROI
  - Useful in imaging of dilated biliary tree

**Subjects**
- 14 patients (M:F = 11:3, age 54 - 76, mean age 61) with obstruction of extra or intrahepatic ducts
- Patients had cholangiocarcinoma (n = 7), bile duct stone (n = 2), hepatocellular carcinoma (n = 2), ampulla of Vater cancer (n = 1), pancreatic head cancer (n = 1), or benign stricture of bile duct (n = 1).
**Klatskin Tumor**

A. Direct cholangiography shows dilatation of the left and right IHDs. Stricture at the right anterior, right posterior segmental IHDs, IHDs in left lobe and proximal CHD are well visualized (arrows).

B. 3D US-MTM image shows dilatation of the IHDs and strictures at the hilar area are demonstrated (arrowheads).

C. Craniocaudal 20º rotation image more sharply demonstrates the strictures (arrowheads). CHD is not demonstrated.

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**Pancreatic Head Cancer**

A 1-4. 3D US-MTM image with multidirectional views show dilatation of the CHD and GB. Obstruction at the CHD (arrow) is demonstrated. Dilatated pancreatic duct is not visualized in this 3D images but dilatation of GB is well seen. ERCP demonstrated dilatation of CBD and pancreatic duct (not shown).

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**Ampulla of Vater Cancer**

A. Direct cholangiography shows obstruction of distal CBD. Blunting end of distal CBD (arrow) suggesting distal CBD mass is also visualized. He was cholecystectomy state.

B. 3D US-MTM image correlates well (arrow).

C. CT shows polypoid mass in distal CBD (arrow). Pylorus preserving pancreaticoduodenectomy was performed. Polypoid mass in ampulla of Vater with invasion to CBD and pancreas was demonstrated. In this patient, dilatation of pancreatic duct that is usual in ampulla of Vater cancer was not prominent on CT (not shown).

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**Benign Stricture of Distal CBD**

A. Direct cholangiography demonstrates obstruction at the common hepatic bile duct (arrow). Bile duct distal to obstruction is faintly visualized (red arrows).

B. ERCP shows dilatation of CBD and GB. Arupt obstruction at the CBD (arrow) is demonstrated. In direct cholangiography, bile duct distal to obstruction is visualized (red arrows) but GB is not opacified. (portal vein, GB)

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**CHD Obstruction by Recurred GB Cancer**

A. Direct cholangiography in a patient with a history of cholecystectomy due to GB cancer shows obstruction at proximal CHD (arrow).

B. 3D US-MTM image demonstrates obstruction at proximal CHD (arrow).

C. Dilatation of IHDs in left lobe of the liver (arrowheads) are also demonstrated.

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**Diagnostic Power of 3D US with MTM**

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<th>n = 12 (86 %)</th>
<th>n = 3 (21 %)</th>
<th>n = 0 (0 %)</th>
<th>n = 12 (86 %)</th>
<th>n = 0 (0 %)</th>
<th>n = 1 (7 %)</th>
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<td>Level of Obstruction</td>
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<td>Demonstrate Whole Biliary Tree</td>
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<td>Demonstrate Proximal Duct of Obstruction</td>
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**Discussion**

**Advantages**

- Brief demonstration of dilated biliary tree and level of obstruction
- Multi-directional & multi-planar reconstruction
  ex: coronal plane

**Imaging Pitfalls**

- Overlap of vessels
  ex: portal vein or hepatic vein
- Cannot demonstrate distal duct below the obstruction
- Cannot discriminate obstruction & severe stenosis
  → exaggerate the degree of stenosis
- Cannot demonstrate whole biliary tree on one image

**Limitation of Hardware**

- Limited spatial resolution
- Limited field of view

**Conclusion**

3D ultrasound with minimum transparent mode is a feasible adjunctive tool for the noninvasive evaluation of dilated biliary anatomy. However, further technical advances are necessary to improve image quality.