Pediatric Hepatobiliary, Pancreatic & Splenic US

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Department of Radiology, The Children’s Hospital of Philadelphia
No Disclosures
Objectives

• Normal
• Abnormal: cases and US advances
Objectives

• Normal

• Abnormal: cases and US advances
Hepatobiliary Ultrasound

- Size
- Echotexture
- Duct dilation
- Gallbladder
- Calculi
Hepatobiliary: Normal Liver Size

Term
307 children
5 days to 16 years
Genders equal
Height best correlate

AJR:171, December 1998
## Hepatobiliary: Normal Liver Size

<table>
<thead>
<tr>
<th>Term</th>
<th>Preterm</th>
</tr>
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<tbody>
<tr>
<td>307 children</td>
<td>498 infants</td>
</tr>
<tr>
<td>5 days to 16 years</td>
<td>24-36 wk GA</td>
</tr>
<tr>
<td>Genders equal</td>
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</table>

**Normal Liver, Spleen, and Kidney Dimensions in Neonates, Infants, and Children: Evaluation with Sonography**

AJR:171, December 1998

Reference ranges for sonographic dimensions of the liver and spleen in preterm infants

Hepatobiliary: Normal Gallbladder

<table>
<thead>
<tr>
<th>Age Range</th>
<th>Mean length</th>
<th>Mean Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth – 1y:</td>
<td>2.5 cm</td>
<td>1 cm</td>
</tr>
<tr>
<td>12-16 y:</td>
<td>6 cm</td>
<td>2 cm</td>
</tr>
</tbody>
</table>

Wall thickness < 3 mm

**Table I: Sonographic Measurements of the Normal Pediatric Gallbladder and Biliary Tract**

<table>
<thead>
<tr>
<th>Age Range</th>
<th>AP Diameter (cm)</th>
<th>Coronal Diameter (cm)</th>
<th>Length (cm)</th>
<th>Wall Thickness (mm)</th>
<th>Common Hepatic Duct Size (mm)</th>
<th>Right Portal Vein Size (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1 (8 patients)</td>
<td>0.9 Mean 0.5-1.2 Range</td>
<td>0.9 Mean 0.7-1.4 Range</td>
<td>2.5 Mean 1.3-3.4 Range</td>
<td>1.7 Mean 1.0-3.0 Range</td>
<td>1.3 Mean 1.0-2.0 Range</td>
<td>3.8 Mean 3.0-5.0 Range</td>
</tr>
<tr>
<td>2-5 (10 patients)</td>
<td>1.7 Mean 1.4-2.3 Range</td>
<td>1.8 Mean 1.0-3.9 Range</td>
<td>4.2 Mean 2.9-5.2 Range</td>
<td>2.0 None</td>
<td>1.7 Mean 1.0-3.0 Range</td>
<td>4.8 Mean 3.0-7.0 Range</td>
</tr>
<tr>
<td>6-8 (11 patients)</td>
<td>1.8 Mean 1.0-2.4 Range</td>
<td>2.0 Mean 1.2-3.0 Range</td>
<td>5.6 Mean 4.4-7.4 Range</td>
<td>2.2 Mean 2.0-3.0 Range</td>
<td>2.0 None</td>
<td>5.7 Mean 6.0-9.0 Range</td>
</tr>
<tr>
<td>9-11 (12 patients)</td>
<td>1.9 Mean 1.2-3.2 Range</td>
<td>2.0 Mean 1.0-3.6 Range</td>
<td>5.5 Mean 3.4-6.5 Range</td>
<td>2.0 Mean 1.0-3.0 Range</td>
<td>1.8 Mean 1.0-3.0 Range</td>
<td>6.8 Mean 4.0-9.0 Range</td>
</tr>
<tr>
<td>12-16 (10 patients)</td>
<td>2.0 Mean 1.3-2.8 Range</td>
<td>2.1 Mean 1.6-3.0 Range</td>
<td>6.1 Mean 3.8-8.0 Range</td>
<td>2.0 Mean 1.0-3.0 Range</td>
<td>2.2 Mean 1.0-4.0 Range</td>
<td>7.8 Mean 6.0-10.0 Range</td>
</tr>
</tbody>
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Hepatobiliary: Normal CHD

Common hepatic duct little variation with age
Always < 4 mm

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<tr>
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<th>AP Diameter (cm)</th>
<th>Coronal Diameter (cm)</th>
<th>Length (cm)</th>
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<td>(yr.)</td>
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<td>Range</td>
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<td>12-16 (10 patients)</td>
<td>2.0</td>
<td>1.3-2.8</td>
<td>2.1</td>
<td>1.6-3.0</td>
<td>6.1</td>
<td>3.8-8.0</td>
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</tbody>
</table>

Radiology 1982; 144:873-875
Hepatobiliary: Echotexture

Homogeneous
No sound attenuation deep lobe
Portal vein/duct wall interfaces
Hepatobiliary: Echotexture

Homogeneous
No sound attenuation deep lobe
Portal vein/duct wall interfaces
Echogenicity > right kidney
Spleen Ultrasound

✓ Shape: cleft, lobules
✓ Location: wandering
✓ Number: polysplenia or asplenia
✓ Size: splenomegaly or atrophy

A Pattern-oriented Approach to Splenic Imaging in Infants and Children¹
Anne Paterson, MRCP, FRCR • Donald P. Frush, MD • Lane F. Donnelly, MD • Joseph N. Foss, MD • Sara M. O’Hara, MD
George S. Bisset III, MD
Radiographics 1999; 19:1465-1485
Spleen Ultrasound

✓ Lesions
✓ Solitary
✓ Multiple
✓ Diffuse

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George S. Bisset III, MD
Radiographics 1999; 19:1465-1485
Spleen: Normal Size

Term

512 children
1 day to 17 years
Genders equal
Height best correlate*

*Others weight best
AJR 1991; 157:119-121
AJR 1993; 160:1107-1109
# Spleen: Normal Size

<table>
<thead>
<tr>
<th>Term</th>
<th>Preterm</th>
</tr>
</thead>
<tbody>
<tr>
<td>512 children</td>
<td>498 infants</td>
</tr>
<tr>
<td>1 day to 17 years</td>
<td>24-36 wk GA</td>
</tr>
<tr>
<td>Genders equal</td>
<td>Girls smaller</td>
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Spleen Length in Childhood with US: Normal Values Based on Age, Sex, and Somatometric Parameters<sup>1</sup>

Radiology 2004; 231:129–134

Reference ranges for sonographic dimensions of the liver and spleen in preterm infants

Spleen Echotexture

Homogeneous

Echogenicity > liver

Echogenicity >> left kidney

Convex surface smooth

Concave surface nodular
Pancreas Ultrasound

- Size
- Echotexture
- Duct dilation
- Fluid collection
Pancreas US Technique

- Sonographic window
  - Left hepatic lobe
  - Left kidney or spleen
  - Stomach with water ingestion
Pancreas: Normal Size

Marilyn J. Siegel, MD • Kenneth W. Martin, MD • Janette L. Worthington, MD
Radiology 1987; 165:15-18

Normal and Abnormal Pancreas in Children: US Studies

<table>
<thead>
<tr>
<th>Patient Age</th>
<th>No. of Patients</th>
<th>Head</th>
<th>Body</th>
<th>Tail</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1 mo</td>
<td>15</td>
<td>1.0 ± 0.4</td>
<td>0.6 ± 0.2</td>
<td>1.0 ± 0.4</td>
</tr>
<tr>
<td>1 mo to 1 y</td>
<td>23</td>
<td>1.5 ± 0.5</td>
<td>0.8 ± 0.3</td>
<td>1.2 ± 0.4</td>
</tr>
<tr>
<td>1–5 y</td>
<td>49</td>
<td>1.7 ± 0.3</td>
<td>1.0 ± 0.2</td>
<td>1.8 ± 0.4</td>
</tr>
<tr>
<td>5–10 y</td>
<td>69</td>
<td>1.6 ± 0.4</td>
<td>1.0 ± 0.3</td>
<td>1.8 ± 0.4</td>
</tr>
<tr>
<td>10–19 y</td>
<td>117</td>
<td>2.0 ± 0.5</td>
<td>1.1 ± 0.3</td>
<td>2.0 ± 0.4</td>
</tr>
</tbody>
</table>

Ultrasound Clin 2013; 8:299-321
Pancreas: Normal Duct Size

Mean 1.65 +/- 0.45 mm

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Pancreatic duct diameter mean ± SD, mm (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1–3</td>
<td>1.13 ± 0.15 (0.9–1.3)</td>
</tr>
<tr>
<td>4–6</td>
<td>1.35 ± 0.15 (1.0–1.5)</td>
</tr>
<tr>
<td>7–9</td>
<td>1.67 ± 0.17 (1.3–1.9)</td>
</tr>
<tr>
<td>10–12</td>
<td>1.78 ± 0.17 (1.5–2.2)</td>
</tr>
<tr>
<td>13–15</td>
<td>1.92 ± 0.18 (1.6–2.4)</td>
</tr>
<tr>
<td>16–18</td>
<td>2.05 ± 0.15 (1.8–2.4)</td>
</tr>
</tbody>
</table>

Pancreas: Echotexture

Echogenicity > liver
Newborn hyperechoic
Preterm > term
Smooth or slightly lobulated

Pediatr Radiol 1990; 20:323-325
Objectives

• Normal

• Abnormal: cases and US advances
Inherited and Congenital

- Fibropolycystic Disease
- Biliary Atresia
- Hyperinsulinism
- Cystic Fibrosis
- Sickle cell disease
3 yo girl with progressive abdominal distension, thrombocytopenia

Size: large
Echotexture: coarse
Duct dilation: variable

10.2 cm (95%)
Congenital Hepatic Fibrosis (CHF)

Size: large
Echotexture: coarse
Duct dilation: variable

Fibrous enlargement of bile ducts and portal tracts
Ducts are present, not paucity

<table>
<thead>
<tr>
<th>Duct Size</th>
<th>Fibropolycystic disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>CHF, biliary hamartoma</td>
</tr>
<tr>
<td>Medium</td>
<td>ADPLD</td>
</tr>
<tr>
<td>Large</td>
<td>Choledochal cyst, Caroli disease</td>
</tr>
</tbody>
</table>
Congenital Hepatic Fibrosis (CHF)

- Size: large
- Echotexture: coarse
- Duct dilation: variable
- Cirrhotic morphology
- Portal hypertension
- Splenomegaly

Additional

10.2 cm (95%)

11.4 cm
Congenital Hepatic Fibrosis (CHF)

Size: large
Echotexture: coarse
Duct dilation: variable

Elastography:
quantify stiffness/fibrosis

Mean 2.58 m/s ± 0.4
4 week old girl with conjugated hyperbilirubinemia
Biliary atresia

- Triangular cord sign (TCS)
- Absent CBD
- Abnormal GB (small)
- No GB change with feed
Biliary atresia

Triangular cord sign (TCS)
- Absent CBD
- Abnormal GB (small)
- No GB change with feed

Meta-analysis 23 studies US in BA

<table>
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<tr>
<th>US Sign</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>GB abnormal</td>
<td>0.85 (0.76-0.91)</td>
<td>0.92 (0.81-0.97)</td>
</tr>
<tr>
<td>TCS</td>
<td>0.74 (0.61-0.84)</td>
<td>0.97 (0.95-0.99)</td>
</tr>
<tr>
<td>GB abn + TCS</td>
<td>0.95 (0.7-0.99)</td>
<td>0.89 (0.79-0.94)</td>
</tr>
</tbody>
</table>

AJR 2016: 206:W73-82
Biliary atresia

Triangular cord

Triangular cord sign (TCS)
Absent CBD
Abnormal GB (small)
No GB change with feed

Images at 1, 4, 6.5 hours no bowel activity, GB not visualized
Biliary atresia

- Triangular cord sign (TCS)
- Absent CBD
- Abnormal GB (small)
- No GB change with feed

Additional

Elastography: BA vs other liver disease

1 month old girl hyperinsulinemic hypoglycemia

18F-DOPA PET/CT
Congenital Hyperinsulinism

18F-DOPA PET/CT

Hyperfunctioning β cells
Focal or diffuse
Unregulated release of insulin
Congenital Hyperinsulinism

Focal can be difficult to find in OR

Intraoperative US assistance

Hypoechoic

Variable homogeneity
Congenital Hyperinsulinism

Focal can be difficult to find in OR
Intraoperative US assistance
Hypoechoic
Variable homogeneity

15 MHz

50 MHz

4.2 x 4.2 mm

0.3 mm duct
12 yo boy with Cystic Fibrosis
Cystic Fibrosis liver disease

Echotexture:
Hyperechoic, homogeneous

Additional
Heterogeneous
Cirrhotic morphology
Portal hypertension
Cystic Fibrosis Liver Disease Network (CFLD NET)

Prediction by US Risk of Hepatic Cirrhosis (PUSH)

719 children, 3-12 yo

No known cirrhosis

J Pediatr 2015; 167:862-868
Cystic Fibrosis Liver Disease Network (CFLD NET)

Prediction by US Risk of Hepatic Cirrhosis (PUSH)

719 children, 3-12 yo

No known cirrhosis

US detected:
3.3% cirrhosis
8.9% heterogeneous

J Pediatr 2015; 167:862-868
Cystic Fibrosis liver disease

Focal biliary cirrhosis

ARFI elastography

Radiol med 2012; 117:1408-1418
Cystic Fibrosis - Pancreas

Size: normal or atrophy
Echotexture: increased
Calcifications, cysts, cystosis
Cystic Fibrosis - Pancreas

Size: normal or atrophy
Echotexture: increased
Calcifications, cysts, cystosis

ARFI Elastography

*Softer in pancreatic insufficiency*
Insufficiency: 0.88 m/s ± 0.66
No insufficiency: 1.07 m/s ± 0.31
Normal: 1.22 m/s ± 0.32*

J Cystic Fibrosis 2013;12:431-439
*Eur J Radiol 2011;80:e226–30*
8 yo boy Hb SS and abdominal pain
8 yo boy Hb SS and abdominal pain

Previously autosplenectomy by 5y
Transfusion & Hydroxyurea
Splenomegaly
Echogenic parenchyma
Nodules
Hemosiderosis
Regenerative nodules
Extramedullary hematopoiesis

Number: present, one
Size: small
Echotexture: increased
Lesions: multiple

8 yo boy Hb SS and abdominal pain

Number: present, one
Size: small
Echotexture: increased
Lesions: multiple

Additional
Absent
Heterogeneous echotexture
Calcification
Abscess
Summary

• Normal

• Abnormal: cases and US advances