

ULTRASOUND LECTURE SERIES

— Presented by —

AIUM • CREOG • ACOG • ACOOG



Fetal Abdomen

Map 3
170dB/C 4
Persist Off
2D Opt:HSCT
Fr Rate:Surv
SonoCT™

ATL

-0
-5
-10
-15



10.12cm
10.17cm



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Objectives

- To define normal anatomy of the fetal abdomen
- To recognize and diagnose selected anomalies particular to the fetal abdomen and ventral wall
- To recognize systemic disease findings within the fetal abdomen

Default
Th30/Dual high2
B44°/V65°
Mix40/60
SRI II 9
3D Static



Situs

- “Relation/place of organs in relation to anatomic sites”

Situs

- *FIRST*: Scan
 - Fetal presentation
 - Fetal lie
 - Anatomic left and right
- *SECOND*: Determine
 - Are fetal abdominal contents in the correct anatomical position and relation?

Abdomen

- Esophagus
- Stomach
- Duodenum
- Small Intestine
- Large Intestine
- Liver and Gallbladder
- Spleen and Pancreas
- Notable Vasculature
- Abdominal Wall

Esophagus

- Runs from pharynx to stomach
- Usually collapsed, occasionally visualized as 2 echogenic lines
- Can be filled with fluid and seen as a tiny tube

Esophageal Atresia

- Prevalence: 1:6000 births
- Majority (>90%) associated with tracheoesophageal fistula (TEF)

Esophageal Atresia

- 5 main types of TEF
 - Type A (82%)
 - Upper esophagus ends in blind pouch, and the TEF is connected to the distal esophagus.
- Up to 64% of cases have associated anomalies (VACTER, aneuploidy)

Esophageal Atresia

- Ultrasound findings
 - Small or absent stomach
 - Polyhydramnios
 - “Pouch sign” of the esophageal blind end
- Sensitivity of detecting in utero is low
- Majority of cases (60%-70%) are detected *after birth*

1. Stringer MD, McKenna KM, Goldstein RB, et al. Prenatal diagnosis of esophageal atresia. J Pediatr Surg 1995; 30:1258.

2. Shulman A, Mazkereth R, Zalel Y, Kuint J, Lipitz S, Avigad I, Achiron R. Prenatal identification of esophageal atresia: the role of ultrasonography for evaluation of functional anatomy. Prenat Diagn 2002; 22:69-74.

Stomach

- Located in upper left abdomen, *below* the diaphragm
- Should be seen in all fetuses by 11 weeks' gestation and thereafter
- Dynamic organ: Nonvisualization only determined after several repeated scans

Map 3
170dB/C 4
Persist Off
2D OptHSC
Fr Rate:Surv
SonoCT®
XRes™

BW 0 Pg 0
Col 0 Pg 0



Nonvisualization of Stomach

- 1:250 to 1:1400 pregnancies
- Fetal outcome usually abnormal
 - 50-100% cases
- Look for additional anomalies
- Variable amniotic fluid volume
 - Depends on etiology

1. Brumfield CG, Davis RO, Owen J, Wenstrom K, Kynerd PM. Pregnancy outcomes following sonographic nonvisualization of the fetal stomach. *Obstet Gynecol* 1998; 91:905-908.

2. McKenna KM, Goldstein RB, Stringer MD. Small or absent fetal stomach: prognostic significance. *Radiology* 1995; 197:729-733.

Nonvisualization of Stomach

Differential diagnosis

- Esophageal atresia
- Tumors
- Goiter
- Diaphragmatic hernia
- Intrathoracic masses
- Cleft palate
- Neurogenic disorders
- Oligohydramnios (will have variable etiologies)

Abnormal Location of Stomach

- Primary
 - Complete situs inversus
 - Abdominal situs inversus
- Secondary
 - Diaphragmatic hernia
 - Subdiaphragmatic pulmonary sequestration
 - Hypoplastic lung
 - Adrenal or renal masses

Bowel

- Occupies lower abdomen
- Homogenous
- Prominent bowel loops visible in 3rd trimester



Duodenum

- Normal duodenum difficult to visualize on ultrasound
- Four parts
 - Head of pancreas within the loop
- Normally collapsed
 - Rarely visualized as 2 echogenic lines

Duodenal Atresia/Stenosis

- 1:5000 to 1:10,000 births
- Most common cause of fetal/neonatal small bowel obstruction
- Unknown etiology
 - Failure of recanalization?
 - Vascular accident?
- Female = male cases
- No racial predilection

1. Dalla Vecchia LK, Grosfeld JL, West KW, Rescorla FJ, Scherer LR, Engum SA. Intestinal atresia and stenosis: a 25-year experience with 277 cases. *Arch Surg.* 1998; 133:490-496.

2. Forrester MB, Merz RD. Population-based study of small intestinal atresia and stenosis, Hawaii, 1986-2000. *Public Health* 2004; 118:434-438.

Stomach



Duodenum



-0

-5

-10

-15



FR 31Hz
RS
2D
43%
C 58
P Low
HGen

M3

Gallbladder

Duodenum

Stomach



ATL

Map 3
150dB/C3
Persist Med
Fr Rate Med
2D OptGen

BW 0 Pg 0
Col 0 Pg 0

✦ 11.81cm
✦ 11.74cm

8:06:55



Duodenal Atresia/Stenosis

- Majority (87%) diagnosed on ultrasound
 - Most in 3rd trimester, after 22 weeks
 - Rarely seen as early as 20 weeks
- Ultrasound findings
 - Double bubble sign
 - Polyhydramnios (50%-75% of cases)

1. <http://www3.ncbi.nlm.nih.gov/entrez/omim>

2. Lawrence MJ, Ford WD, Furness ME, Hayward T, Wilson T. Congenital duodenal obstruction: early antenatal ultrasound diagnosis. *Pediatr Surg Int* 2000; 16:342-345.

Duodenal Atresia/Stenosis

- Double bubble sign
 - Dilated stomach and proximal duodenum
- Differential diagnosis
 - Annular pancreas
 - Transient idiopathic dilation
 - Superior mesenteric artery syndrome

Duodenal Atresia/Stenosis

- Prematurity (50% of cases)
- Associated anomalies (70% of cases)
- Classic marker of Down syndrome (24%-35% of cases)
- Long-term outcome
 - Surgical success
 - Severity of associated anomalies

1. <http://www3.ncbi.nlm.nih.gov/entrez/omim>

2. Torfs CP, Christianson RE. Anomalies in Down syndrome individuals in a large population-based registry. *Am J Med Genet* 1998; 77:431-438.

Jejunum and Ileum

- Jejunum located in the upper left side of abdomen
- Ileum located in lower right side of abdomen

Jejunioileal Atresia

- 1.3 to 2.9 per 10,000 live births
- Risk factors
 - Multiple pregnancies
 - Black race
 - Vaginal bleeding during pregnancy
 - Low birth weight

1. <http://www3.ncbi.nlm.nih.gov/entrez/omim>

2. Werler MM, Sheehan JE, Mitchell AA. Association of vasoconstrictive exposures with risks of gastroschisis and small intestinal atresia. *Epidemiology* 2003; 14:349-354.

Jejunoileal Atresia

- Usually not aneuploidy related
 - Less than 1% of cases
- Etiology
 - Ischemic insult to the developing midgut
- Ultrasound diagnosis difficult
 - 51%-86% of cases have ultrasound findings
 - Usually noted in 3rd trimester

Jejunoileal Atresia

- Ultrasound findings
 - Echogenic bowel
 - Enlarged stomach
 - Dilated bowel
 - Intraperitoneal echogenic material
 - Polyhydramnios

1. Stoll C, Alembik Y, Dott B, Roth MP. Evaluation of prenatal diagnosis of congenital gastro-intestinal atresias. *Eur J Epidemiol* 1996; 12:611-616.

2. Wax JR, Hamilton T, Cartin A, Dudley J, Pinette MG, Blackstone J. Congenital jejunal and ileal atresia: natural prenatal sonographic history and association with neonatal outcome. *J Ultrasound Med* 2006; 25:337-342.

Map 3
170dB/C 4
Persist Off
2D OptHSCT
Fr Rate:Surv
SonoCT™

BW 0 Pg 0
Col 0 Pg 0

AL

-0
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-5
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-10
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-15
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2.31cm

ATL

Map 3
170dB/C 4
Persist Off
2D OptHSCT
Fr Rate:Surv
SonoCT™

-0
-5
-10
-15



Meconium Ileus

- Definition
 - Meconium plug obstructing small intestine
- Leading cause: cystic fibrosis
- Specific, NOT sensitive marker for cystic fibrosis
- Can be associated with congenital cytomegalovirus (CMV) and syphilis

Bowel Perforation: Meconium Peritonitis

- RARE
 - Incidence 3.3 per 100,000 births
- Underlying cause usually unknown

Bowel Perforation: Meconium Peritonitis

- Possible causes
 - Intestinal stenosis
 - Atresia
 - Volvulus
 - Intussusception
 - Cystic fibrosis
 - Infection (CMV, hepatitis)

Bowel Perforation: Meconium Peritonitis

- Group 1
 - Idiopathic perforation without signs of intestinal obstruction
 - Only sonographic finding is intraperitoneal calcifications
 - Occurs early in second trimester

1. Dirkes K, Crombleholme TM, Craigo SD, Latchaw LA, Jacir NN, Harris BH, D'Alton ME. The natural history of meconium peritonitis diagnosed in utero. *J Pediatr Surg* 1995; 30:979-982.

2. Kamata S, Nose K, Ishikawa S, Usui N, Sawai T, Kitayama Y, Okuyama H, Imura K, Okada A. Meconium peritonitis in utero. *Pediatr Surg Int.*2000; 16):377-379.

3. Shyu MK, Shih JC, Lee CN, Hwa HL, Chow SN, Hsieh FJ. Correlation of prenatal ultrasound and postnatal outcome in meconium peritonitis. *Fetal Diagn Ther* 2003; 18:255-261.

Bowel Perforation: Meconium Peritonitis

- Group 2:
 - Perforation of bowel due to intestinal obstruction
 - Dilated bowel loops, ascites, polyhydramnios, intraperitoneal calcifications
 - Occurs in 3rd trimester

1. Dirkes K, Crombleholme TM, Craigo SD, Latchaw LA, Jacir NN, Harris BH, D'Alton ME. The natural history of meconium peritonitis diagnosed in utero. *J Pediatr Surg* 1995; 30:979-982.

2. Kamata S, Nose K, Ishikawa S, Usui N, Sawai T, Kitayama Y, Okuyama H, Imura K, Okada A. Meconium peritonitis in utero. *Pediatr Surg Int.*2000; 16:377-379.

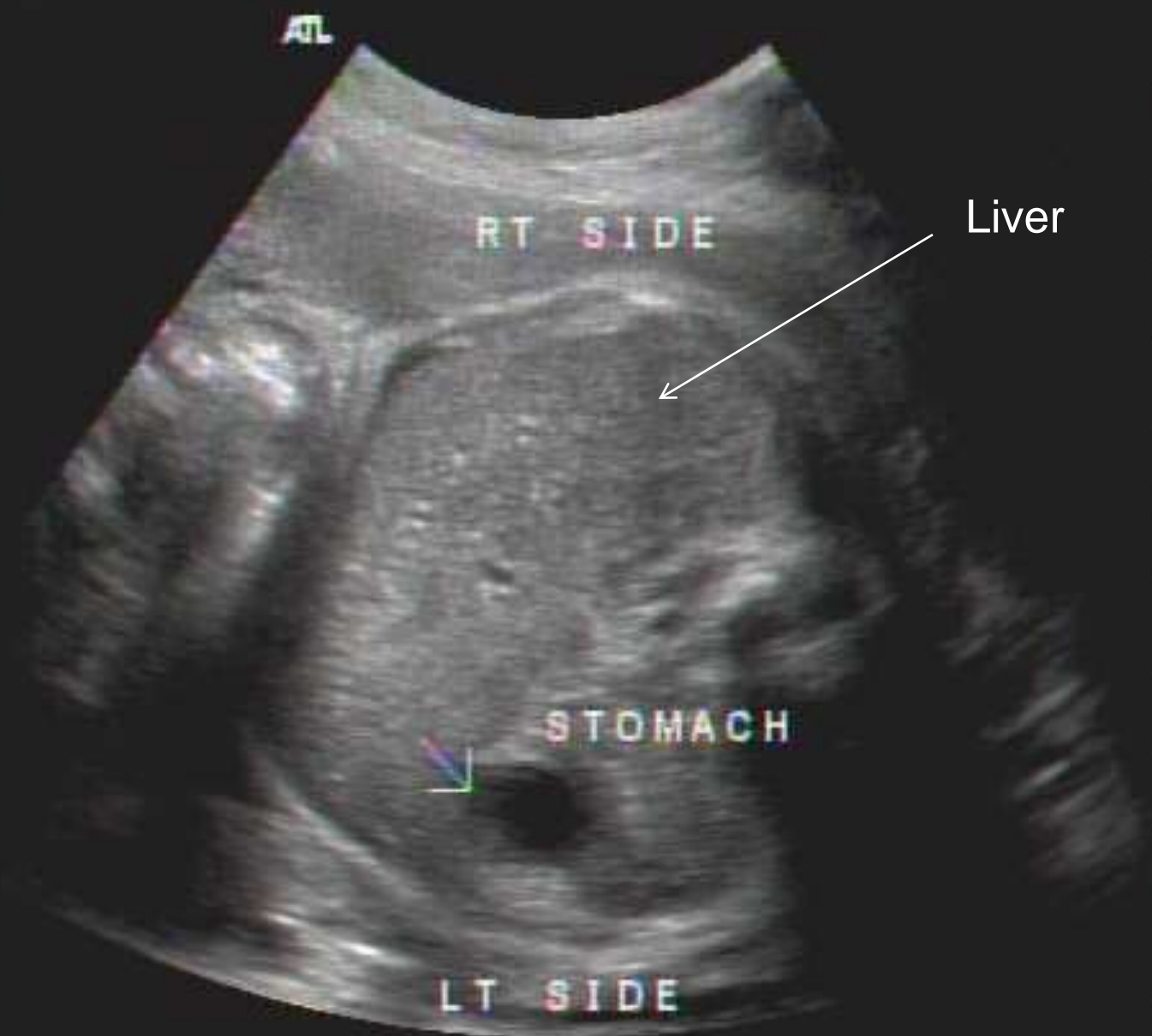
3. Shyu MK, Shih JC, Lee CN, Hwa HL, Chow SN, Hsieh FJ. Correlation of prenatal ultrasound and postnatal outcome in meconium peritonitis. *Fetal Diagn Ther* 2003; 18:255-261.

Liver

- Occupies right upper abdomen, below diaphragm
- Left lobe crosses the midline
- Homogenous texture
- Umbilical vein and gallbladder closely associated structures

Map 3
170dB/C 4
Persist Off
2D OptHSC
Fr Rate:Surv
SonoCT®
XRes™

BW 0 Pg 0
Col 0 Pg 0



Liver Echogenicities

- Incidence: 1:1000 to 1:1750 pregnancies
- Differential diagnosis
 - Infection (CMV)
 - Vascular pathologies
 - Tumors
 - Chromosomal anomalies
- Associated anomalies in 20%-65%

1. Bronshtein M, Blazer S. Prenatal diagnosis of liver calcifications. *Obstet Gynecol* 1995; 86:739-743.

2. Stein B, Bromley B, Michlewitz H, Miller WA, Benacerraf BR. Fetal liver calcifications: sonographic appearance and postnatal outcome. *Radiology* 1995; 197:489-492.

Liver Abnormalities

Hepatomegaly: large differential diagnosis

- Isoimmunization
- Heart failure
- Infections
- Metabolic disorders
- Macrosomia

Gallbladder

- Visible on ultrasound from 7-14 weeks
- Transforms from teardrop to club shaped as pregnancy progresses

FR 52Hz
RS

-3:13:07

M3

2D
42°
C 58
P Low
HGen

Gallbladder



Spleen and Pancreas

- Spleen
 - Left upper quadrant behind stomach
- Pancreas
 - Difficult to differentiate between normal pancreas, intestinal loops, and retroperitoneal texture

FR 39Hz
R5

-0:14:30

M3

2D
54%
C 58
P Med
HRes



Spleen

Cyst

Stomach

0.0

Vasculature



- Umbilical vein
- Umbilical arteries
- Right/left portal veins
- Ductus venosus

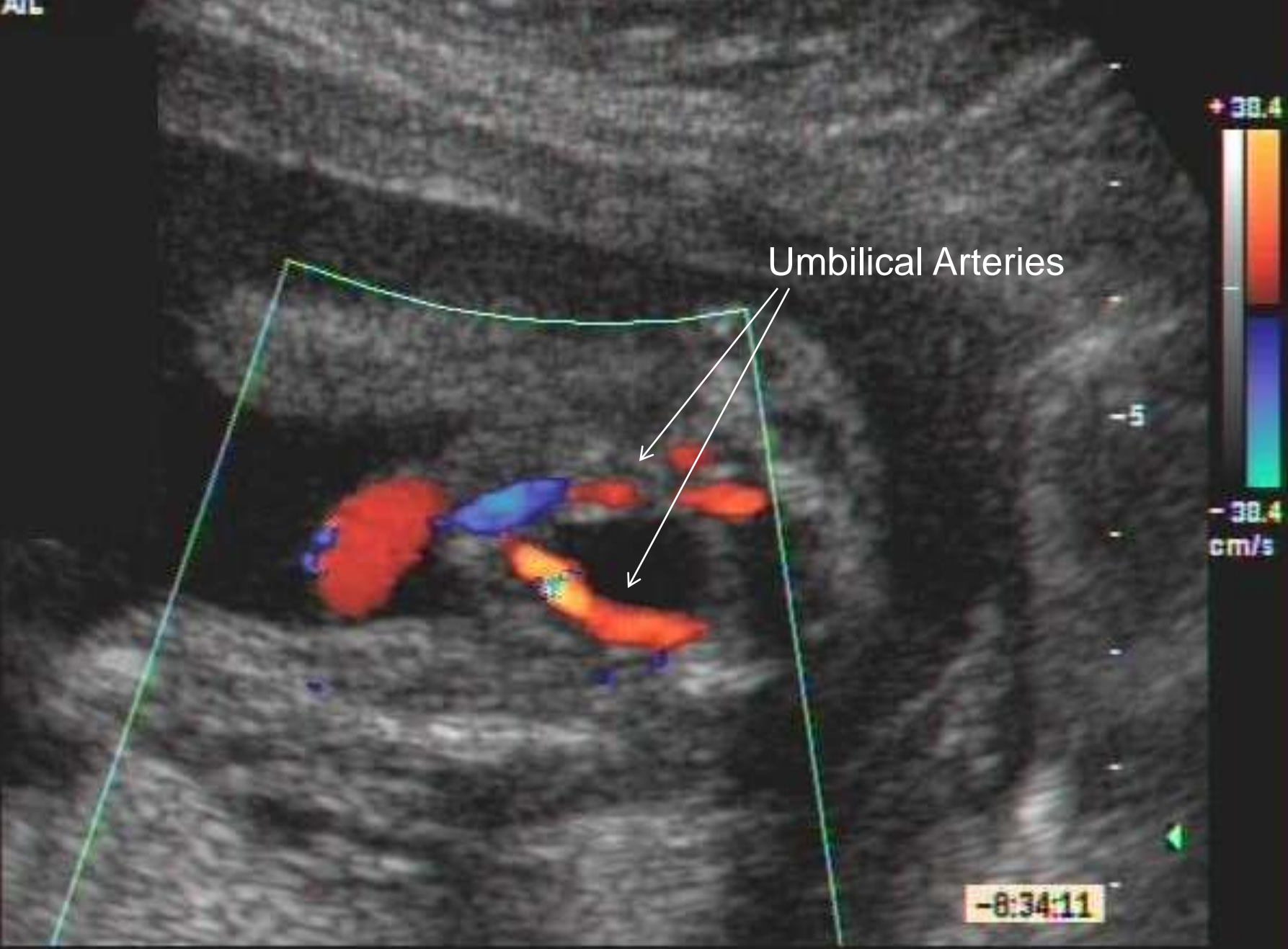
2.+3. Trim.
Har-low
Pwr 100 dB
Gn 0
C7 / M5
E2
CRI 2

83

Umbilical Vein



AL



3 VC



2+3.Trim
Har-mid
Pwr 1
Gn -5
C7 / M8
P5 / E2
MI 1.1
TIS 0.7

Gn 1.8
Bal 170
Qual norm
WMF low1
PRF 0.9kHz
Disp. POW

Map 3
170dB/C 4
Persist Off
2D Opt:HSCT
Fr Rate:Surv
SonoCT™

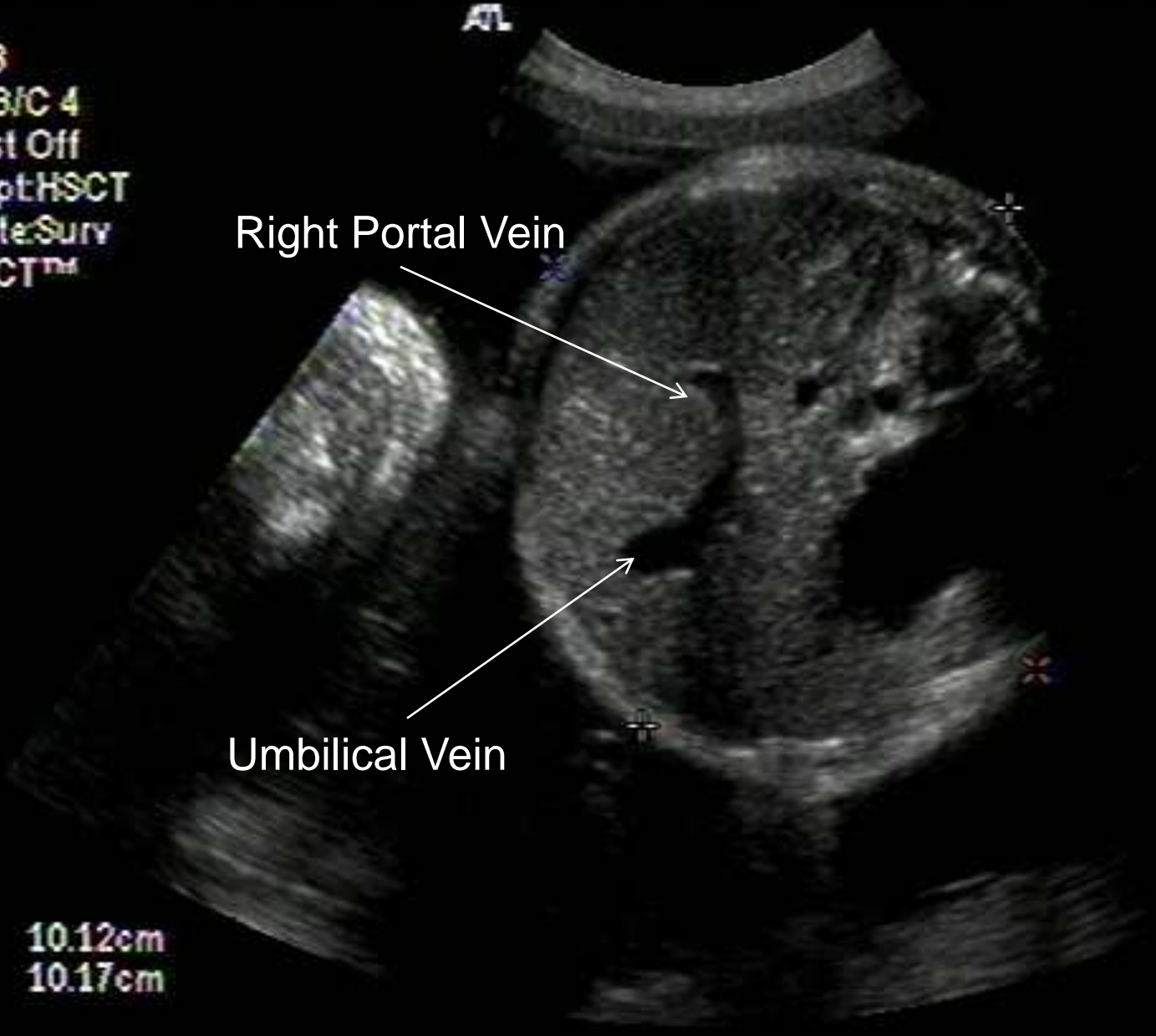
ATL

Right Portal Vein

Umbilical Vein

10.12cm
10.17cm

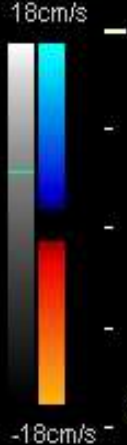
-0
-5
-10
-15



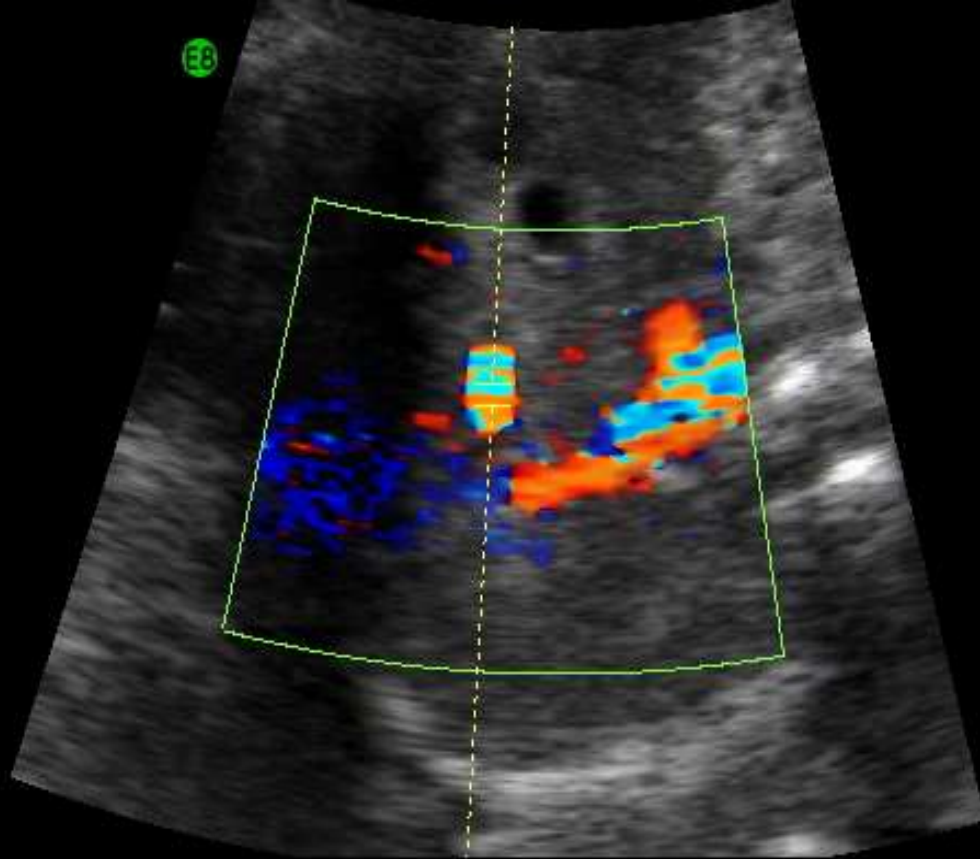
Ductus Venosus

- Originates from umbilical vein
- Courses steeply upward to join the inferior vena cava just below right atrium
- High-velocity flow throughout
- Decreased, absent, and reversed velocities pathologic

Pwr 92 %
Gn -4
WMF 70 Hz
SV Angle 0
Size 2.0mm
Frq mid
PRF 4.4kHz

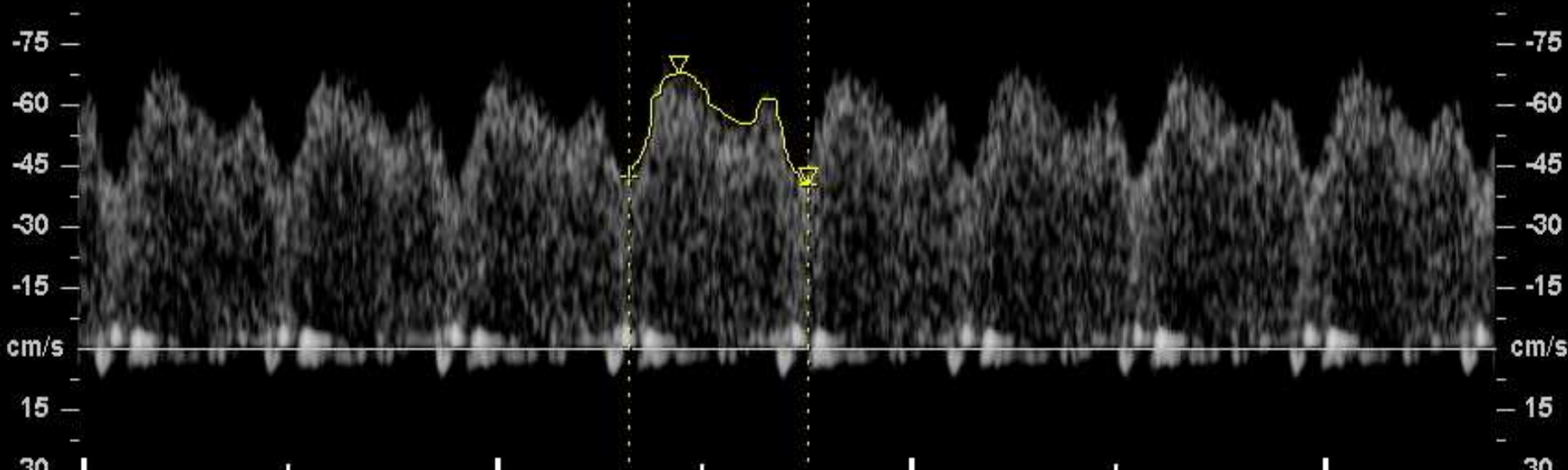


Ductus Venosus



DV-S -67.90cm/s
DV-a -40.44cm/s
DV-RI 0.40
DV-PI 0.48
DV-S/a 1.68
DV-TAmax -57.27cm/s
DV-HR 139bpm

Pwr 100 %
Gn -1.4
Frq mid
Qual norm
WMF low1
PRF 1.3kHz

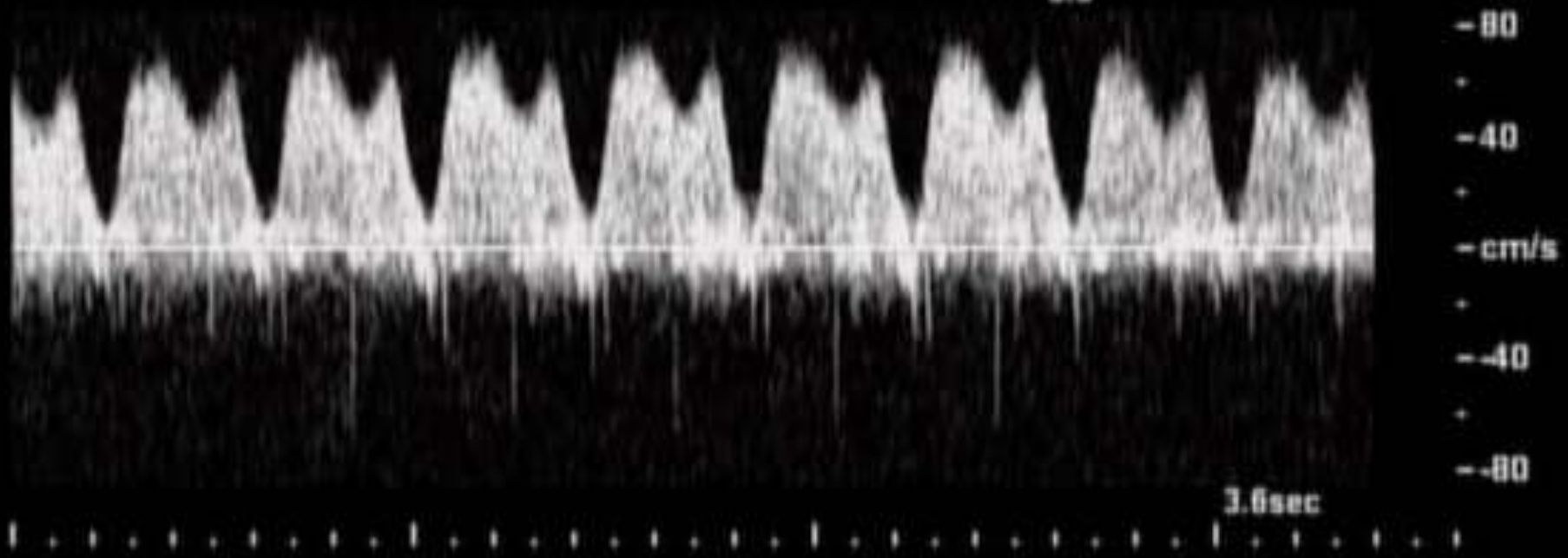


FR 16Hz
RP
2D
50%
C 56
P Low
HGen
CF
60%
1650Hz
WF 98Hz
Med

Abnormal DV:
Decreased EDF



Case:
Severe IUGR
30w EGA
Reversed EDF in
umbilical artery



Vasculature Anomalies: Umbilical Vein Varix



Abdominal Wall

Physiological Midgut Herniation

- Definition
 - Embryonic abdomen becomes too small to accommodate rapid growth of abdominal contents; intestinal loops enter the extraembryonic coelom in the umbilical cord.

Physiological Midgut Herniation

- Occurs at week 6 and returns to the abdominal cavity by week 10
- Herniation *should not be visible* after 12 weeks

Map 3
170dB/C 4
Persist Off
2D Opt:HSCT
Fr Rate:Surv
SonoCT®
XRes™

BW 0 Pg 0
Col 0 Pg 0



-10

Map 3
170dB/C 4
Persist Off
2D Opt:FSCT
Fr Rate:Surv
SonoCT®

ATL

26
30
35
37 - 1
39
40
40
41

- 2

- 3

-2:29:15



Physiologic Gut Herniation



-5



Omphalocele (Exomphalmos)



Omphalocele

- Definition

Midline defect in ventral abdominal wall, herniated intra-abdominal contents, covered by a membrane consisting of peritoneum and amnion

Omphalocele

- Most common contents
 - Small bowel
- Less common contents
 - Liver
 - Large intestine
 - Stomach
 - Spleen

Omphalocele

- Prevalence: 1:4000 births
- Advanced maternal age (increased risk)
- Associated anomalies (67%-88%)
- Elevated α -fetoprotein (AFP; 70%)

1. Byron-Scott R, Haan E, Chan A, Bower C, Scott H, Clark K. A population-based study of abdominal wall defects in South Australia and Western Australia. *Paediatr Perinat Epidemiol* 1998; 12:136-151.
2. Stoll C, Alembik Y, Dott B, Roth MP. Risk factors in congenital abdominal wall defects (omphalocele and gastroschisi): a study in a series of 265,858 consecutive births. *Ann Genet* 2001; 44:201-208.

FR 30Hz
RS
Z 2.4
2D
44%
C 58
P Low
HGen

2:03:17

KG



LIVER

Omphalocele

- Cardiac defects in 50% of cases
- Gastrointestinal anomalies in 40% of cases
- Chromosomal defects in 30%-40% of cases
- Beckwith-Wiedemann syndrome in 10%-22% of fetuses with isolated omphalocele

1. Gibbin C, Touch S, Broth RE, Berghella V. Abdominal wall defects and congenital heart disease. *Ultrasound Obstet Gynecol* 2003; 21:334-337.

2. Blazer S, Zimmer EZ, Gover A, Bronshtein M. Fetal omphalocele detected early in pregnancy: associated anomalies and outcomes. *Radiology* 2004; 232:191-195.

Omphalocele

Differential Diagnosis

- Physiologic gut herniation
- Gastroschisis
- Umbilical hernia
- Cloacal exstrophy
- Pentalogy of Cantrell
- Umbilical cord cyst
- Bladder exstrophy
- Cord hemangioma
- Body stalk anomaly
- Amniotic band syndrome

Gastroschisis



Gastroschisis

- Definition

Paraumbilical defect in the abdominal wall, possibly due to a vascular accident of the right omphalomesenteric artery during embryonal development, resulting in evisceration of small bowel



FR 35Hz
RS

-2:30:53

M4

2D
60%
C 48
P Low
HRes

P



FR 35Hz
RS

-2:30:53

M4

2D
60%
C 48
P Low
HRes

P



SMALL BOWEL



Gastroschisis

Ultrasound findings

- Freely floating intestinal loops
- No membranous sac covering viscera
- Normal umbilical cord insertion
- Defect virtually always right sided
- First trimester diagnosis possible
- AFP elevated in >95%

Gastroschisis

- Regional variation of incidence
 - 0.5/10,000 in Japan
 - 4.4/10,000 in England
- Incidence is increasing
- Affected fetus *does* have increased risk of additional structural anomalies
- Mode of delivery
 - No difference in neonatal morbidity

1. Penman DG, Fisher RM, Noblett HR, Soothill PW. Increase in incidence of gastroschisis in the south west of England in 1995. *Br J Obstet Gynaecol* 1998; 105:328-331.
2. Suita S, Okamatsu T, Yamamoto T, et al. Changing profile of abdominal wall defects in Japan: results of a national survey. *J Pediatr Surg* 2000; 35:66-71.
3. Salihu HM, et al. Mode of delivery and neonatal survival of infants with isolated gastroschisis. *Obstet Gynecol* 2004; 104:678-683.

FR 35Hz
RS

-2:30:53

M4

2D
60%
C 48
P Low
HRes

P



10-

Abdominal Findings Related to Systemic Disease

Echogenic Bowel



Echogenic Bowel

- Definition
 - Echogenicity of the intestine reaches that of surrounding bone
- Prevalence: 0.2%-1.8% in 2nd trimester

FR 35Hz
R5
2D
43%
C 58
P Low
HGen



Echogenic Bowel



Echogenic Bowel



Echogenic Bowel

Potential causes

- Chromosomal abnormalities
- Structural anomalies
- Viral infections (eg, CMV)
- Pregnancy-related bleeding
- Intrauterine growth restriction
- Cystic fibrosis

Echogenic Bowel

High likelihood of normal outcome if
workup negative

Hydrops Fetalis: Ascites

- Definition

Presence of extracellular fluid in at least 2 fetal body compartments



Map 3
170dB/C 3
Persist Off
2D OptH5CT
Fr Rate:Surv
SonoCT®

BW 0 Pg 0
Col 0 Pg 0

AOI



-
-
-
-5
-
-
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-10
-
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-15



243,11m.
Har-low
Pwr 100 %
Gn -1
C7 / M7
P5 / E2
SRI II 7



AC 370.10mm
GA 41w0d

Hydrops Fetalis

- Immune hydrops
 - Formation of maternal antibodies to more than 40 different red cell antigens
- Nonimmune hydrops
 - 25% cardiovascular disease
 - 10% chromosomal abnormalities
 - 9% thoracic lesions
 - 8% twin to twin transfusion
 - 6% nonimmune causes of fetal anemia
 - 4% fetal infection

243.17mm.
Har-low
Pwr 100 %
Gn -1
C7 / M7
P5 / E2
SRI II 7

Ascites



AC

AC 383.91mm
GA OOR



Infection

- CMV
 - Abdominal ultrasound findings
 - Echogenic bowel
 - Echogenic foci in liver or spleen
 - Hydrops fetalis
 - Hepatosplenomegaly

Infection

Parvovirus

- Ascites/hydrops fetalis
- Hepatosplenomegaly
- Hepatic calcification

Infection

Congenital syphilis

- Hepatosplenomegaly
- Hydrops fetalis

Infection

Toxoplasmosis

- Hepatosplenomegaly
- Hepatic echogenic densities
- Ascites/hydrops fetalis

Infection

Varicella zoster

- Ascites
- Liver calcifications

Summary

- Due to the number and complexity of the abdominal organs, intra-abdominal pathology can be diverse and variable.
- Many fetal systemic problems have intra-abdominal manifestations.

Additional Reading

- Callen. *Ultrasonography in Obstetrics and Gynecology*. 5th ed. Philadelphia: Saunders; 2008.
- *Structural Fetal Abnormalities: The Total Picture*. 2nd ed. St Louis: Mosby; 2002.