Embryology
Gastrointestinal (GI) tract arises from the primordial gut, which appears during the fourth conceptual week. Gut endoderm gives rise to GI tract endoderm and digestive glands. Splanchnic mesoderm surrounding the gut gives rise to muscular, connective tissue, and other layers of the GI tract wall.

**FOREGUT** gives rise to the:
- Primordial pharynx
- Lower respiratory system
- Esophagus and stomach
- Duodenum
- Liver, biliary apparatus and pancreas
- Arterial supply via celiac artery

**MIDGUT** gives rise to the:
- Small intestine including most of the duodenum
- Cecum and appendix
- Descending colon
- Right side of transverse colon
- Arterial supply via superior mesenteric artery

**HINDGUT** gives rise to the:
- Left side of transverse colon
- Descending colon
- Sigmoid colon
- Rectum and proximal anal canal
- Arterial supply via inferior mesenteric artery

**REDUCTION OF MIDGUT HERNIATION**
While still in the base of the cord the midgut loop rotates and 90° counterclockwise around the axis of the SMA. During this rotation, loops of small intestine are formed. During the 8th menstrual week the intestines return to the abdominal cavity. The small intestine returns first followed by the still rotating large intestine. This process should be completed by the end of the 12 menstrual week.
**Normal Sonographic anatomy**

**ESOPHAGUS:** difficult to image unless fetus is swallowing or there is stenosis of the gastrointestinal tract.

**STOMACH:** transversely seen as an ovoid/spherical fluid collection in upper abdomen. Coronal image can demonstrate fundus, body and pylorus. Muscular layer is very thin in normal fetuses and may be thickened in hypertrophic pyloric stenosis.

**INTESTINES:** difficult to isolate specific segments unless there is sufficient fluid content to provide sonographic contrast. Normally mixed echogenic/cystic appearance. Peristalsis should be seen by late second trimester. Meconium (a mixture of bile and swallowed vernix, desquamated epithelium, and fetal hairs) becomes packed in the large bowel and may appear as highly echogenic areas within the bowel.

**CORD INSERTION:** important anatomical landmark in the fetus. Normal structures visible in a cord insertion view include:
- Intact anterior abdominal musculature and skin line
- Two umbilical arteries
- One umbilical vein

**DIAPHRAGM:**
Herniation Defects

**GASTROSCHISIS**
Protrusion of intestines into amniotic cavity through an open defect in the anterior abdominal wall. Occurs adjacent to the cord insertion, usually on the right, and is not covered by membranous sac. Results from a muscular defect.

**PATHOLOGY:**
- 3-5cm defect in abdominal wall.
- Herniated bowel loops covered by inflammatory exudate.
- Associated with IUGR but few other anomalies.

**SONOGRAPHIC FINDINGS:**
- Cord is seen adjacent to defect
- No membranous sac covering hernia
- Thick-walled loops of bowel seen extending into amniotic cavity.

**OMPHALOCELE**
Results from a failure of the intestines to return to the abdomen during the second stage of intestinal rotation. May consist of a single loop of bowel or may contain most of the intestines, liver, etc. Hernia is covered by a layer of amniotic epithelium and occurs at the level of the umbilical cord.

May also result from defective closure of midline musculature in which case there may be total eventration of abdominal viscera. Associated with exstrophy of bladder and/or ectopia cordis.

Rupture of sac during vaginal delivery causes sepsis therefore prenatal diagnosis is essential. Because of the high association between omphalocele and other congenital anomalies, patients should receive genetic counseling.

**PATHOLOGY**
- Midline defect with cord inserting.
- Associated with cardiac anomalies in pentalogy of Cantrell.
Associated with macroglossia and gigantism in Beckwith-Wiedemann syndrome.

**SONOGRAPHIC FINDINGS:**
- Mass contiguous with umbilical cord.
- Membranous sac covering herniated organs.
- Extra-abdominal mass consisting of a combination of fluid-filled bowel loops, mesentery, omentum, and usually liver, pancreas, spleen.

**Bladder extrophy**
Caused by incomplete closure of the inferior part of the anterior abdominal wall. Fissure involves abdominal wall as well as anterior wall of urinary bladder. Exposure and protrusion of urinary bladder, associated with genital anomalies, i.e. cleft clitoris, epispadias, wide separation on pubic bones.

**SONOGRAPHIC FINDINGS:**
- Bladder not identified over 30 minutes of scanning but normal amniotic fluid volume
- Separation of pubic bones seen (diastasis)
- Microphallus in male fetus

**Diaphragmatic hernia**
A protrusion of abdominal contents into the thorax through a defect in the diaphragm.
- Most common type is a posterolateral Bochdalek hernia which occurs along the primitive pleuropertitoneal canal. May be right or left.
- Less common is a parasternal defect located in the anterior portion of the diaphragm between its attachment to the ribs and the sternum, a Morgagni hernia. Most occur on the right.
- Usually occurs on the left side (80%) and small bowel, stomach, spleen and colon may herniate.
- Associated with ipsilateral pulmonary hypoplasia.
- Compression of heart and lung causes severe respiratory distress.
Frequent association with CNS anomalies, i.e. anencephaly, spina bifida, hydrocephaly, encephalocele and iniencephaly.

**SONOGRAPHIC FINDINGS:**
- Heart displaced from the left chest
- Identification of fluid filled bowel and especially stomach within the thoracic cavity at the level of the four chamber view of the heart.
- Associated polyhydramnios
Abdominal Anomalies

GASTROINTESTINAL ATRESIA

ESOPHAGEAL
Congenital discontinuation of esophagus. Usually associated with T-E fistula. May be associated with cardiovascular, gastrointestinal and musculoskeletal anomalies.

SONOGRAPHIC FINDINGS:
- Failure to demonstrate stomach on serial sonograms
- Associated polyhydramnios.
- Not ALWAYS detectable with sonography

DUODENAL
Obstruction of duodenum of varied etiology; failure of normal embryonic development, choledochal cysts, extrinsic pressure. There is a 30% incidence of duodenal atresia in cases of Down’s syndrome.

PATHOLOGY:
- Most frequently a web, or membrane, obstructs the duodenum.
- Associated with an annular pancreas: a ring of pancreatic tissue encircling the distal portion of duodenum.

SONOGRAPHIC FINDINGS:
- “Double bubble sign” due to simultaneous distention of stomach and first portion of the duodenum.
- Polyhydramnios.

INTESTINAL
Obstruction of intestine with subsequent distention of bowel loops. May occur anywhere along the intestinal tract or at the level of the anus. The precise site is frequently indeterminate.

SONOGRAPHIC FINDINGS:
- Multiple fluid filled bowel loops
- Increased peristalsis
- Impossible to determine exact site of obstruction
**Meconium Peritonitis**
Peritoneal inflammatory reaction following intrauterine bowel perforation. May occur after a fetal bowel obstruction caused by intestinal atresia, volvulus or meconium ileus. Cystic fibrosis is considered to be the etiology in 25-40% of all patients because of thick, sticky meconium.

**Sonographic Findings:**
- Brightly echogenic, intra-abdominal mass which casts an acoustic shadow
- Fetal ascites and polyhydramnios
- Presence of meconium pseudocyst

**Ovarian Cysts**
Stimulation of fetal ovaries by maternal hormones may cause functional cysts in the fetus. May be small and undetected or large enough to fill the entire fetal pelvis. Unilateral occurrence is more frequent than bilateral. Frequently these cysts resolve spontaneously post partum. Follow up is recommended.

**Sonographic Findings:**
- Simple cystic mass found in fetal pelvis separate from the gastrointestinal tract, kidney, ureter and bladder.
- Female gender identified
- May be hard to distinguish from urachal or mesenteric cysts.

**Teratomas**
A congenital germ cell tumor arising from the sacral area. Three pathologic types exist: mature, immature and malignant. Tumors frequently are hypervascular and consist of solid, cystic and calcific components. They are described by site of origin:
- **Pre-Sacral** arising from the anterior aspect of the sacrum and growing into the fetal pelvis
- **Sacrococcygeal** arising from the posterior sacrum/coccyx and projecting exophytically from the fetal sacrum.

**Sonographic Findings:**
- A complex, large mass seen in the fetal pelvis or arising from the fetal rump
- May contain cystic, solid and calcific components
- Possible differential diagnosis includes meningomyelocele
**HELPFUL HINTS**

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<thead>
<tr>
<th>Omphalocele vs. Gastroschisis</th>
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<tbody>
<tr>
<td>May contain a variety of organs</td>
<td>May contain a variety of organs</td>
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<tr>
<td>Enclosed by a membrane</td>
<td>No membrane, free floating</td>
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<tr>
<td><strong>AT</strong> level of cord insertion</td>
<td><strong>LATERAL</strong> to cord insertion</td>
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