Development of the digestive tube
Embryonal grooving at the 4th week of development

Day 21
- Intramembranous coelom
- Ext. view
- Cloacal membrane

Day 22
- Oropharyngeal membrane
- Embryonic stalk

Day 26
- Umbilicus

Day 28
- Foregut
- Midgut
- Hindgut

Sag view
- Neural fold
- Notochord
- Forebrain
- Cloacal membrane
- Heart
- Stalk from sac
- Umbilicus

Front view
- Neural crest
- Neural tube
- Somatopleura
- Later line
- Spinal ganglion
Development of digestive tube

Primitive gut

Week 4: folding of embryo causes partial incorporation of yolk sac

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Development

- Endoderm of primordial gut → Epithelium and glands of digestive tract
- Ectoderm of stomodeum → Epithelium in part of oral cavity
- Ectoderm of proctodeum → Epithelium in anal canal

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Development

**Foregut**

From oral cavity to duodenum (below papilla duodeni major)

- Celiac trunk

**Midgut**

From duodenum to transverse colon

- Superior mesenteric artery

**Hindgut**

The rest of colon

- Inferior mesenteric artery

**Oropharyngeal membrane**

**Cloacal membrane**

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mesocolic arteries and their relation to the alimentary tube segments
Foregut (*preentereon*)

- separated by mebrana oropharyngea from stomodeum (ruptures on 26th day)
- evagination of:
  - submandibular and sublingual glands
  - thyroid gland
  - evagination of primitive pharynx
  - diverticle for lower respiratory tract
  - diverticle for liver, gallbladder and ventral part of pancreas
- artery: *truncus coeliacus*
- nerve: *n.X (parasympathetic)*
Midgut (*mesentereon*)

- distally to hepatic diverticule towards ductus omphaloentericus
- further aborally as far as Cannon-Böhm's point (at flexura coli sinistra)
- evangination:
  - appendix vermiformis
- artery: *a. mesenterica superior*
- nerve: *n.X (parasympathetic)*
Hindgut (*metentereon*)

- further aborally from Cannon-Böhm‘s point at flexura coli sinistra
- as far as linea pectinata (anal canal)
- from proctodeum separated by membrana cloacalis (ruptures at the end of 8th week)
- artery: *a. mesenterica inferior*
- nerve: plexus hypogastricus inferior (*parasympathetic*)
Hinge of primitive gut

- mesenterium ventrale primordiale
  - only till the level of the end of foregut
  - only a thin serous duplicature
→ omentum minus
→ peritoneum viscerale of liver
→ ligamentum falciforme
MESENTERIES OF GUT

Liver
Lesser omentum
Stomach
Spleen
Aorta
Celiac a.
Dorsal mesogastrium
Superior mesenteric a.
Intestinal mesentery
Inferior mesenteric a.
Falciform ligament
Vitelline duct
Allantois
Cloaca
Hinge of primitive gut

• mesenterium dorsale primordiale
  – whole length of intestine, fixation to posterior abdominal wall
  – contains connective tissue and vessels
  – spleen originates within it

→ ligamentum gastrocolicum
→ omentum majus
→ peritoneum viscerale of the spleen
→ peritoneum viscerale of the transverse and sigmoid colon
→ mesocolon transversum, mesoappendix, mesogimoideum

• mesogastrium dorsale

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Oesophageal development

- rotation → asymmetric course of n.X
- temporary obliteration of caliber
- upper third – skeletal muscle from lower pharyngeal arches
- developmental defects:
  - atresia
  - stenosis
  - fistula tracheooesophagealis

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Stomach development

• enlargement of aboral part of foregut
• faster growth of posterior wall
• subsequent rotation to the left by 90° along the horizontal axis
• evagination of dorsal mesogastrium
• origin of bursa omentalis
• developmental defect: congenital hypertrophic pylorostenosis
  – 1:150 males x 1:750 females
  – projectile vomiting

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Development of greater omentum

- dorsal mesogastrium growth to the length
- extends ventrally to small intestine
- adhesions appear
  - mesocolon + mesogastrium dorsale
  - both layers of mesogastrium dorsale merge
    → recessus inferior bursae omentalis
Animation

http://www.youtube.com/watch?v=s2cNCUL1r3A&feature=BFa&list=PL9A2D6BB7F131CA12
Intestine development
Midgut development

- subsequent formation of tubular gut
- *ductus omphaloentericus* (*vitellio-intestinalis*) remains (6)
- midgut enlarges → loop around the axis of *arteria mesenterica superior* (9)

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Development of the midgut

- further enlargement of cranial limb of intestinal loop
- rotation 90° anti-clockwise along the axis of a. mesenterica sup.
- physiological herniation (6th-10th week)
  - due to large liver and two pairs of kidneys

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Midgut development

- further 90° rotation
- colon (19) appears in front of duodenum (10)
- subsequent return of loops (3rd month)
- caecal bud

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Midgut development

- terminal rotation by 90° (totally 270°)
- caecal bud (16) located on the right side under liver
Midgut development

- caecum descends caudally
- formation of *colon ascendens*
- *appendix vermiformis* evaginates
  - firstly it grows slowly, then rotates medially due to irregular growth of caecum
Change of gut position and peritoneal cover

- ascending and descending colon
- duodenum

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Animation

http://www.youtube.com/watch?v=j7OG4wSpDqI&NR=1&feature=endscreen

http://www.youtube.com/watch?v=rs44cXvjbMA&list=PL9A2D6BB7F131CA12
Development of duodenum

• week 5-6: delumination of duodenum happens (caliber fades out)
• week 8: subsequently the lumen reappears
Development of liver, gallbladder and bile duct

• ventral endoderm of caudal part of foregut (*preenteron distale*)
  → hepatic evagination (4th week)
    – ingrowth into ventral mesenterium
Development of liver, gall bladder and bile duct

• gemma hepatopancreatica
  → division into:
• diverticulum hepatis
  – cranial larger part → liver diverticle
  – caudal smaller part → gallbladder diverticle
    • formation of ductus cysticus
• ductus choledochus forms by narrowing of connection of liver with foregut
  – opens together with ductus pancreaticus Wirsungi at papilla duodeni major Vateri
Liver development

• 2 origins: foregut and septum transversum
• epithelial cells grow into mesenchyme of septum transversum → hepatocyte columns
• mesoderm →
  – tissue of interlobular spaces
  – hematopoietic cells
  – Ito cells
  – Kupffer cells (migrated from bone marrow)
Liver development

• blood production since 6th week
  – subsequently ceases last 2 months of intrauterine development

• mesogastrium ventrale:
  – mesohepaticum → lig. falciforme hepatitis + peritoneum viscerale of liver + omentum minus

• liver covered by peritoneum except for area nuda

• bile production since 12th week

developmental defects:
  – extrahepatal bile ducts atresia
  – pseudocysts

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Atresia of bile ducts

Typ A: 83%

Typ B: 11%

Typ C: 6%
Pseudocysts of bile ducts
Diaphragm development

21t. day

26th da

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Septum transversum

30th day

- Septum transversum
- Liver
- 30 days
- Stomach
- Dorsal mesentery
- Dorsal pancreatic
- Ventral mesentery (falciform ligament)
- Ventral pancreatic bud

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Diaphragm development

7th week

3rd month

Obr. 8.83 Schéma vývoje bránice. Pohled z dutiny břišní na vznikající bránici u embrya 17 mm dlouhého, asi 7 týdnů starého (A) a u fětu 80 mm dlouhého (TK), asi 3 měsíce starého (B).
1 – část bránice pocházející ze septum transversum (modré), 2 – vena cava inferior, 3 – oesofagus, 4 – část bránice pocházející z pleuroperitoneální membrány (červené), 5 – aorta, 6 – část bránice pocházející ze stěny tělní (šarovenec).

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Development of pancreas

- 4th week
- aboral part of foregut
- 2 pancreatic evagination (11) from endoderm
  - dorsal (larger)
  - ventral – from liver diverticle
5th-8th week
• dorsal pancreas (7) grows between layers of dorsal mesentery (mesoduodenum)

• ventral pancreas (5) grows into ventral mesoduodenum
  • future processus uncinatus and part of pancreatic head

• their connection can happens due to duodenal rotation
  • ductus pancreaticus *Wirsungi* → papilla duodeni major *Vateri*
  • proximal part of duct of dorsal pancreas remains as ductus pancreaticus accessorius *Santorini* → papilla duodeni minor *Santorini*
Pancreatic development

- pancreas with duodenum and mesoduodenum flops and fuses with parietal peritoneum (→Treitz‘s retropancreatic membrane)
Pancreatic development

- tissue cover and interlobular septa originate from surrounding splanchnic mesenchyme
  - insuline production
    - begins in approx. 10th week, hypertrophy of beta-cells in case of maternal diabetes mellitus

- developmental defects of pancreas:
  - accessory pancreatic tissue
    - stomach wall, duodenal wall, Meckel’s diverticle
  - pancreas anulare (1:20,000) → duodenal stenosis
  - pancreas divisum (5-8 %)
PANCREAS DIVISUM

PANCREAS ANULARE

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Developmental defects of foregut

- stenosis or atresia of duodenum and gut
- diverticulum ilei Meckeli
- Inborn omphalocele
  - umbilical hernia
- gastroschisis – defect of anterior abdominal wall
- defects of rotation
  - situs viscerum inversus
- volvulus
- internal herniae
- gut duplication – defect of vacuolisation
STENOSIS

ATRESIA
Diverticulum ilei

- ductus omphaloentericus may persists
  → diverticulum ilei Meckeli
    - 2%
    - 0-100 cm from ostium ileocaecale
Diverticulum ilei Meckeli

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Developmental defects of gut

• herniae
  – omphalocele = defect of intestinal oops return
    • covered only by amion
  – inborn umbilical hernia
    • normal return, later herniation
    • covered by peritoneum and amnion

• abnormal rotation
  • lesser rotation
  • reversal rotation

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Developmental defects of digestive tube

- defects of tube luminization
  - atresiae and stenoses
    - duodenum, oesophagus, anus
  - duplication
    - gut
- cysts
Bochdalek posterolateral hernia
Gut malrotation

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Inborn umbilical hernia
Omphalocele
Gastroschisis
Situs viscerum inversus
Development of hindgut

- *proctodeum* – invagination of ectoderm
- *septum urorectale* grows into cloaca
  → differentiation into anorectal and urogenital part
  → differentiation of *membrana cloacalis* into *membrana urogenitalis et membrana analis*
Proctodeum

- invagination of ectoderm
- from linea dentata/pectinata onward
- artery: a. pudenda interna
- innervation: n. pudendus
- disappears at the end of 8th week by rupture of membrana analis
Developmental defects of hindgut

- anus imperforatus
- agenesis of anus
- stenosis / atresia of anus
- rectal fistula
- intestinal agangliosis (megacolon congenitum; *Hirschsprung disease*)
Development of peritoneum

- intraembryonal coelom
- coelomic „epithelium“ = mesothel
- classification of organs according to the peritoneal cover (tunica serosa):
  - intraperitoneal
    - visceral and parietal peritoneum
    - duplicatures
  - retroperitoneal
    - primary x secondary
  - subperitoneal
- mesos and folds (*bursa omentalis*)
Development of bursa omentalis
Development of bursa omentalis
Development of bursa omentalis

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1. Normal greater omentum. 2. Greater omentum wrapped around an inflamed appendix. 3. Greater omentum adherent to the base of the gastric ulcer. One important function of the greater omentum is to attempt to limit the spread of intraperitoneal infections.

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