ver1.1

Zambia Perinatal Ultrasonography Certification System

Ultrasound Examination in the Perinatal Period

I. Ultrasound Examination of the Female Genitalia

Objective Understand the basic principles of ultrasound examination of the uterus, ovaries, and fallopian tubes, and the ultrasound findings of normal and pathological conditions, and to be able to apply this knowledge to diagnosis and treatment.

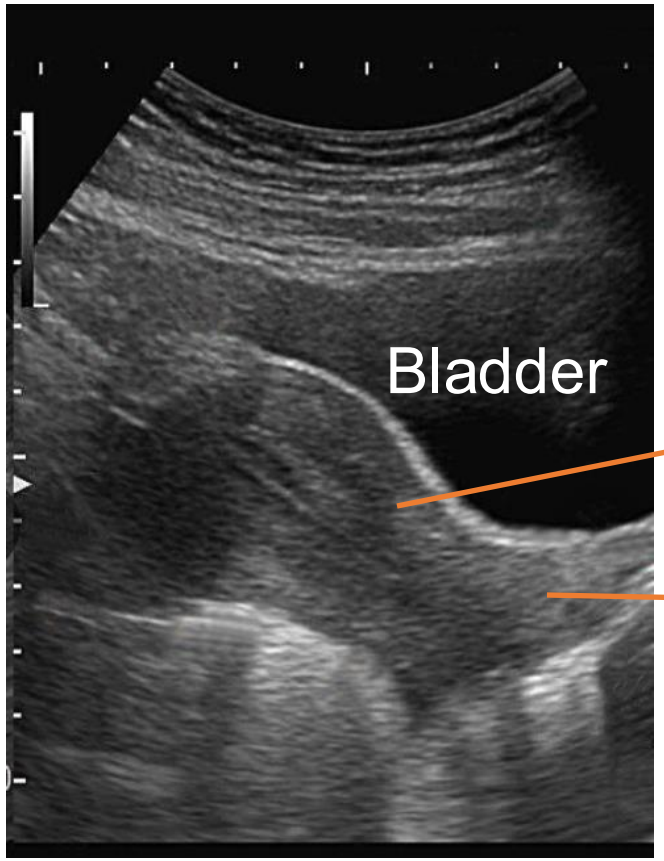
Safety of ultrasound on the fetus

In the embryo and fetus, cells are actively proliferating, and organ differentiation and development are occurring rapidly. Therefore, they are susceptible to external stimuli (radiation, drugs, etc.), especially from 4 to 12 weeks of gestation (critical period). Ultrasound is considered to be noninvasive to the embryo and fetus. No definite adverse events have been reported with ultrasound used in diagnosis in the past 30 years. However, with the development of ultrasound equipment, the acoustic output tends to increase, and safety must always be kept in mind when ultrasound examinations of the fetus are performed.

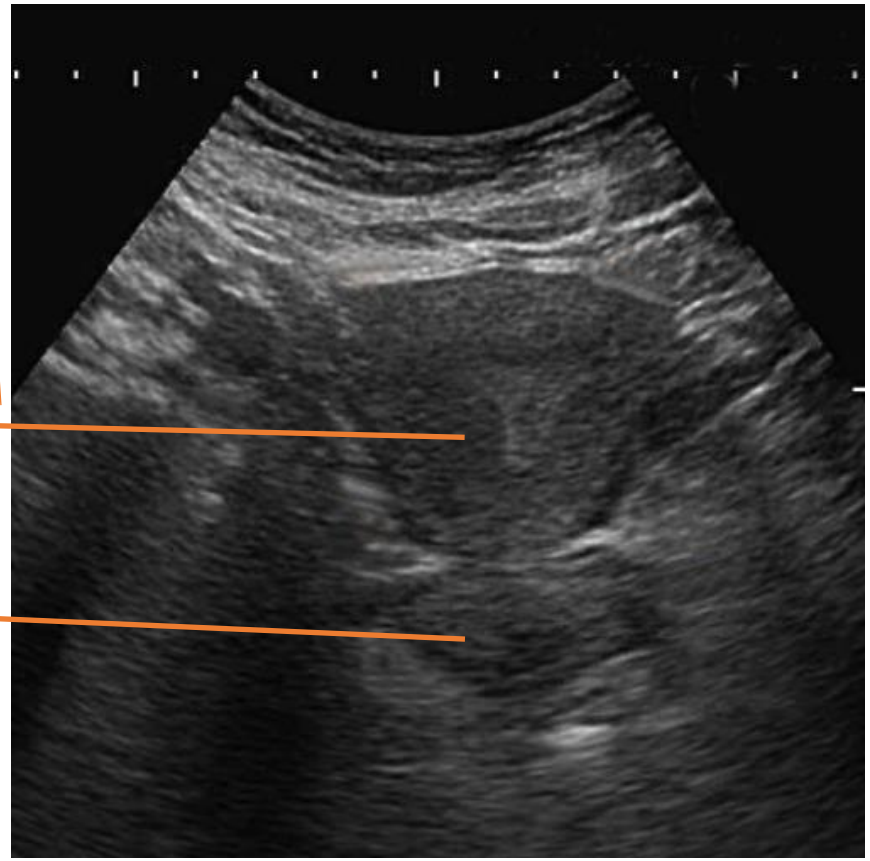
Is the ultrasound Doppler technique at 11-14 weeks gestation safe?

It is reported that ultrasound even at low power increased apoptosis in fetal liver tissue. Although heat production may occur at the bone/soft tissue interface because bone tissue absorbs energy of ultrasound and the energy is reflected at the bone/soft tissue interface, it is considered more prudent to examine fetal brain in late pregnancy because calcification is lower in early pregnancy than in late pregnancy, and heat production is higher in late pregnancy. The injury of the ultrasound to the fetus in early pregnancy is not well understood and should be performed with caution.

Anatomy/Physiology
Uterus
1: Explain the ultrasound image of the uterus obtained by transabdominal scanning.



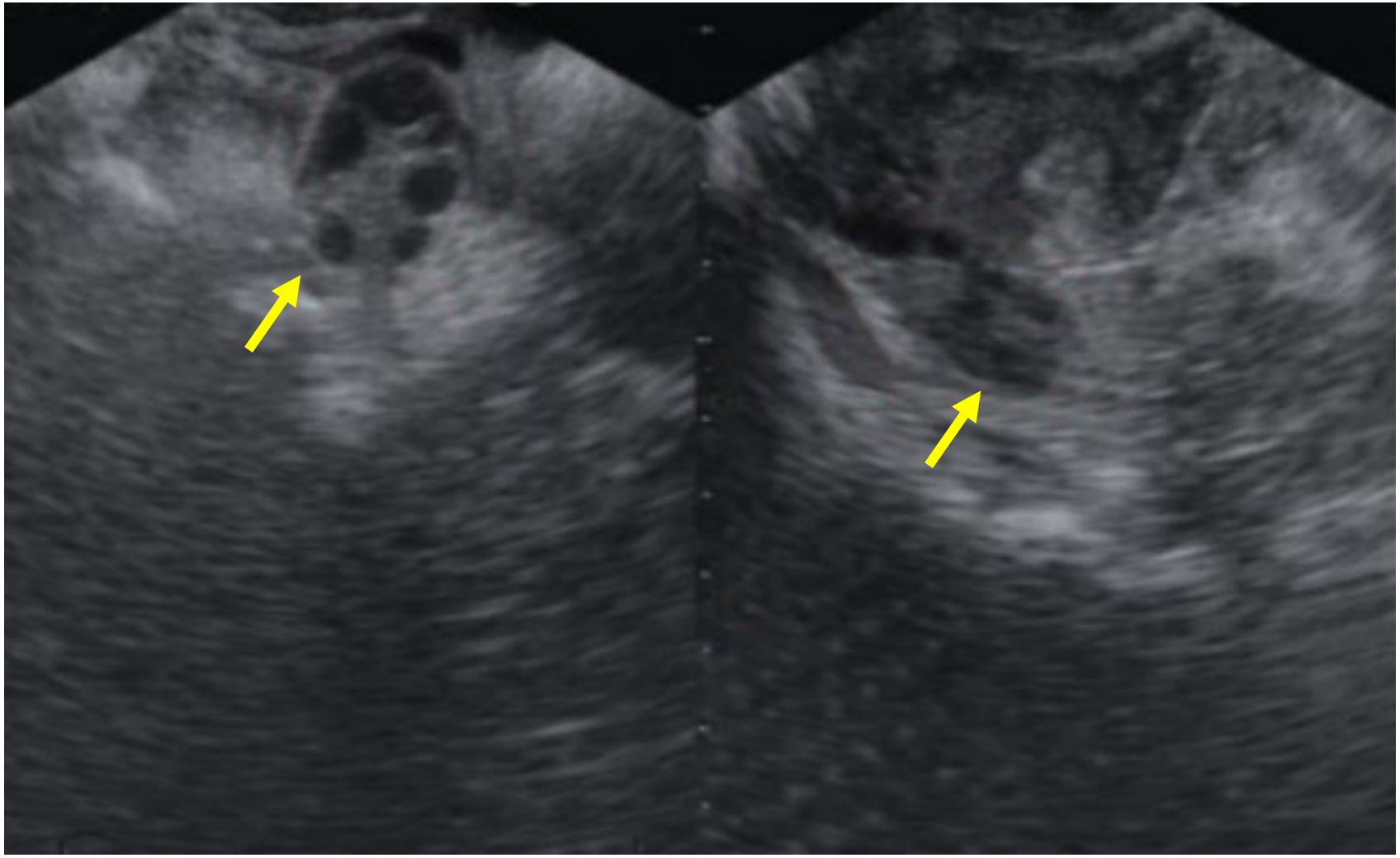
Sagittal section of the uterus



Transverse section of the uterus

Ovary

2: Explain the ultrasound image of the ovary obtained by transabdominal scanning.



You can see some follicles in the ovary.

Technique/Method
Ultrasound Examination Procedure

Objective Explain the imaging display method for transabdominal scanning in perinatal ultrasound examinations.

Check the position and size of the uterus and ovaries, uterine myoma and abnormalities of the endometrium, the presence or absence of ovarian tumor and their type, the presence or absence of pregnancy, and the presence or absence of ascites or blood around the uterus.

For pregnant women, also check the abnormalities of the fetus.

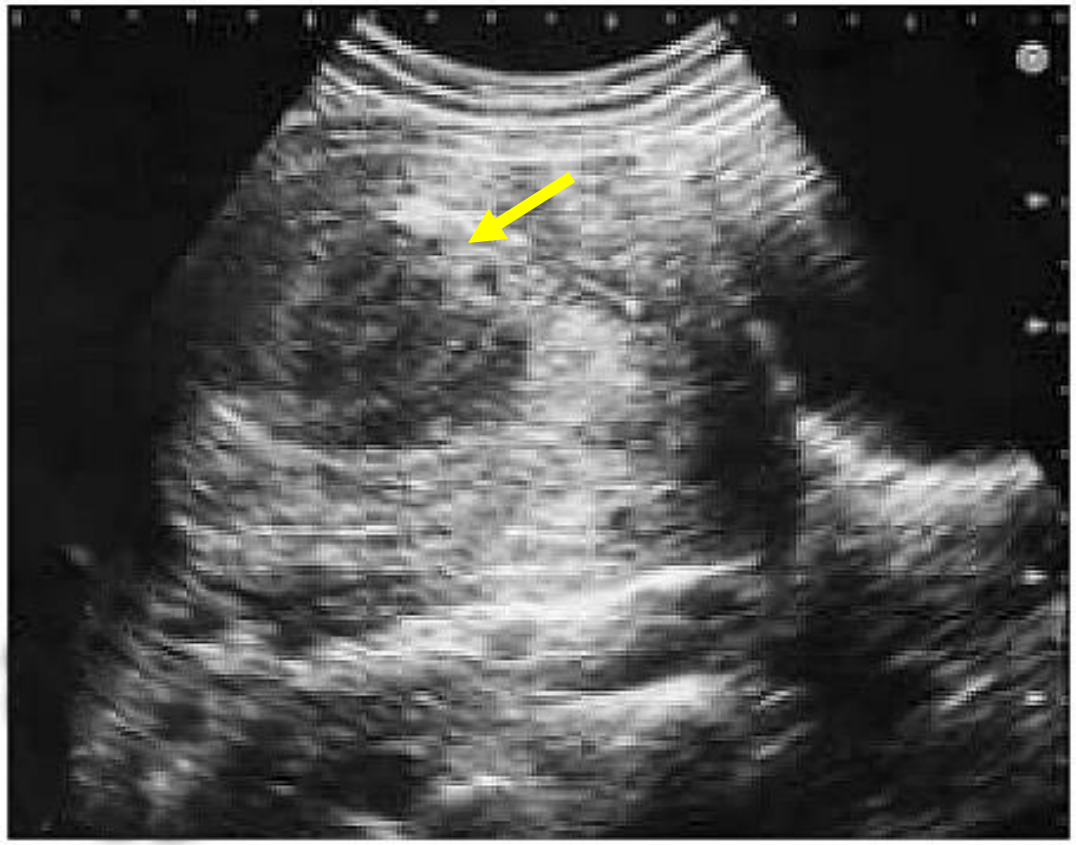
uterus/ovary

Perform the necessary scans to evaluate the uterus by transabdominal scanning.

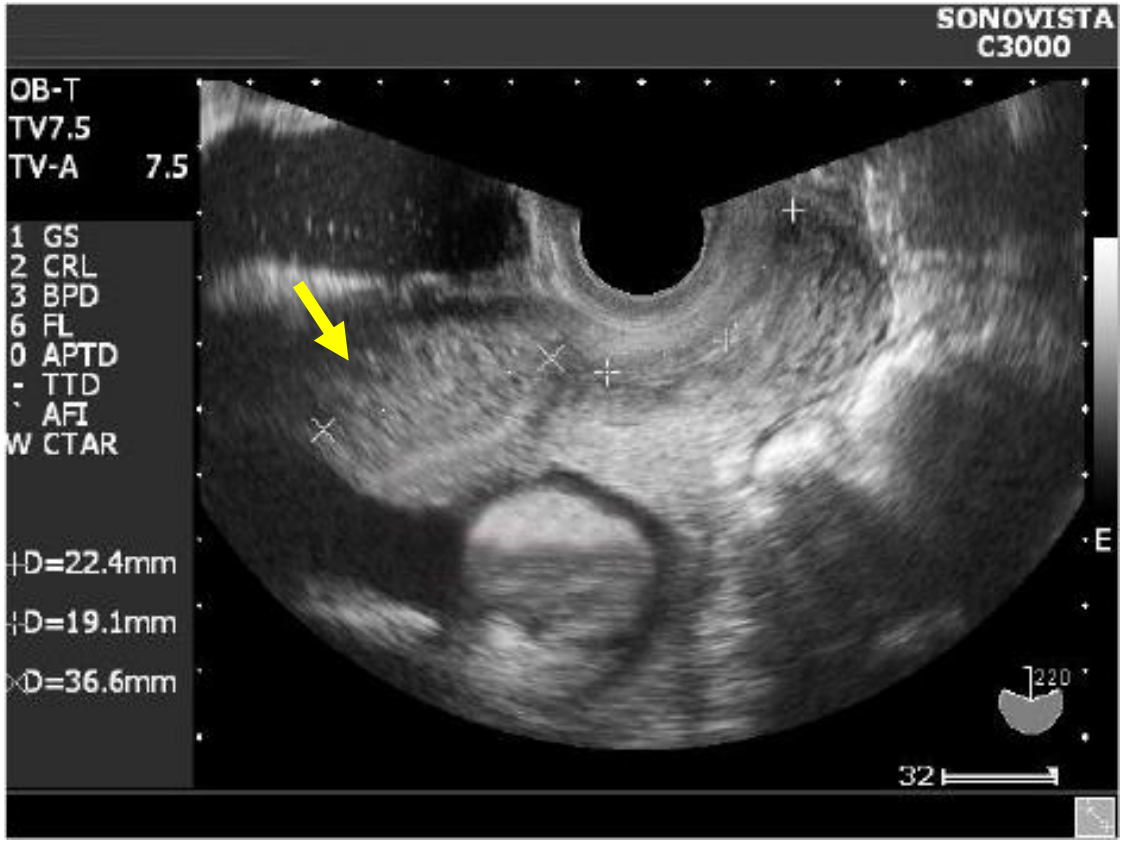
The positional relationship between the bladder and the uterus is confirmed by sagittal section. The shape of the uterus (presence or absence of myoma or adenomyosis, anteversion or retroversion) and the condition of the endometrium or uterine cavity are confirmed. The condition of the adnexa is evaluated by transverse section.

Uterine Diseases

Describe the ultrasound images of uterine myoma by transabdominal scanning



typical myoma uteri



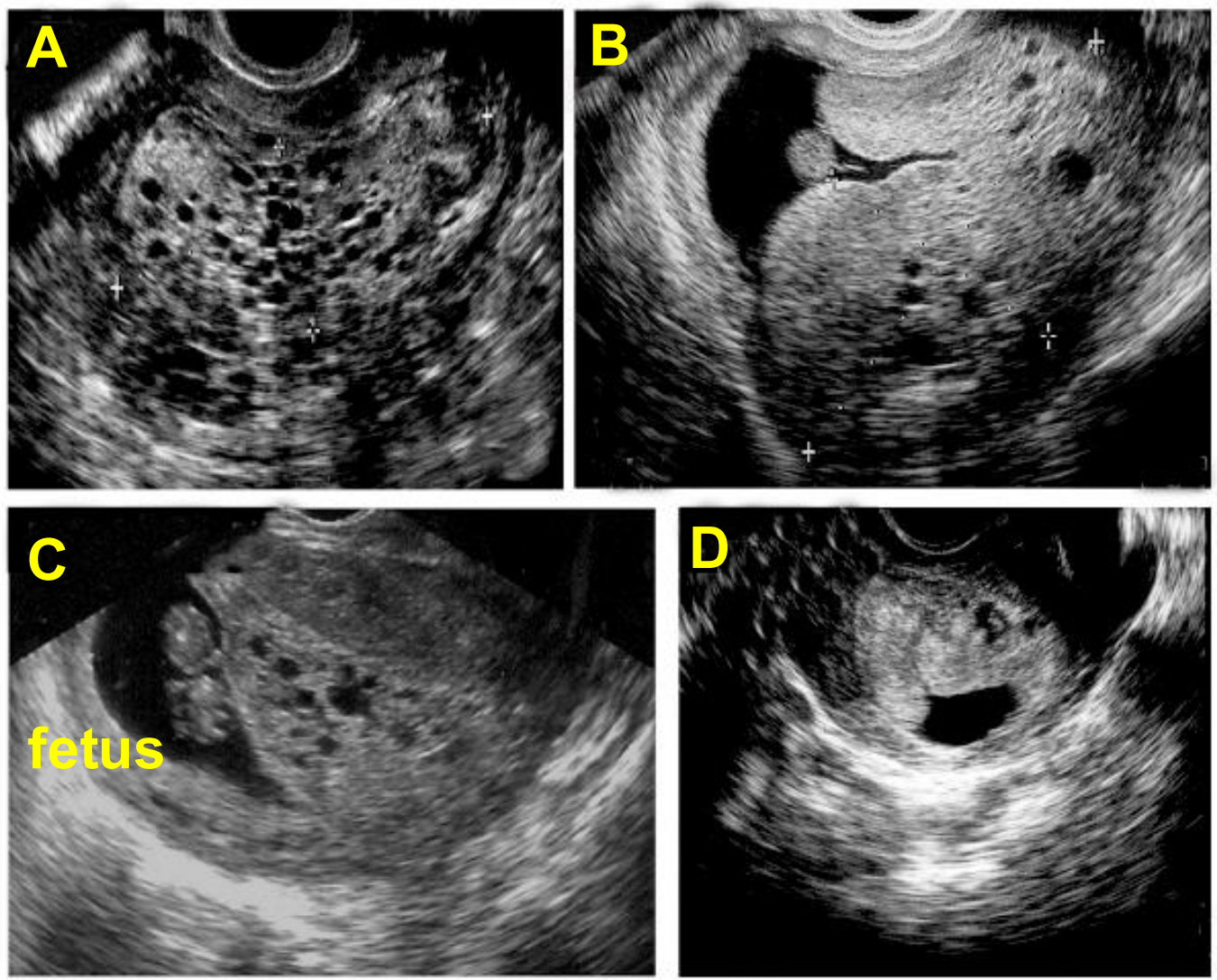
Braxton Hicks contractions?

During pregnancy, physiological uterine contractions may look like myoma.

Diagnose malignant tumors in the uterus.

androgenetic diploid

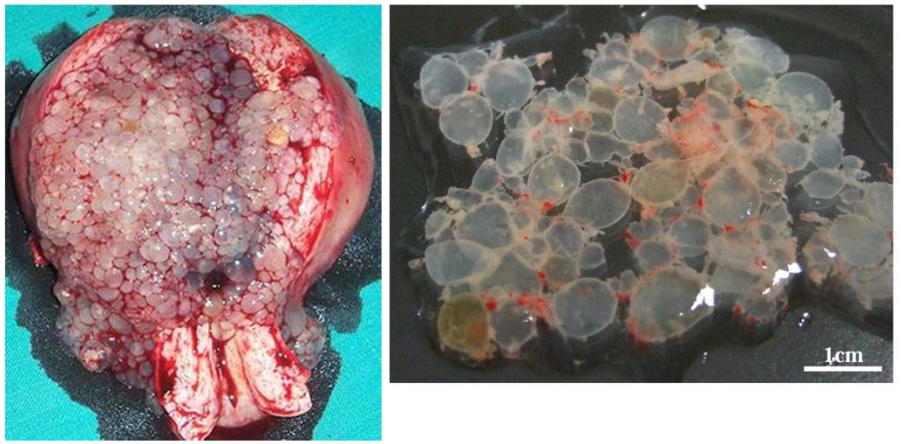
triploid



hydatidiform mole

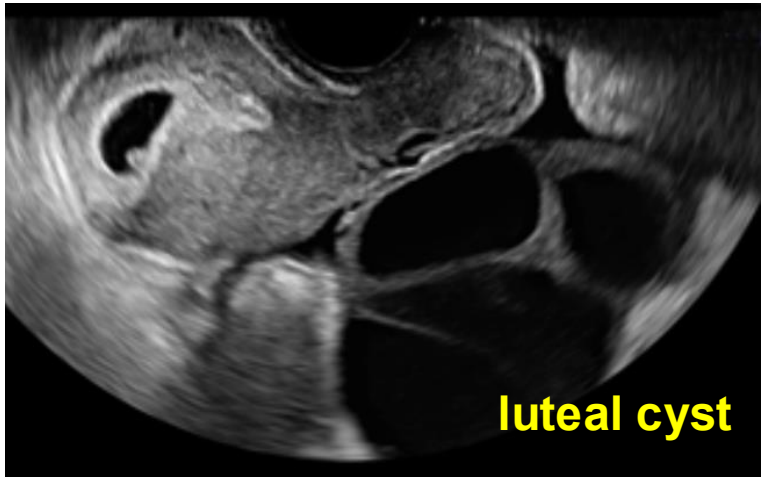
A: complete hydatidiform mole
B: partial hydatidiform mole
C: hydatidiform mole with coexis-
tent fetus
D: partial hydatidiform mole

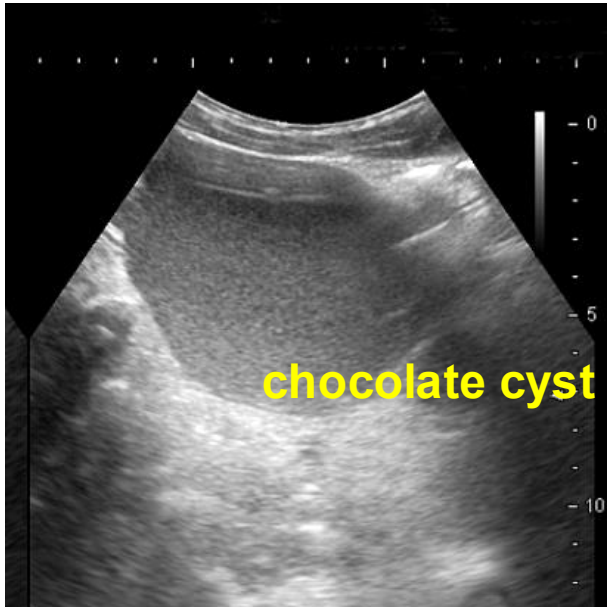
complete hydatidiform mole

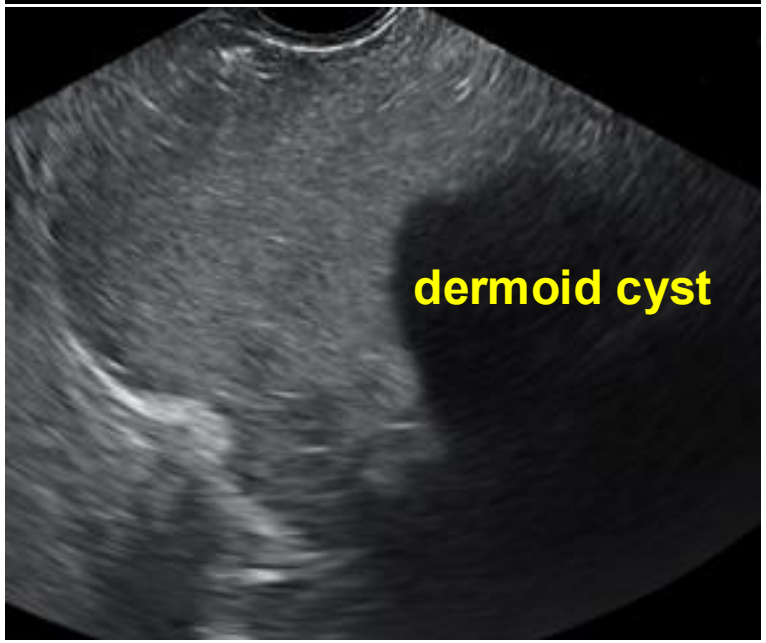


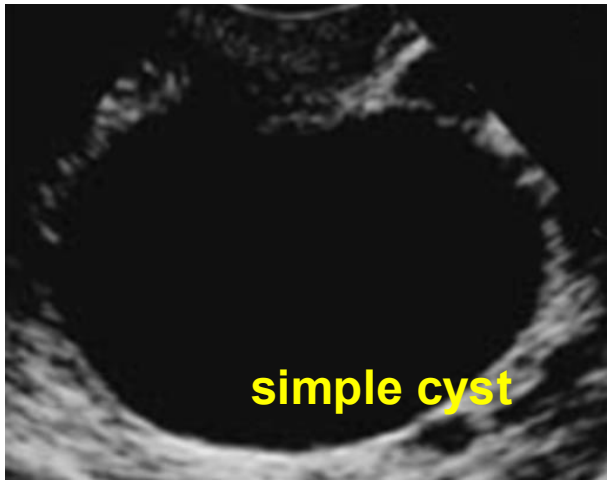
Ovarian Disease

Differentiate the ultrasound images of ovarian tumors and similar tumor by transabdominal scanning.



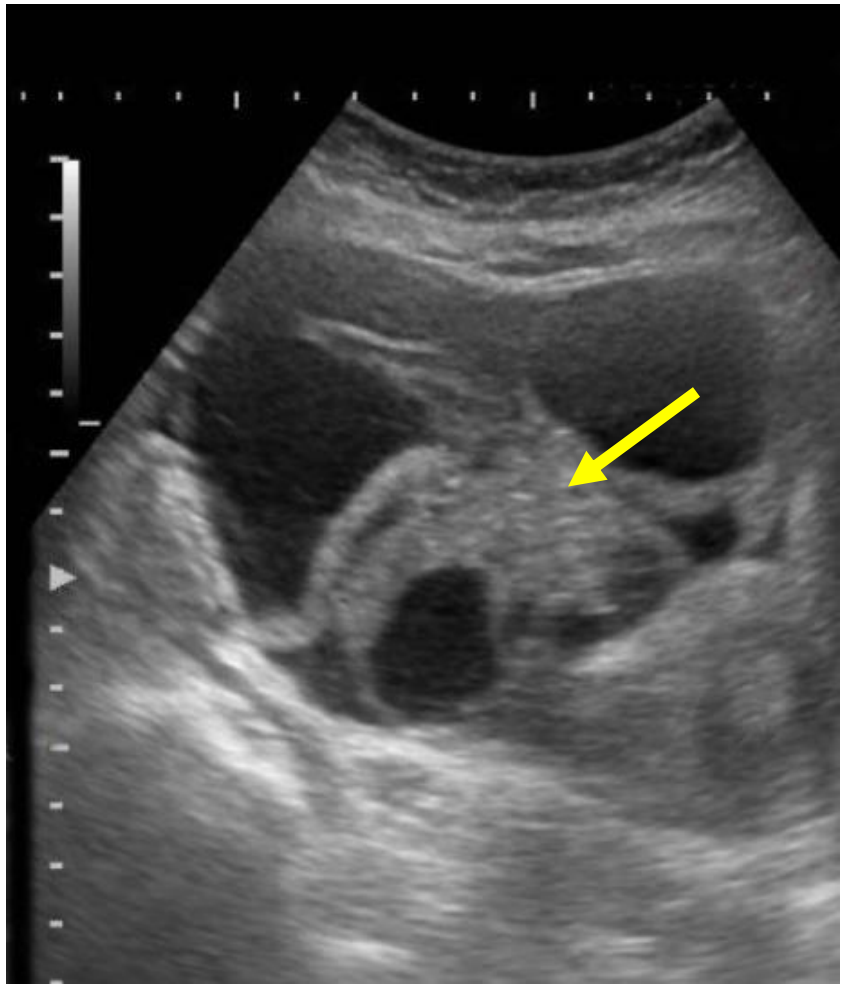


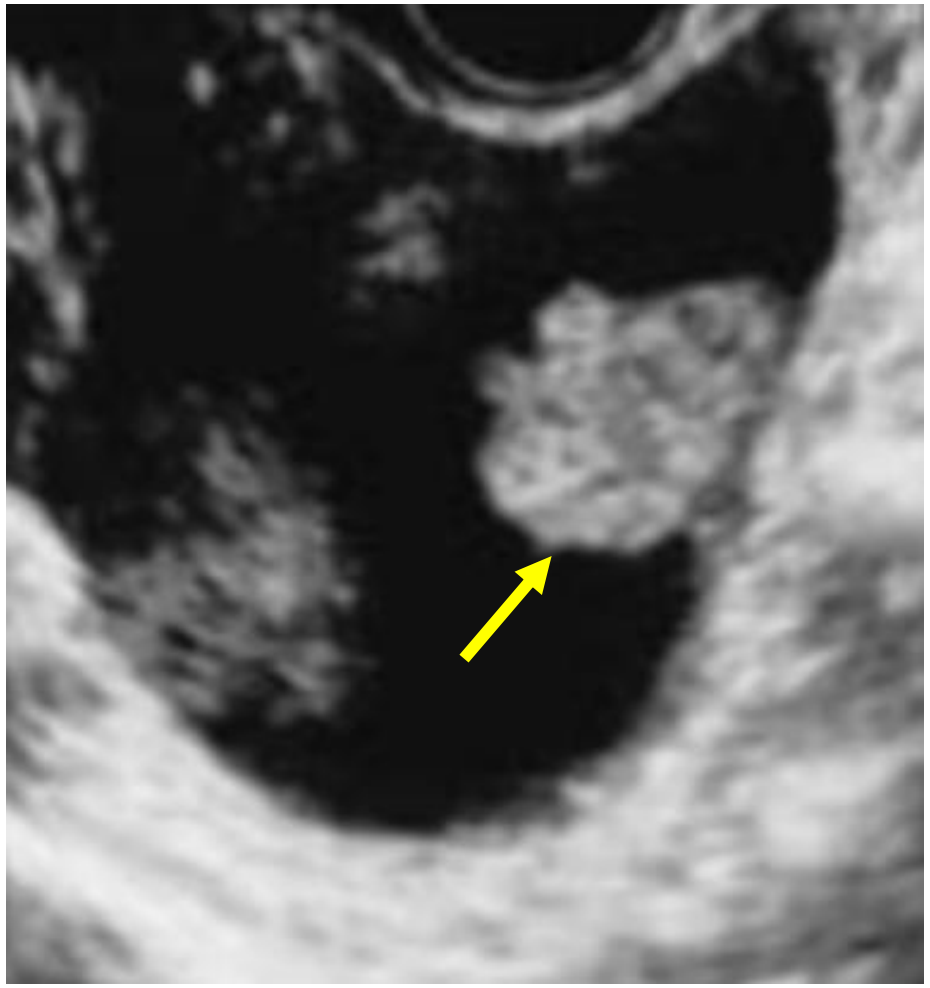




Sometimes, dermoid cyst looks like a malignant tumor due to thickening of the solid part caused by decidualization due to pregnancy.

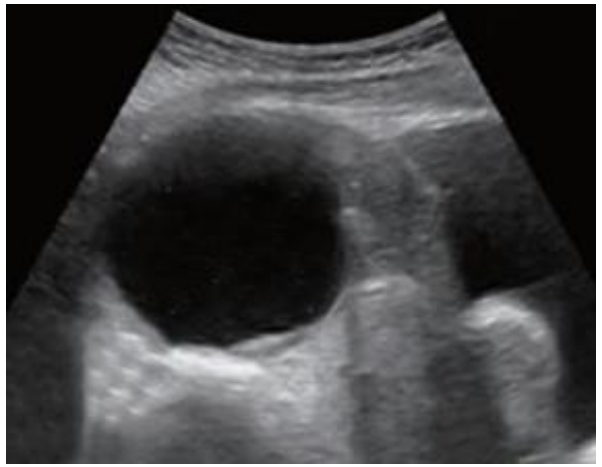
Explain the ultrasound image of malignant ovarian tumor.



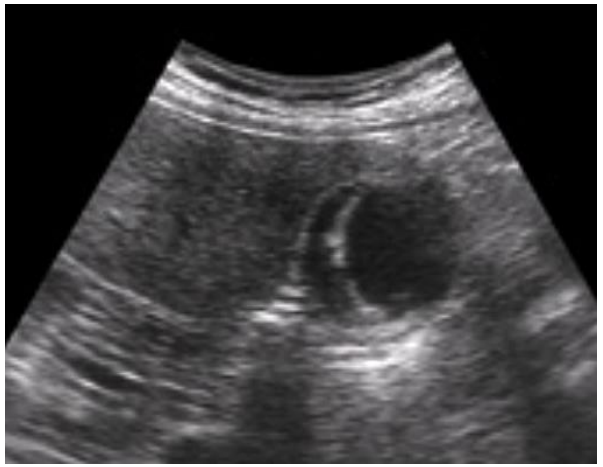


Arrows: solid part, wall thickening, and bloody ascites in the abdominal cavity indicate malignancy.

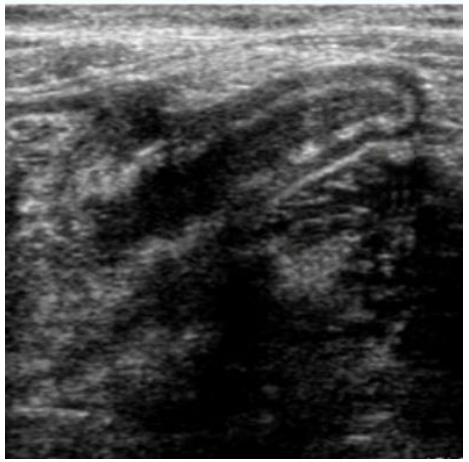
Typical diseases should be differentiated from the torsion of ovarian tumor as a cause of acute abdomen.



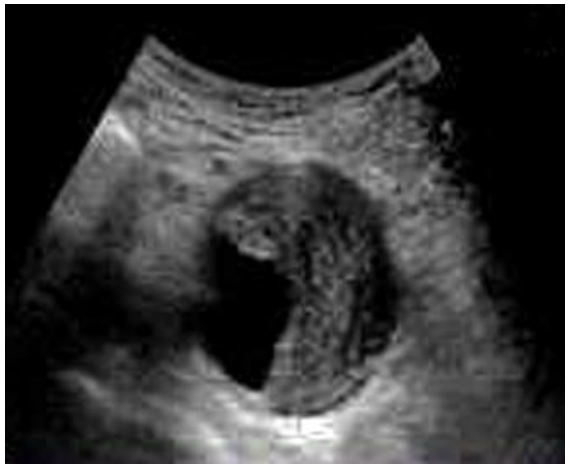
torsion of ovarian tumor



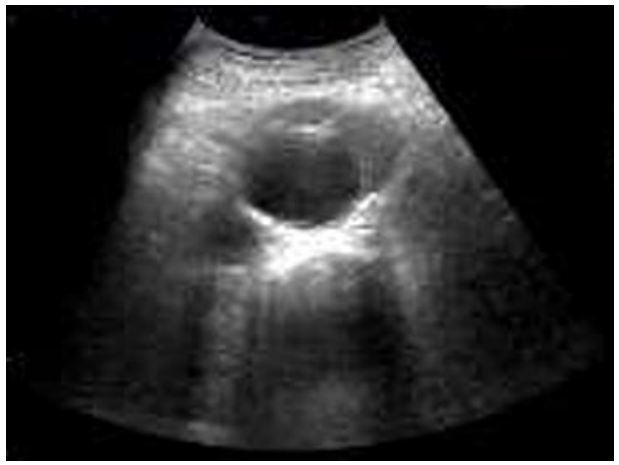
acute cholecystitis



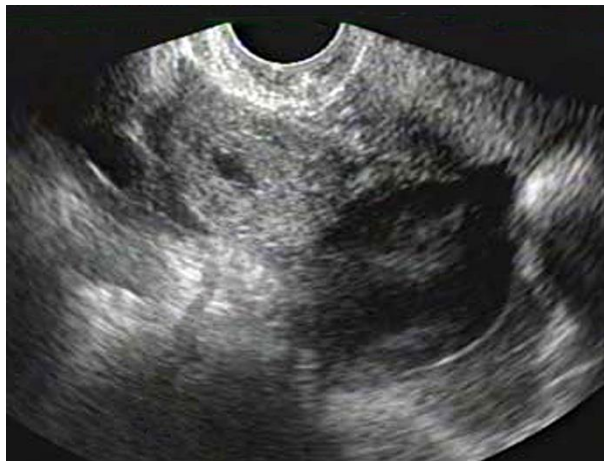
acute appendicitis



abdominal
aortic aneurysm



abdominal
aortic dissection



ectopic pregnancy

Ultrasonography in the presence of abdominal pain (point-of-care ultrasonography (POCUS))

1. Intra-abdominal fluid retention (blood, ascites)

- Intra-abdominal fluid retention can be detected rapidly with high accuracy using ultrasonography. The Morrison's fossa, peri-splenic area, and the abdominal and pelvic cavity are the primary sites for detecting intra-abdominal fluid retention. The amount of fluid detected depends on the anatomic site and patient position. In initial trauma care, focused assessment with sonography for trauma (FAST) is used to evaluate intra-abdominal fluid retention to assess circulation and suspect blood loss. FAST has high specificity and low sensitivity in detecting and ruling out organ damage. Therefore, in patients with suspected blunt trauma, a positive finding may help guide treatment decisions, whereas a negative finding cannot exclude intra-abdominal fluid and should be confirmed by CT scan or other means. In endogenous diseases, the search for intra-abdominal fluid retention by FAST is recommended in patients presenting with abdominal symptoms or shock. Although there are limited validation studies on the detection of endogenous intra-abdominal effusions by ultrasonography, there are reports of shorter time to diagnosis and treatment in ectopic pregnancies and a higher rate of emergency surgery in positive cases.

2. Acute cholecystitis

- Acute cholecystitis is a frequent disease, and the gallbladder is relatively easy to visualize by ultrasonography, so the first use of POCUS is to find a positive diagnosis of acute cholecystitis. In addition to clinical symptoms such as pain in the right hypochondrium, a positive finding on ultrasound can be quickly identified as acute cholecystitis and is often used as the first imaging diagnosis. In addition to the basic right hypochondriacal scan, an intercostal scan can also be performed to increase the accuracy of the examination. Ultrasound findings in acute cholecystitis include gallbladder stones, gallbladder wall thickening, gallbladder swelling and peri-gallbladder fluid retention. Although there are reports that excellent sensitivity and negative predictive value can be obtained even with the presence of gallbladder stones alone, it should be noted that identification of gallbladder stones lodged in the neck is not always easy. The sonographic Murphy's sign, in which pain is enhanced when the gallbladder is pressed with a probe, is also useful for diagnosis.

3. Abdominal aortic aneurysm, abdominal aortic dissection

- The normal diameter of the adult abdominal artery is generally considered to be 20mm. When the diameter exceeds 30 mm and the size of the aneurysm is spindle-shaped or when the arterial wall is locally dilated (saccularly), it is called an abdominal aortic aneurysm. The indication for invasive treatment of asymptomatic abdominal aortic aneurysms is recommended to be at least 50 mm in the shortest diameter for women, but invasive treatment may be considered even if the diameter is less than the indicated size. In particular, saccular aneurysms are considered to have a high risk of rupture and are therefore often indicated for surgery at an early stage, even if the size is smaller than that of a spindle-shaped aneurysm. The diameter of a spindle-shaped aneurysm is determined by drawing the largest short-axis cross section perpendicular to the long axis, and the diameter (round) or short-axis (oval) is used as the diameter of the aneurysm. The diameter of the aneurysm is defined as the longitudinal diameter from the normal artery to the tip of the saccular aneurysm. The diameter of the aneurysm is measured between the external membranes. The most important problem with abdominal aortic aneurysms is rupture, and generally, if there is leakage of fluid outside the vessels, the aneurysm will rupture or leak.

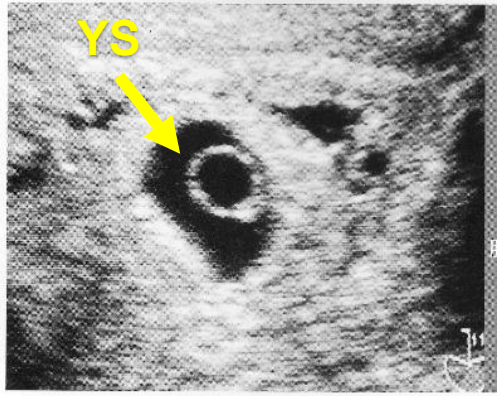
4. Ureteral calculi (hydronephrosis), urinary retention

- Colic attacks due to ureteral calculi are characterized by severe abdominal pain, lumbar back pain and radiating pain to the external genitalia and thighs. Gastrointestinal symptoms such as nausea, vomiting, and abdominal distention may also be seen. Because typical symptoms may be absent, appropriate diagnostic imaging is necessary. Ultrasonography is noninvasive and useful in the evaluation of obstruction of the upper urinary tract as hydronephrosis and for evaluation of stones near the bladder. Hydronephrosis is evaluated at the long axis cross section of the kidney. The diagnosis of hydronephrosis is made by echo-free dilated renal pelvis or renal cup within a high-echoic renal sinus.

5. Acute appendicitis

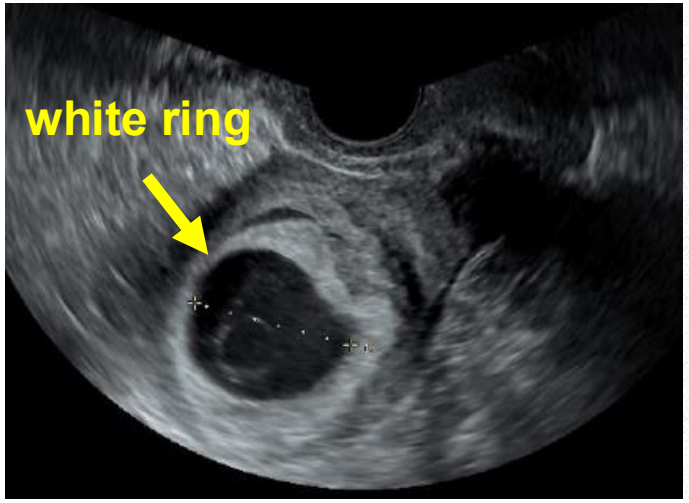
- Acute appendicitis is a common disease, and in most cases the clinical picture is typical, but there are some cases in which the past history and physical findings are not consistent with a typical clinical picture. Even if acute appendicitis is suspected, there are many conditions that should be differentiated, including diverticulitis and enteritis, and CT is often needed. In acute appendicitis, the swollen appendix is depicted as a luminal structure with a maximum diameter exceeding 6 mm that is not easily deformed by pressure without peristalsis. A sonographic McBurney sign is present, with the location of the sign coinciding with the point of tenderness. Fecal calculus, inflammatory findings in the surrounding fatty tissue, and the presence of surrounding fluid retention are also helpful. Failure to demonstrate a swollen appendix on ultrasonography alone does not rule out acute appendicitis. If the diagnosis of acute appendicitis cannot be made by POCUS, repeat the examinations at intervals, and additional imaging studies (CT or MRI) are recommended to confirm the diagnosis of acute appendicitis.
- The greatest feature of the appendix in pregnant women is that its position changes with the weeks of gestation. Since the uterus is enlarged and the appendix shifts to the lateral side after the fourth month of pregnancy, it is necessary to use careful imaging from the right lower abdomen to the lateral abdomen. The pain is felt in the right lower abdomen in the early stages of pregnancy, but it should be noted that the site of pain shifts with the weeks of gestation. Acute appendicitis is diagnosed when the enlarged appendix exceeds 6 mm in short diameter and is not deformed by compression.

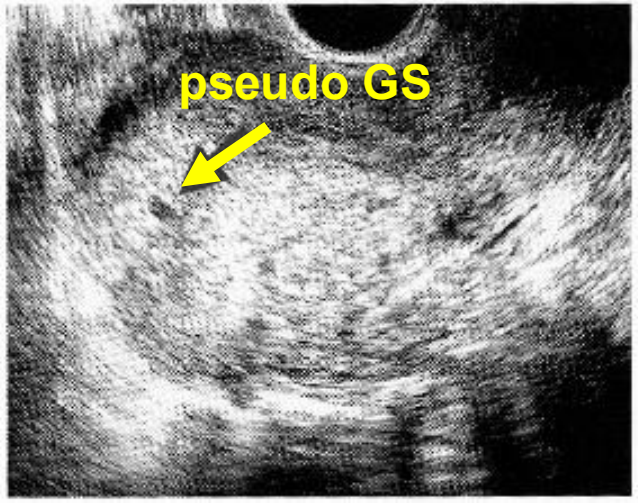
Ultrasound Examination in the Perinatal Period
II. Ultrasound examination of the fetus, fetal appendages, and pregnant uterus



- Ultrasonography should be performed along with physical examination for pregnant women who visit the clinic with symptoms such as abdominal pain and genital bleeding. Ultrasonography is used to detect intrauterine pregnancy (normal pregnancy), ectopic pregnancy, fetal weight at all stages of pregnancy, gestational age, and large fluid retention in the pelvic cavity. Concomitant intrauterine and extrauterine pregnancy is rare in pregnancies after assisted reproductive technologies, which have been increasing in recent years. Normal pregnancy is confirmed by the presence of an intrauterine gestational sac (GS), but definitive proof can only be obtained by observation of the yolk sac (YS) in GS. In most cases, YS becomes visible when the diameter of GS exceeds 8 mm and the diameter increases to a maximum of 6 mm at 10 weeks, after which it disappears completely by 12 weeks. Maternal trauma after 23 weeks may cause complications such as abruptio placentae, uterine rupture, and preterm delivery.

[Anatomy and Physiology]
Evaluate gestational sac (GS) (5th to 8th week of gestation)





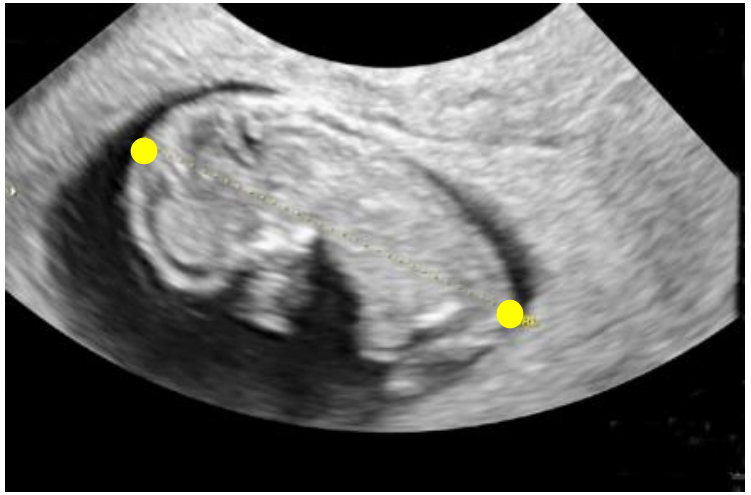
Measure the longest distance of GS

GS = gestational weeks - 4cm

Pseudo GS : w/o white ring

(= chorionic villi)

Evaluate CRL (crown rump length) (8th to 11th week of gestation)



CRL = gestational weeks - 7cm

Explain the effects of ultrasound on living organisms and the safety limits of ultrasound on fertilized eggs and embryos

- It is reported that after diagnostic pulsed ultrasound was irradiated on pre-implantation embryos of small animals 72 hours after fertilization, no abnormalities were observed in the embryos, and after the irradiated embryos were transferred to the animal uterus, there were no abnormalities in the implantation rate, fetal development, or newborn's condition.

Explain the indicators and definitions used to quantitatively evaluate the intensity and biological effects of ultrasound

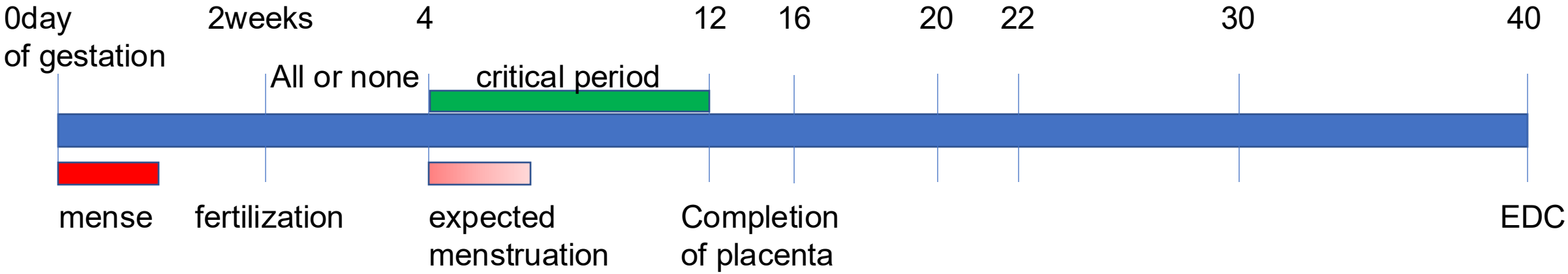
- **Intensity of ultrasound:** Acoustic energy passing through a unit area in a unit of time perpendicular to the direction of the ultrasound wave propagation (W/m^2)

- The effects of ultrasound on the human body are thought to be due to tissue damage caused by the mechanical effects of ultrasound and an increase in tissue temperature caused by the thermal effects.
  - **Thermal effect:** When ultrasound is conducted through tissue, the energy is rapidly absorbed by the deeper tissue and converted into heat energy as it dissipates.
  - **Non-thermal (mechanical) effect:** The fine vibrations of ultrasound promote the circulation of intercellular tissue fluid resulted in activating the cells.

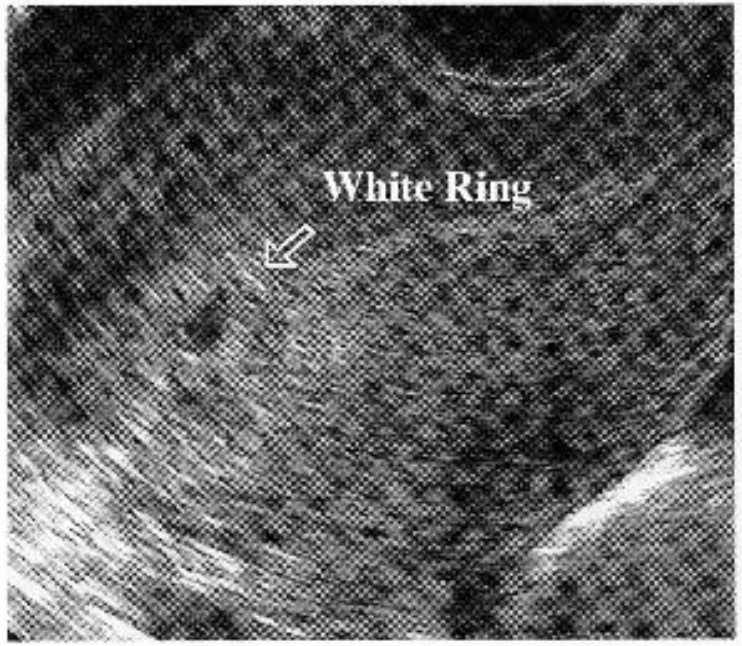
Data of echo in the beginning of pregnancy

- **fertilization ・implantation～8th weeks of gestation：embryo**
  - 3rd～4th ：human chorionic gonadotropin (hCG) 25 IU/L
  - end of 4th ：gestational sac（GS）visible（pseudo GS in ectopy）
  - 5th ：yolk sac（YS）visible
  - 6th ：fetal heart beat (FHB) visible

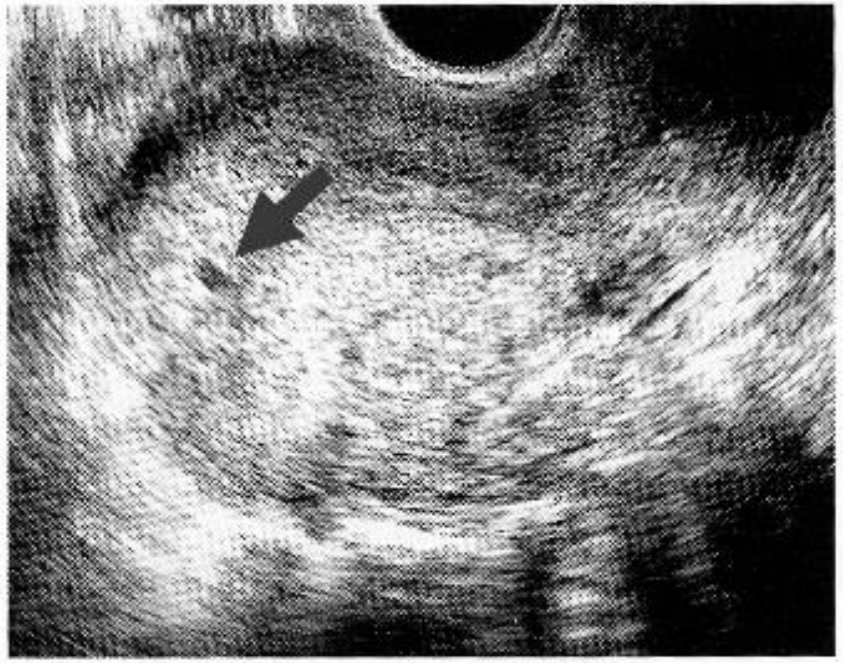
- **after 8th weeks of gestation：fetus**
  - 8th～11th：CRL is accurate
  - 12th～ ：biparietal diameter (BPD) = gestational week/4 (cm)



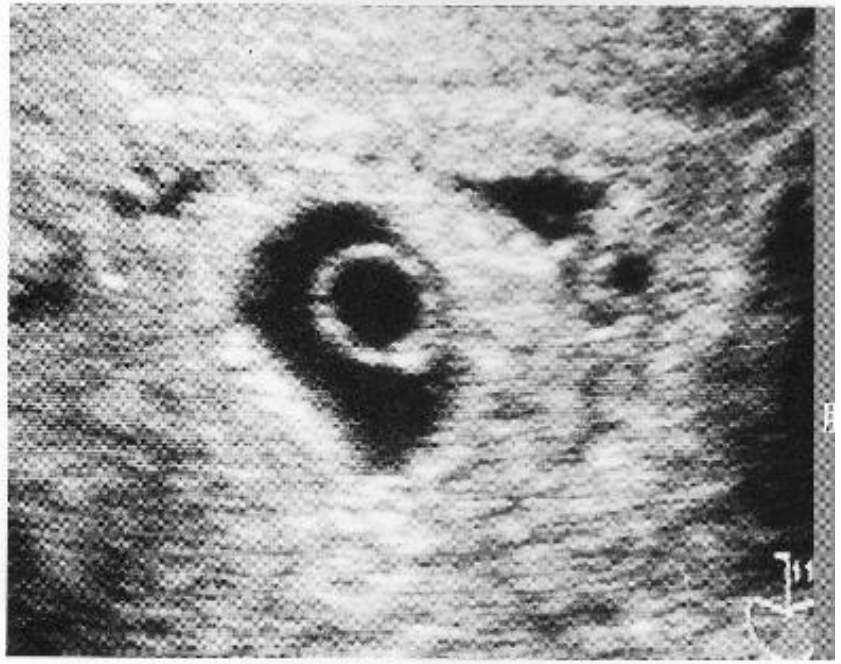
GS: w/ white ring



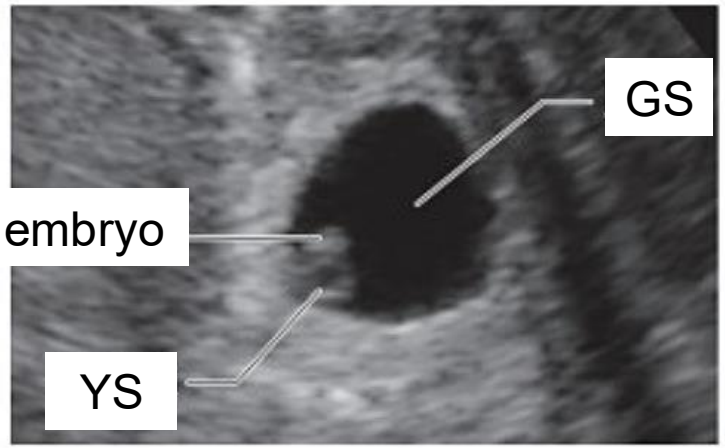
pseudo GS: w/o white ring



YS



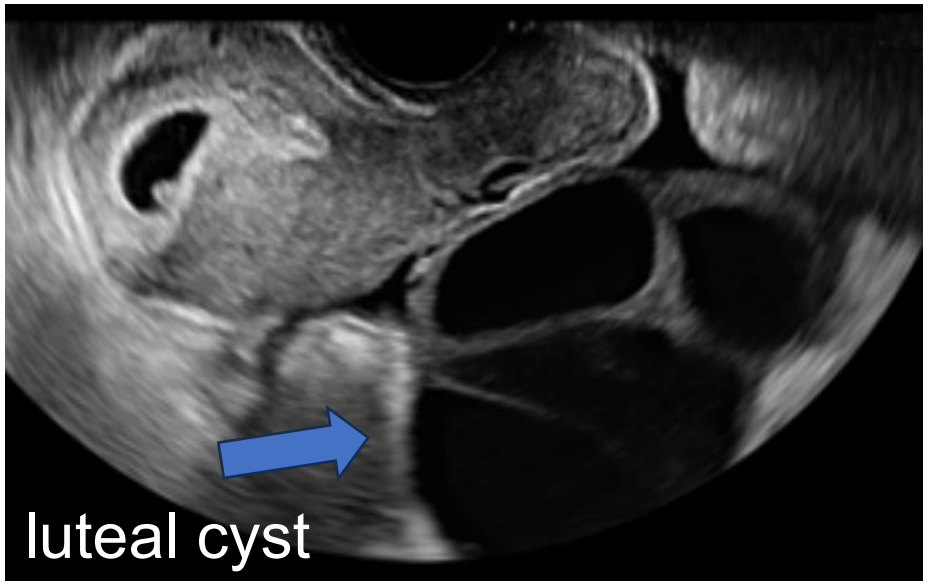
6 weeks of gestation

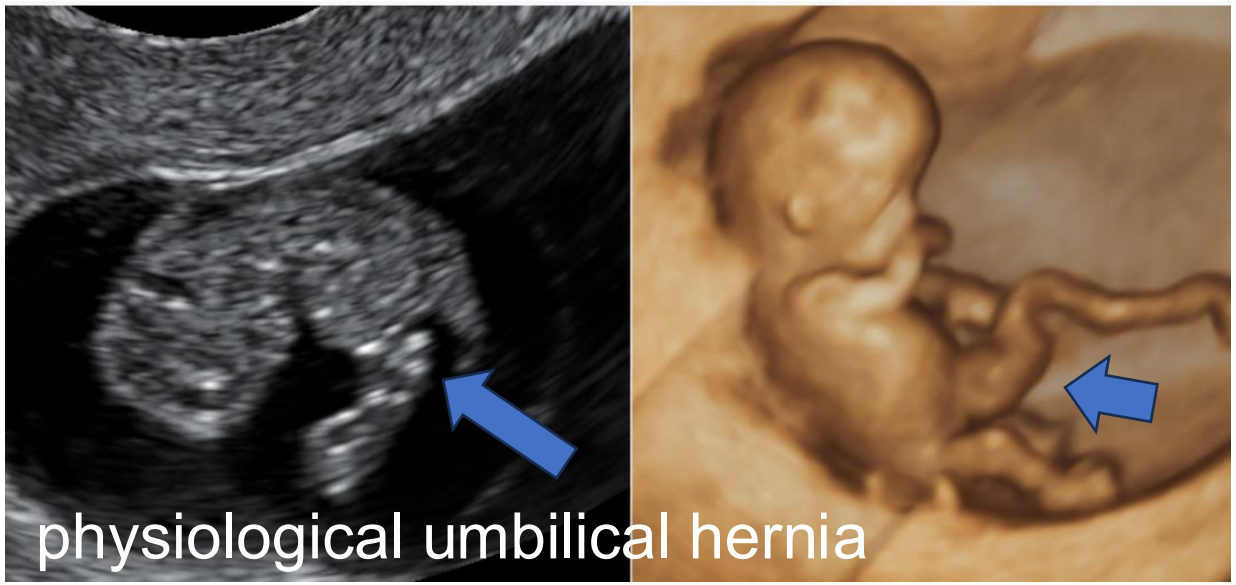


Ultrasonography at 7-8 weeks of gestation

- 7th ：brain vesicles in the cranium of embryo
- end of 8th ：physiological umbilical hernia（diameter < 7 mm）

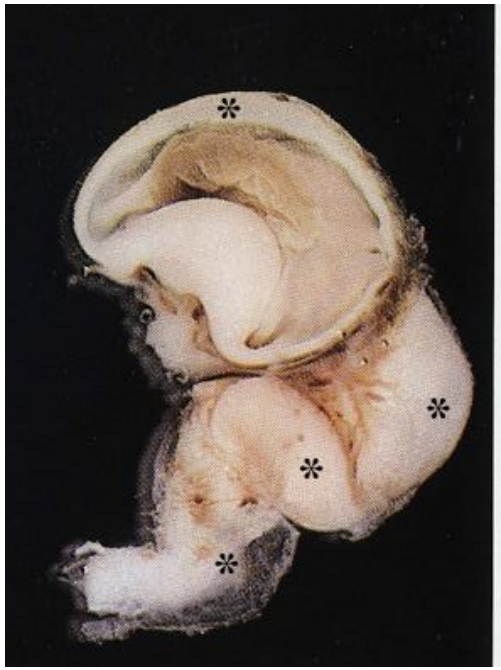
  （repaired by 12 weeks of gestation）
- luteal cyst： Shrinking at 12-16 weeks of gestation

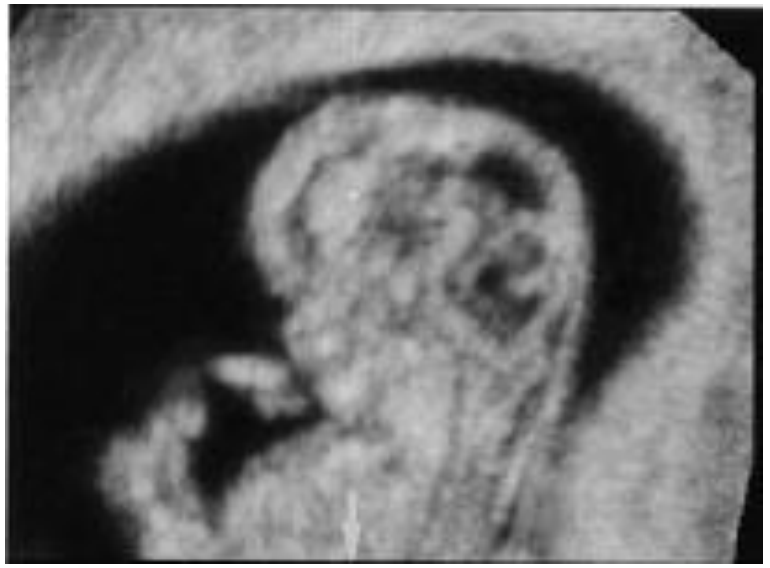


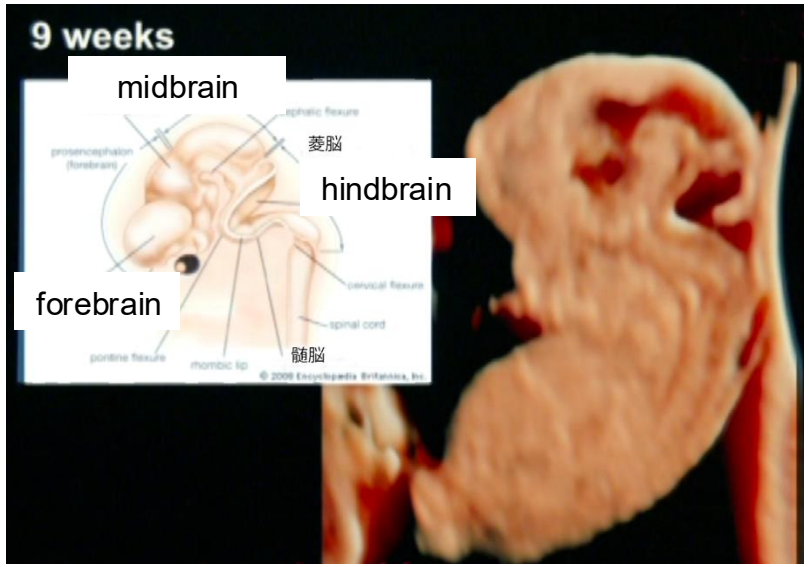


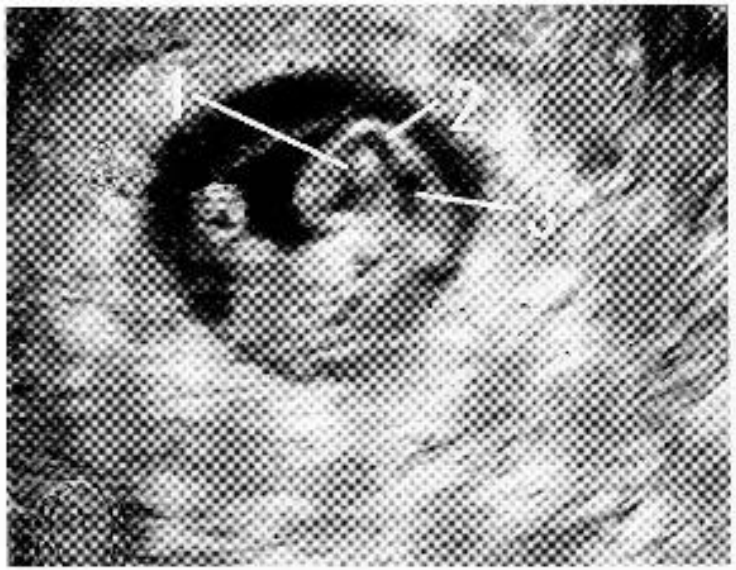
Embryology early in pregancy (central nervous system)

8th weeks of gestation









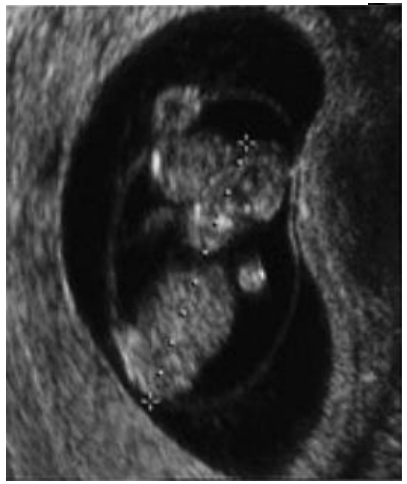
1: forebrain（lateral ventricle・third ventricle）
2: mesencephalon（mesencephalic aqueduct）
3: hindbrain（fourth ventricle）

At 11th weeks gestation, the brain structure is almost completed, and the cerebellum can be observed.

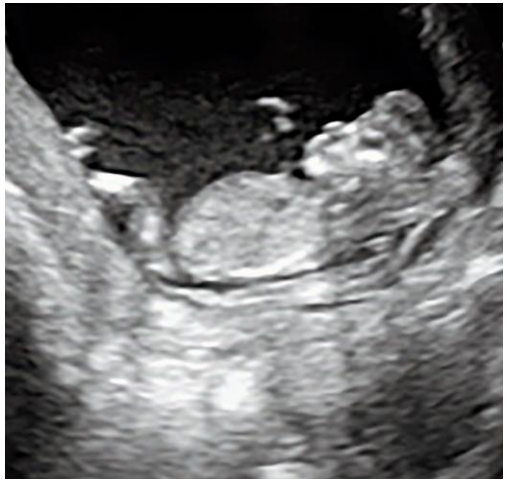
Ultrasonography checkpoints ～ 15th week gestation

ultrasonographic findings	Diseases to speculate on
Abnormality of head (irregular skull)	Anencephaly, acrania
Defect of four extremities	
Single cerebral ventricle	Holoprosencephaly (13+)
Rt deviated heart	Congenital diaphragmatic hernia
Organs outside the abdominal cavity	Umbilical hernia, abdominal wall rupture
Multicystic mass in utero	Hydatidiform mole
Intramuscular myometrial mass	Myoma uteri
Extrauterine mass	Ectopic pregnancy
Severe nuchal translucency (NT)	Down syndrome (21+)

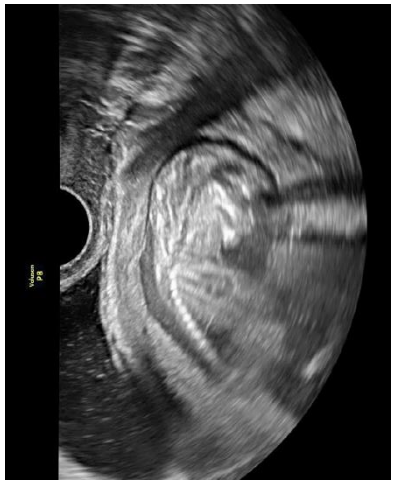
Head abnormalities found in early pregnancy



10th week’ gestation

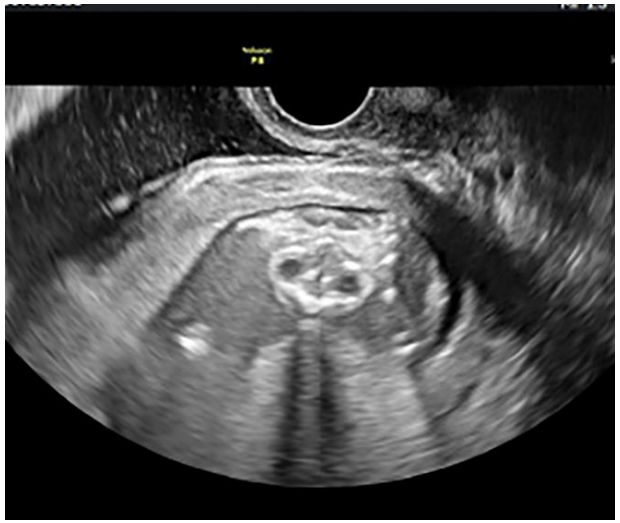


13th

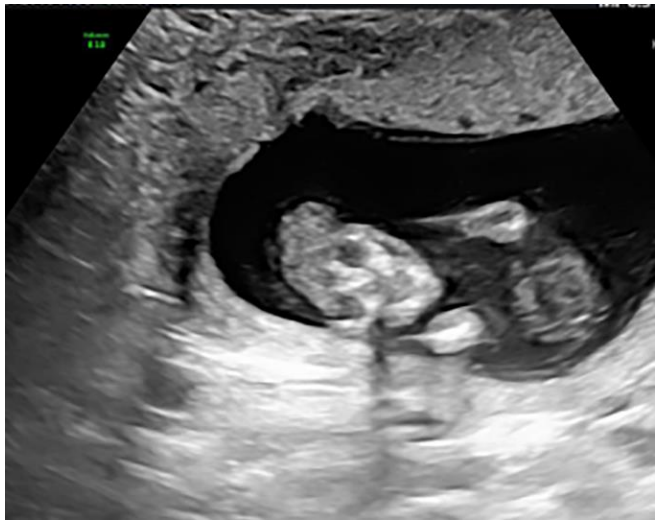


15th

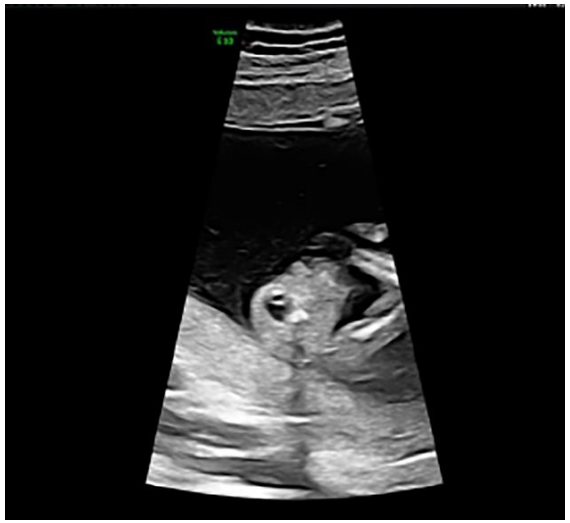
- **Acrania～anencephaly**: A condition in which the skull is missing, and the brain is exposed into the amniotic cavity, but by 12 weeks' gestation, the escaped brain is destroyed and lost, resulting in anencephaly.



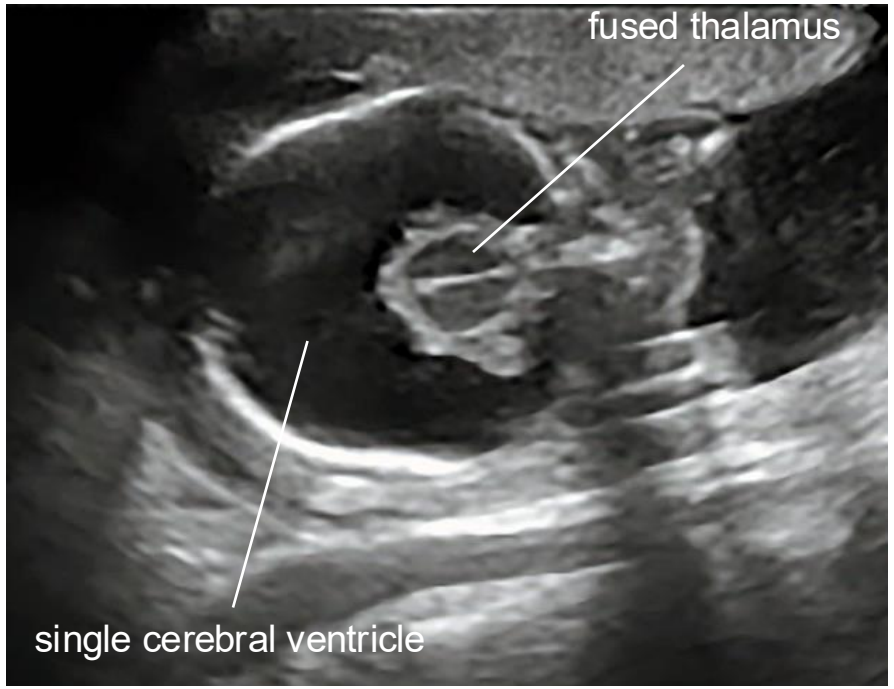
15th weeks' gestation

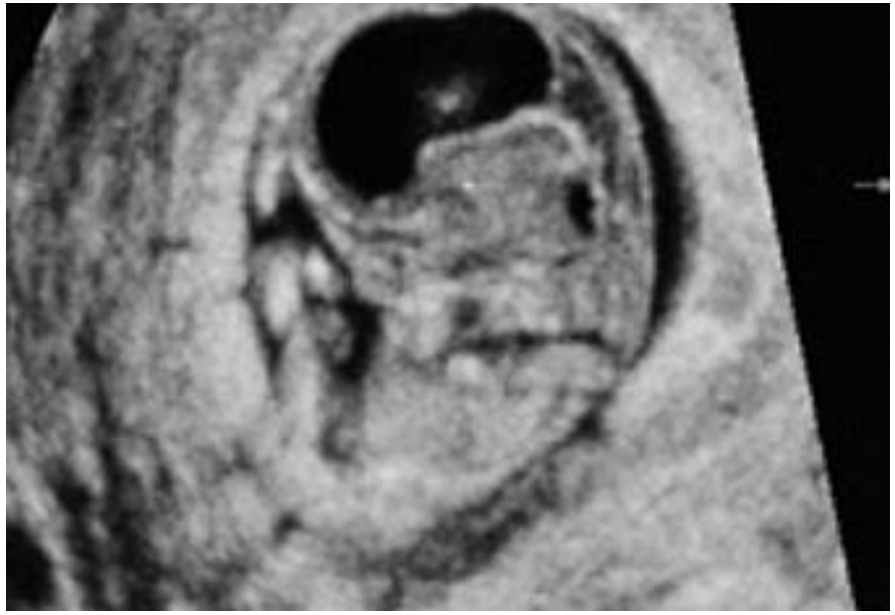


16th



16th

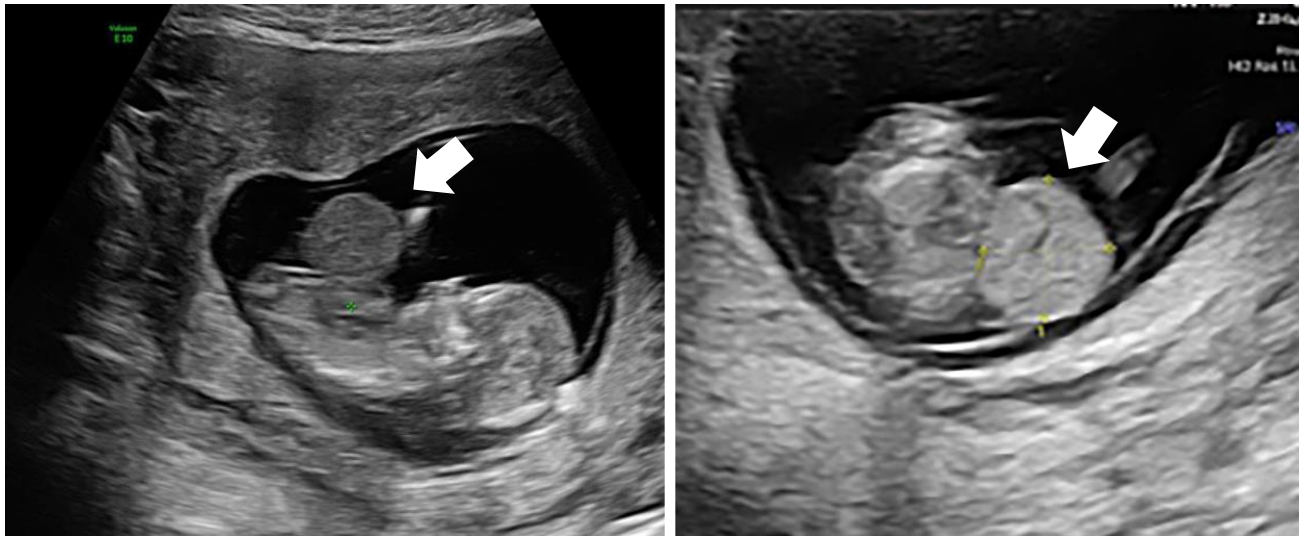




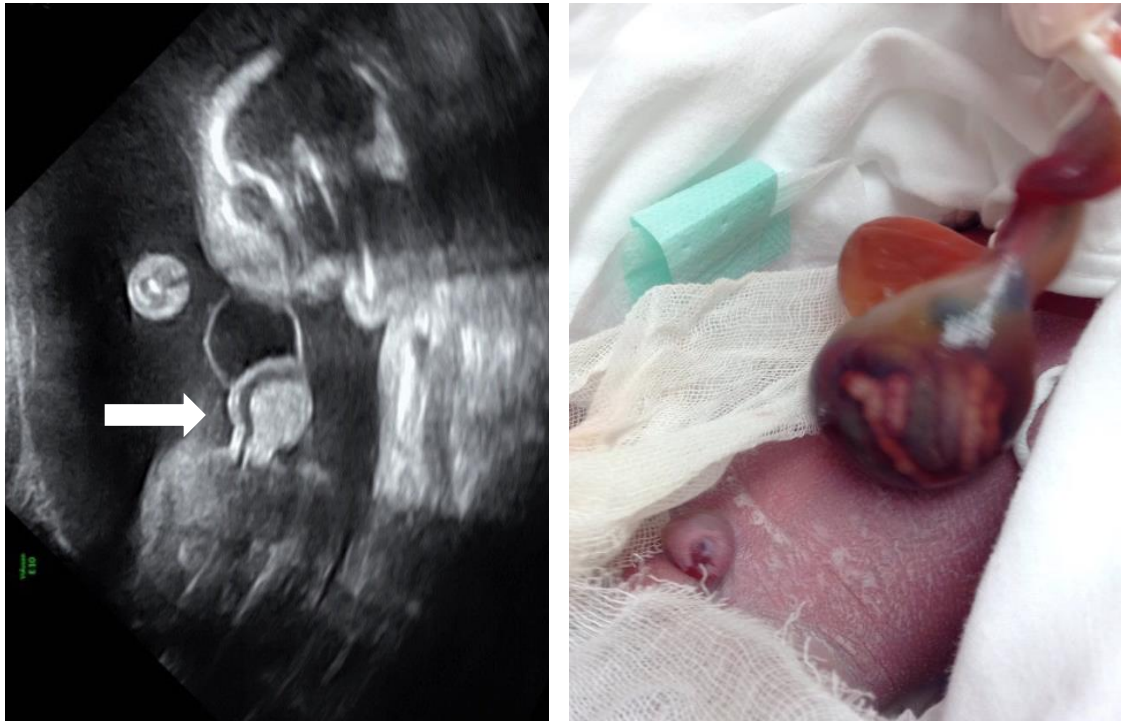
13 weeks' gestation

Holoprosencephaly : Insufficient formation of the forebrain. Differentiation into the left and right lateral ventricles is impaired, forming a single cerebral ventricle. The thalamus is fused due to impaired differentiation of the mesencephalon resulting in no 3rd cerebral third ventricle. If facial malformations are present, 13 trisomy is mostly suspected.

Pathological umbilical hernia



12th weeks gestation; 18+



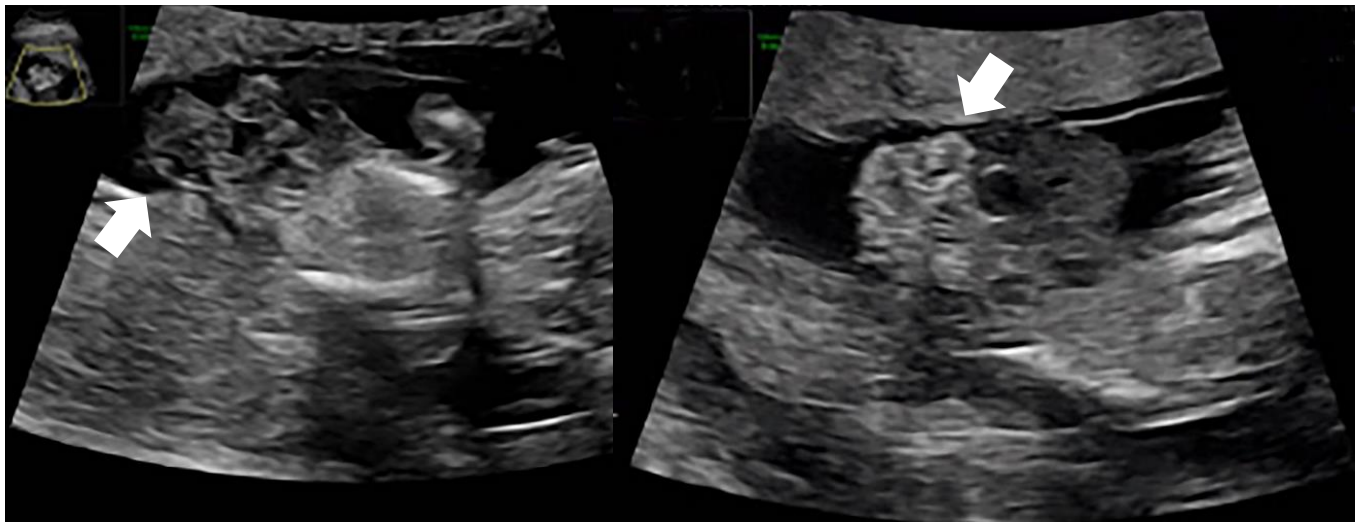
24th weeks gestation; 18+

- Umbilical hernia (12 weeks' gestation): The hernia sac is more than 10 mm and NT 7 mm, so trisomy is suspected.
- Association with 18+, 13+: If only the intestinal tract migrates into the hernia sac, the risk of chromosomal abnormality is increased compared to when the liver is included.
- Physiological hernia sacs are never more than 7 mm.

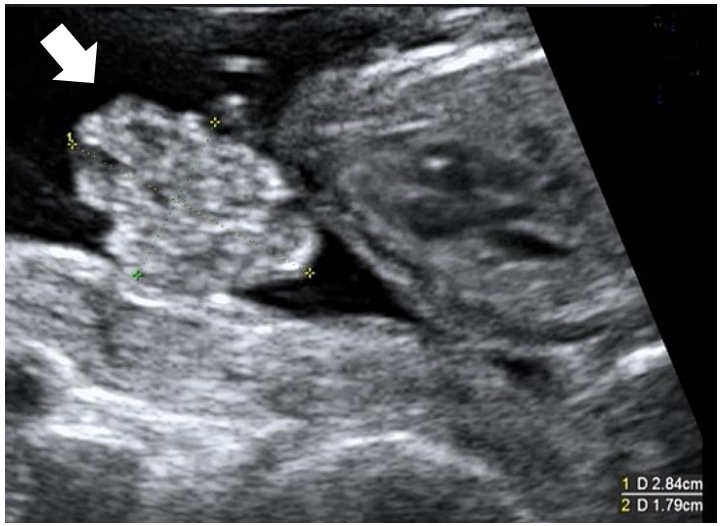
Gastroschisis

- Chromosomal abnormalities are rare.
- The umbilical cord is normal, and the intestinal tract go from a nearby defect in the abdominal wall. **Causes:** smoking, abdominal wall dysplasia, etc.
- The intestinal tract becomes inflamed and thickened by amniotic fluid, causing postnatal intestinal obstruction.

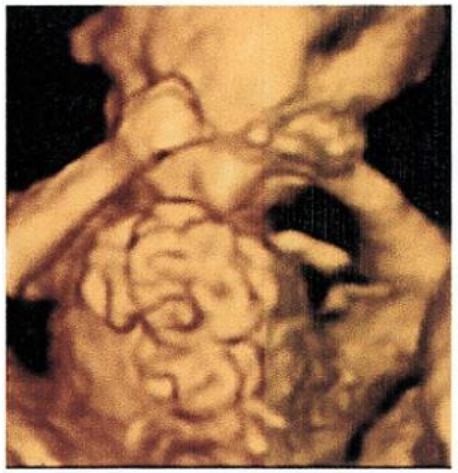
14th weeks gestation



18th



12th

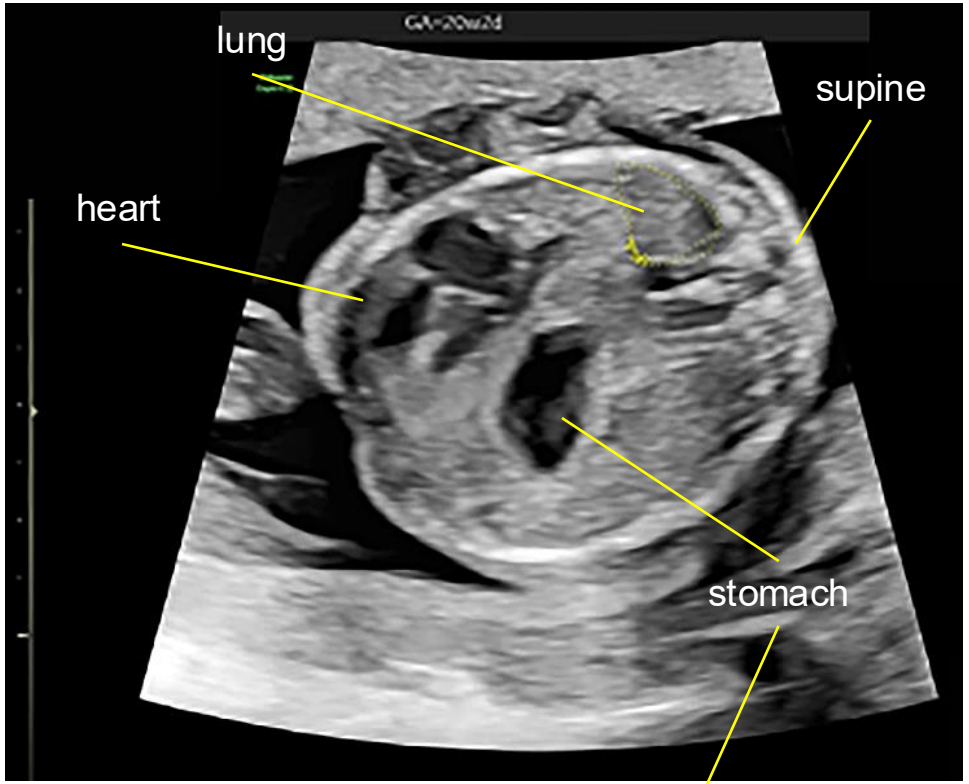


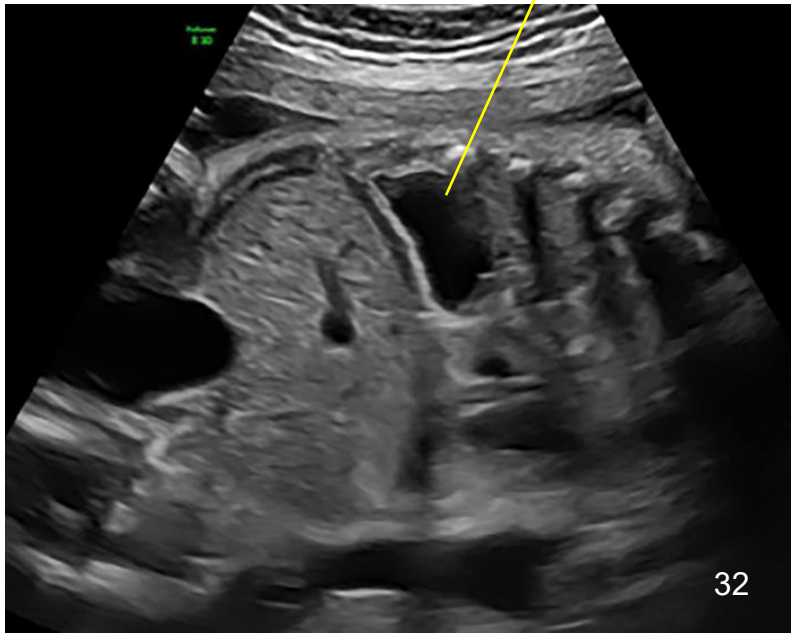
Diaphragmatic hernia

- When a physiologic umbilical hernia is refluxed, increased intra-abdominal pressure causes intrusion of abdominal organs into the thoracic cavity through the incomplete primitive diaphragm (Bochdalek foramen: 90%).

- **Poor prognosis:** early intrusion of (many) abdominal organs into the thorax. liver up.

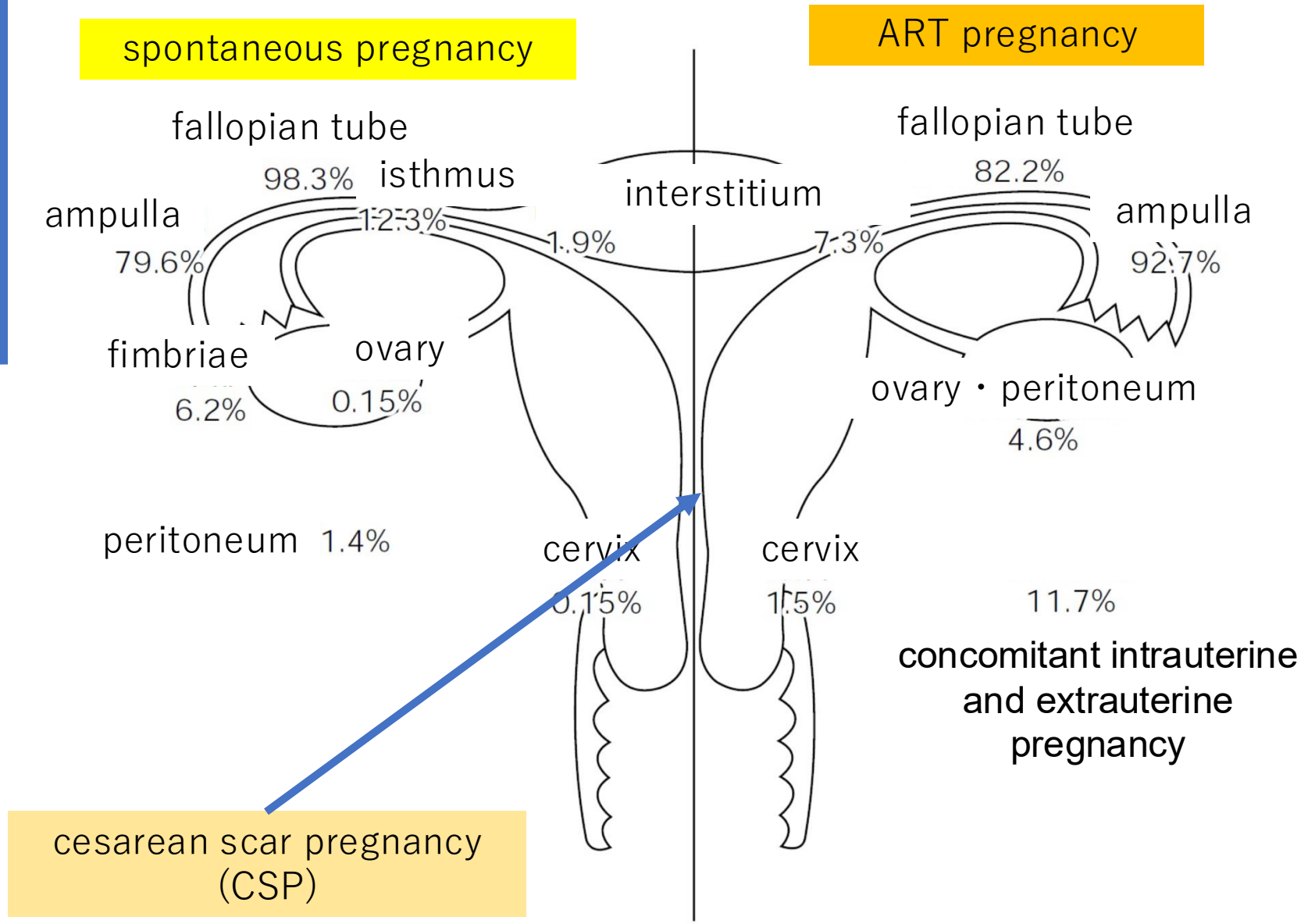
  → severe pulmonary hypoplasia



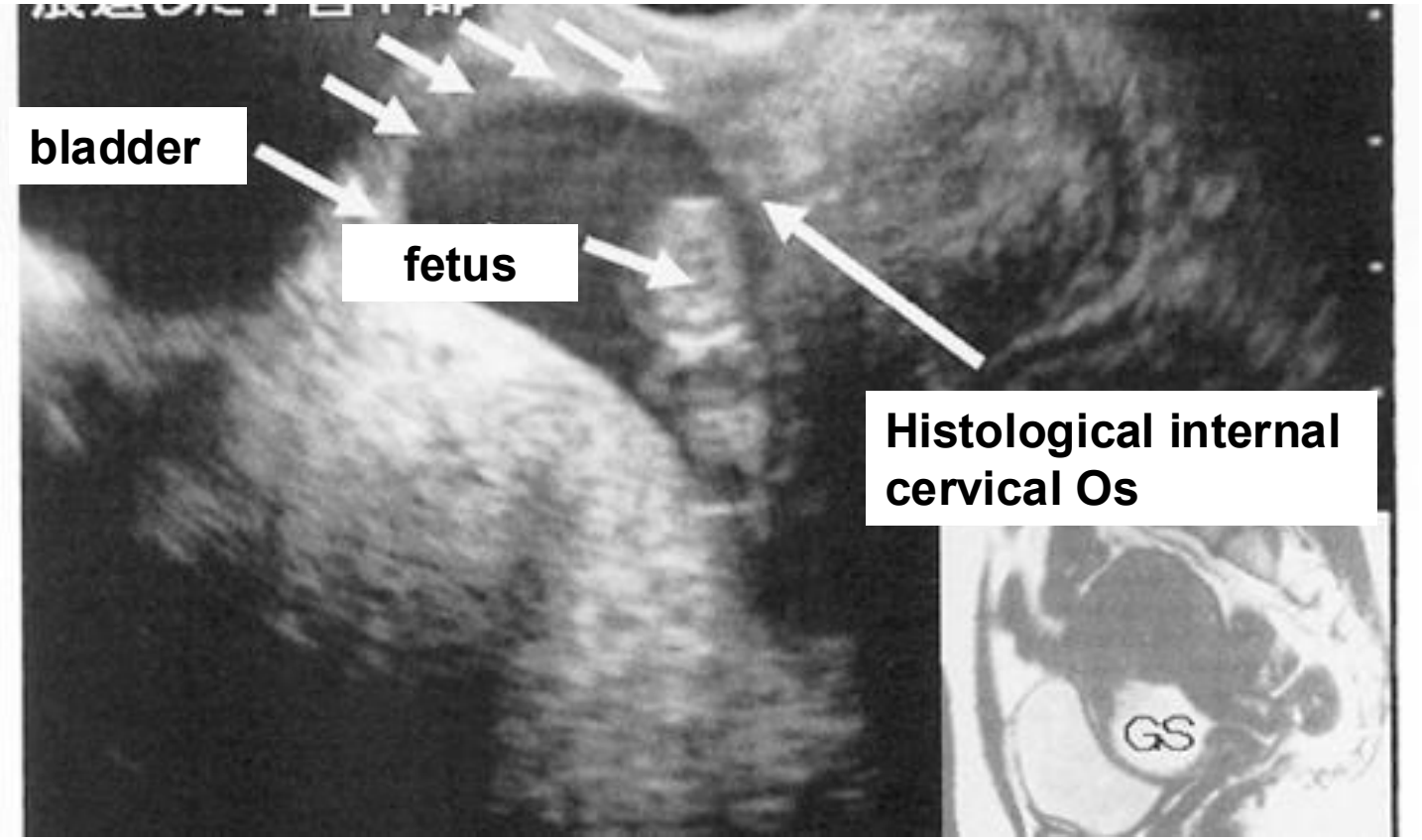


33th weeks gestation

Ectopic pregnancy

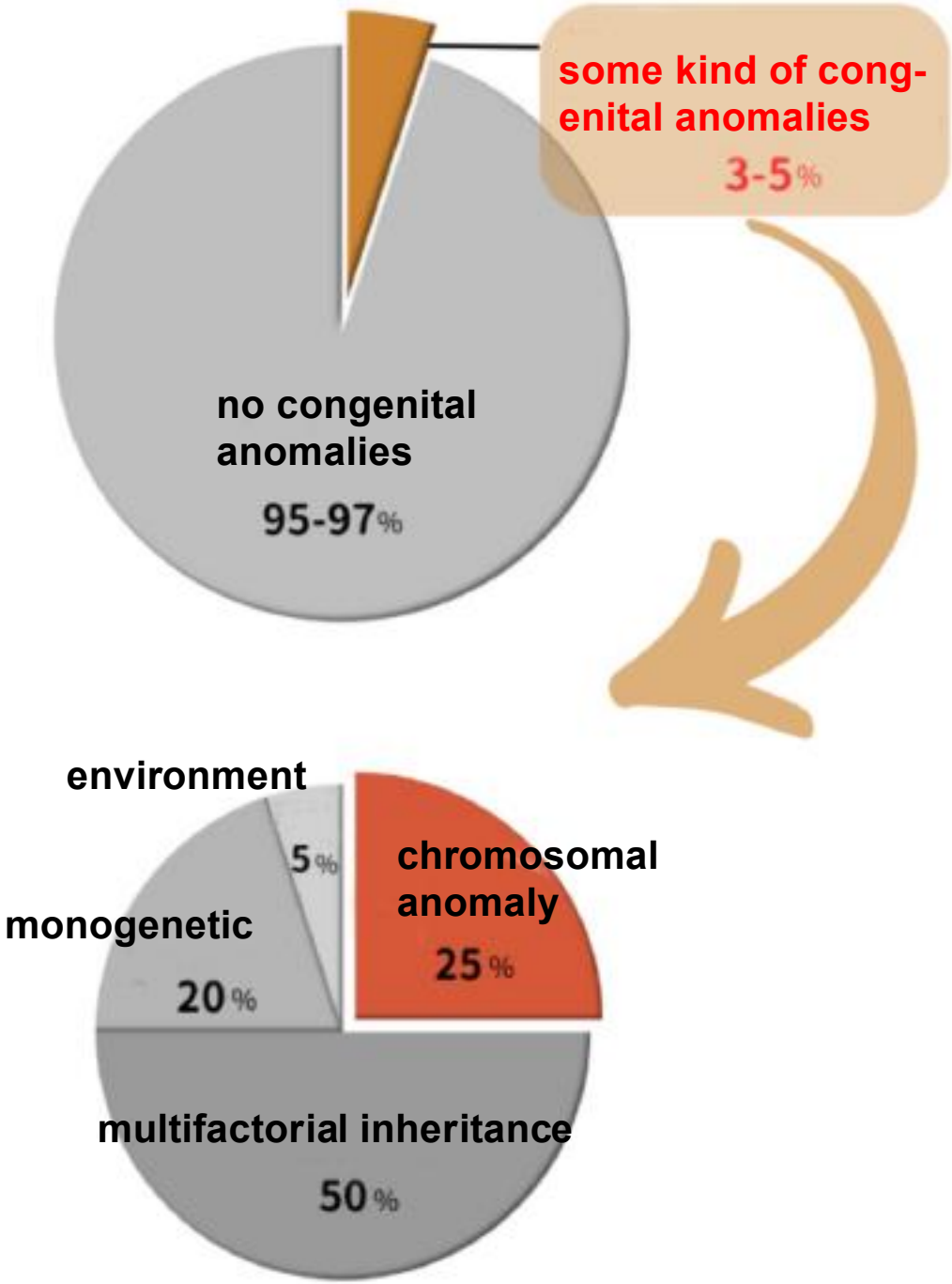


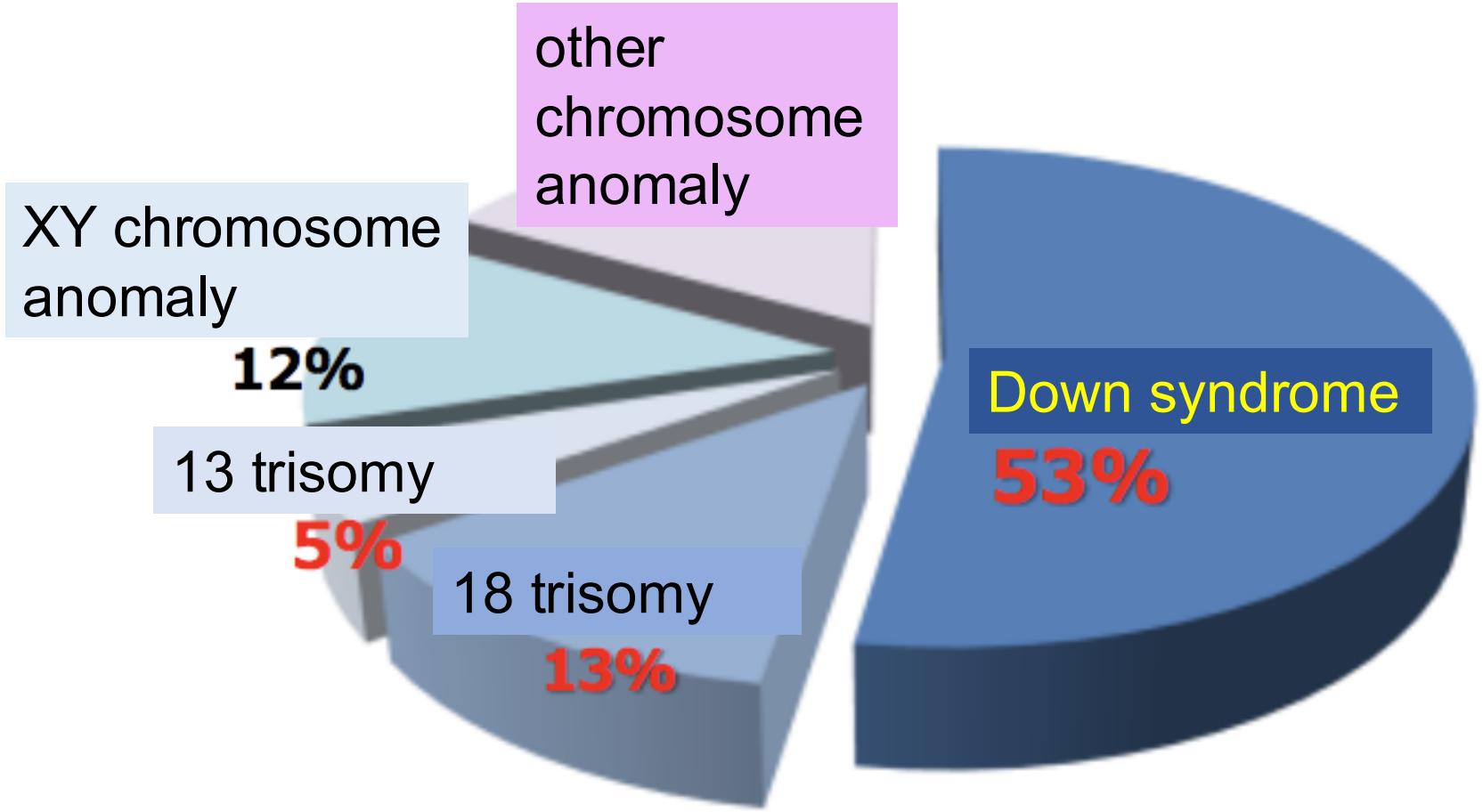
Cesarean scar pregnancy (CSP)



- The lower part of corpus uteri is expanded, and a gestational sac is formed despite the early stage of pregnancy. The myometrium is very thin and in a state of silent rupture. If the uterus is to be preserved, conservative treatment is performed by anti-cancer drugs such as MTX or UAE.

Congenital Anomaly

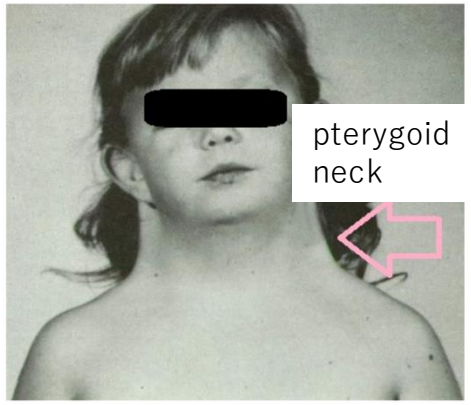


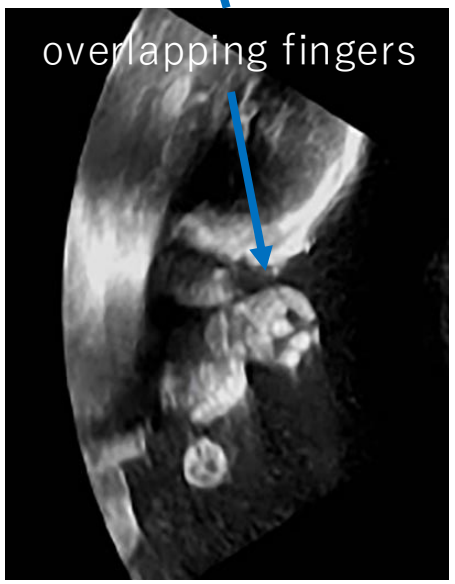


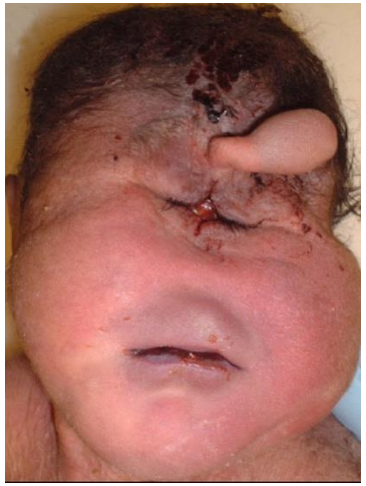
Frequency of Chromosomal Anomaly in Early Pregnancy

Data adapted from Wellesley, D, et al., Rare chromosome abnormalities, prevalence and prenatal diagnosis rates from population-based congenital anomaly registers in Europe(2000-2006). *Eur J of Hum Gen*, 11 January 2012.

Major fetal malformations and chromosomal abnormalities







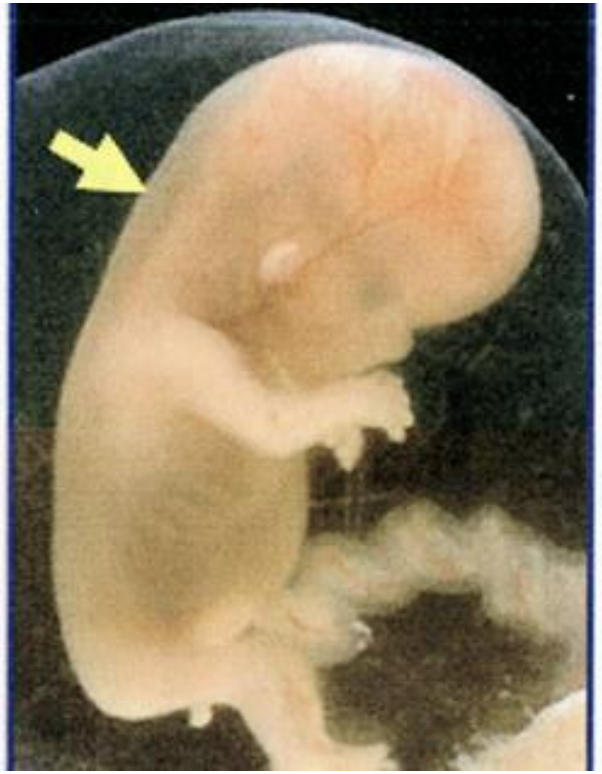
- **21 trisomy：** Low nasal bone formation or nasal bone defect, increased nuchal translucency (NT), cardiac anomaly, duodenal atresia
- **18 trisomy：** cardiac anomaly, esophageal atresia, fetal growth restriction, overlapping fingers
- **13 trisomy：** holoprosencephaly, microcephaly, facial deformity, cardiac anomaly
- **Turner syndrome (45XO)：** fetal hydrops, pleural effusion, ascites, cardiac anomaly, ductal dysplasia

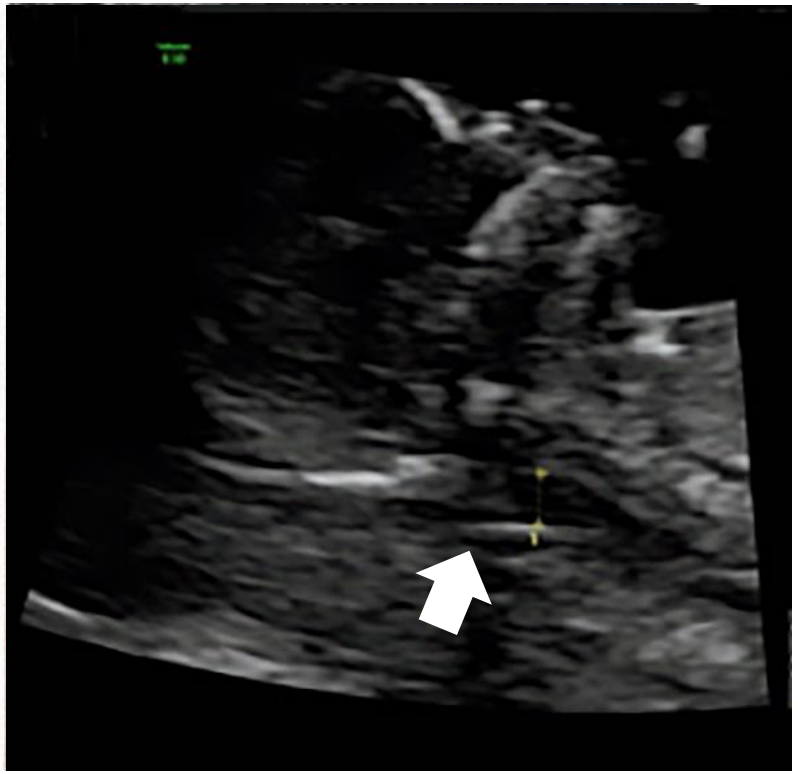
- If a major malformation is found, recommend a chromosome test such as amniocentesis.
- If compound malformations are observed: the possibility of chromosomal abnormalities increases.

Important soft marker

- nuchal translucency (NT), nasal bone defect
  - The likelihood ratio of 21trisomy in high NT (≧ 3.5mm) alone or nasal bone defect is 10-fold.

nuchal translucency (NT：11～13th)

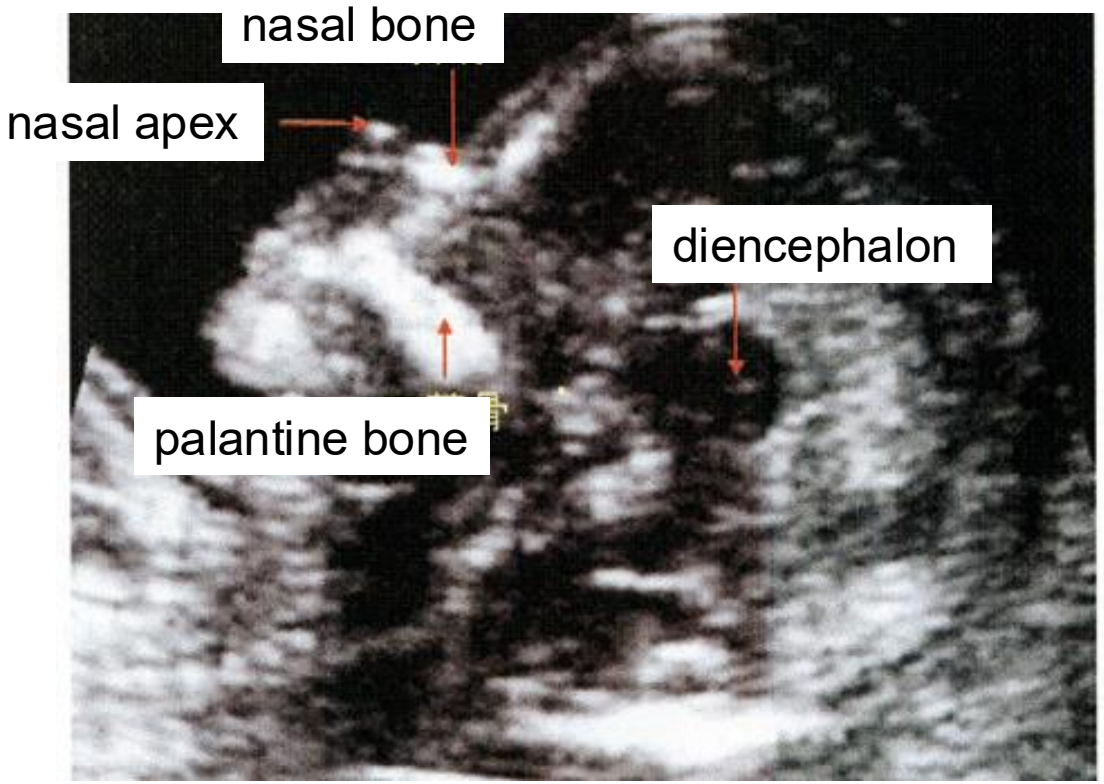




- Edema in the fetal neck, which may resolve spontaneously during the course of pregnancy.

- NT ≥ 3.5 mm (1% of all pregnancies): chromosome anomaly, cardiac malformation, impaired lymphatic return (45XO), fetal anemia (Parvovirus B19), fetal viral infection (Toxoplasma, Cytomegalovirus)

Nasal bone defect （11～13th）



- Sagittal section: high-echo nasal apex and palatine bone are present.
- Hypoechoic diencephalon is seen.

- normal karyotype ：1-3%
- 21 trisomy ： 60%
- 18 trisomy ： 50%
- 13 trisomy ： 40%

Ultrasonography checkpoints 18th～ week gestation

ultrasonographic findings	Diseases to speculate on
Systemic edema	Fetal hydrops (45XO)
Small head (small BPD)	Fetal growth restriction (FGR)
Abnormal heart structure	Congenital heart disease
Gastric bubble not visible on left side	Esophageal atresia
Abnormal cyst in the abdominal cavity	Ovarian cyst, duodenal atresia, hydronephrosis
Oligohydramnion	Potter syndrome, MCDK
Polyhydramnion	Micrognathia
Lumbar back mass	Meningocele, sacrococcygeal teratoma
Ventriculomegaly	Agenesis of corpus callosum, Chiari type II Malformation, Dandy-Walker syndrome
Short limb	Osteogenesis imperfecta, thanatophoric osteodystrophy

Fetal hydrops

- Fetus has pleural and ascites effusions and subcutaneous edema.
- Sometimes, anemia can be diagnosed by an increased maximum systolic velocity of the middle cerebral artery (MCA). → fetal transfusion is necessary
- **Immune fetal hydrops**: Rh incompatibility is frequent. When fetal hydrops appears, Hb is already less than 5 g/dL. Polyhydramnion and edematous placenta are observed. This hydrops can be decreased by γ-globulin.
- **Non-immune fetal hydrops**: 90% of fetal hydrops.

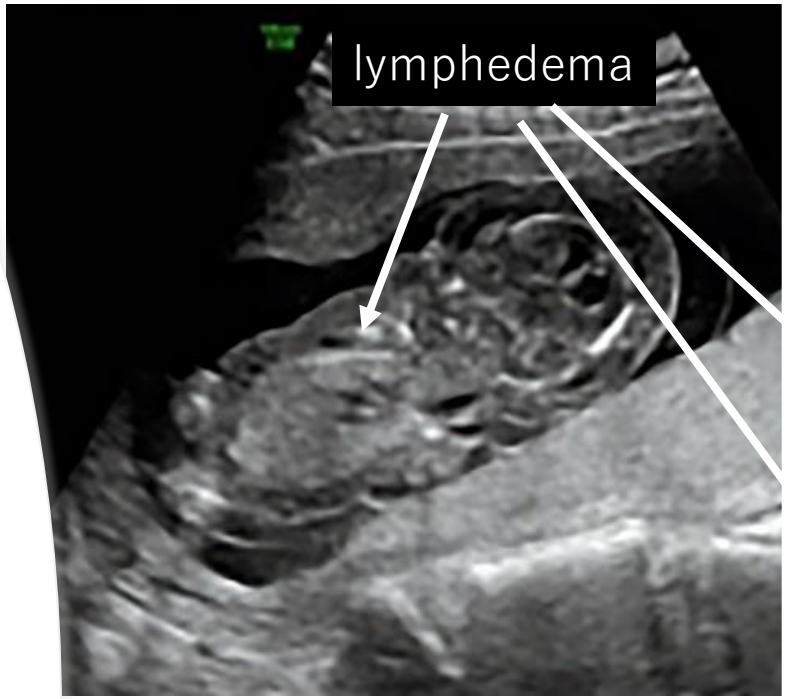
  Causes: Chromosomal abnormalities (45XO, 18+, 13+), intrauterine infection (parvovirus B19, cytomegalovirus), TTTS, cardiac malformation, fetal arrhythmia, CCAM, diaphragmatic hernia.

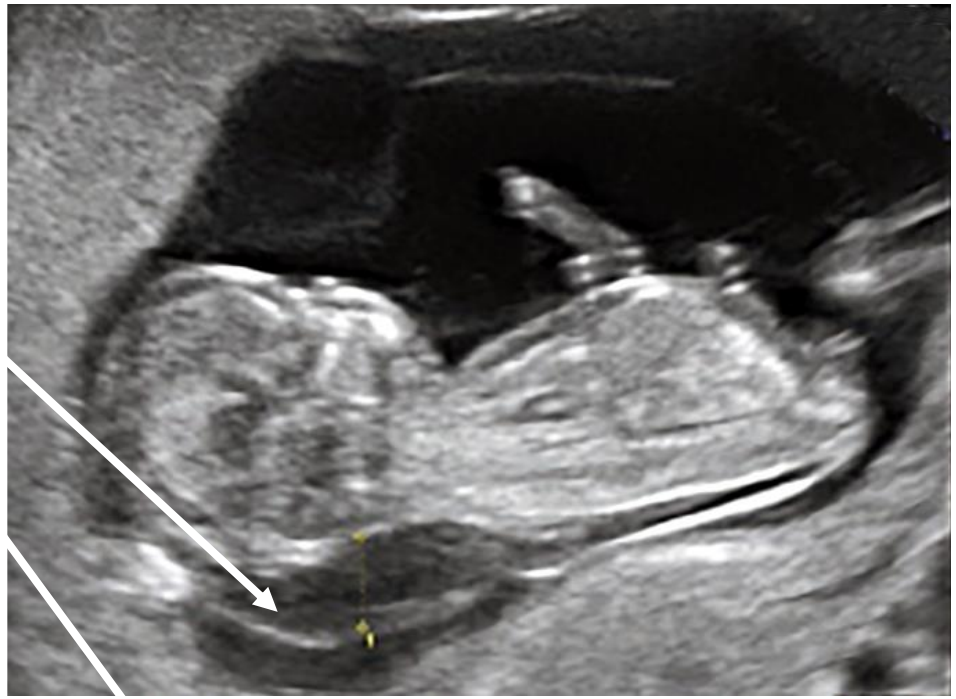
  - 40% of patients are found to have morphological abnormalities.
  - Mortality rate is 70%.

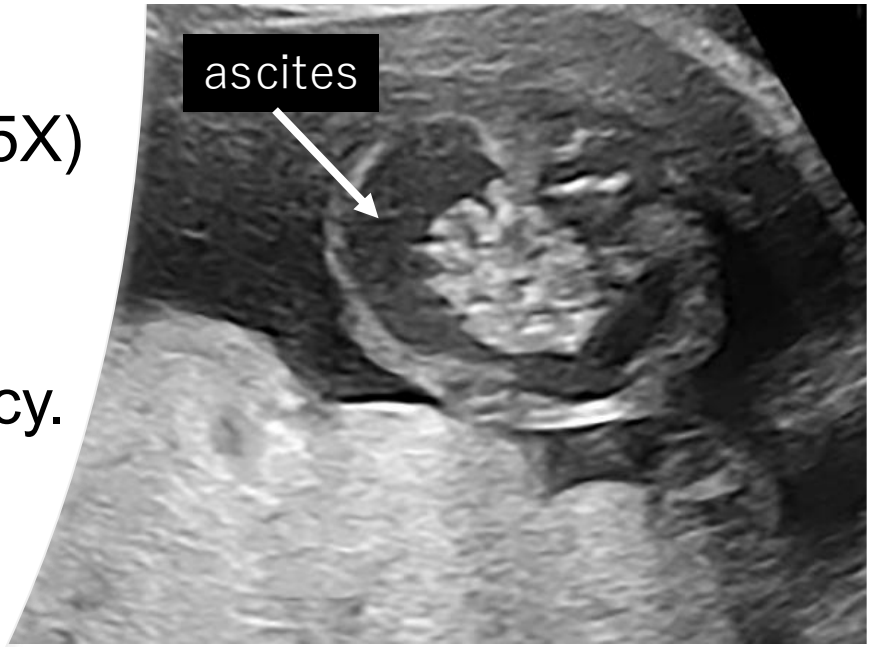
cystic hygroma

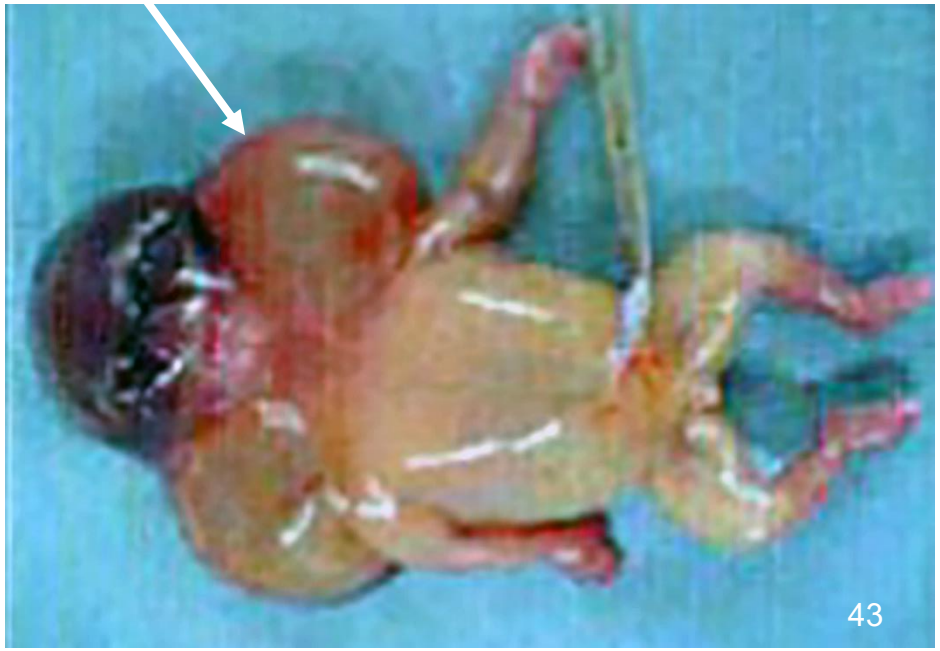
- Malformation of the lymphatic system in the neck, axilla, thorax, etc. It may spontaneously resolve during pregnancy. Often associated with chromosomal abnormalities (21+, 45X)

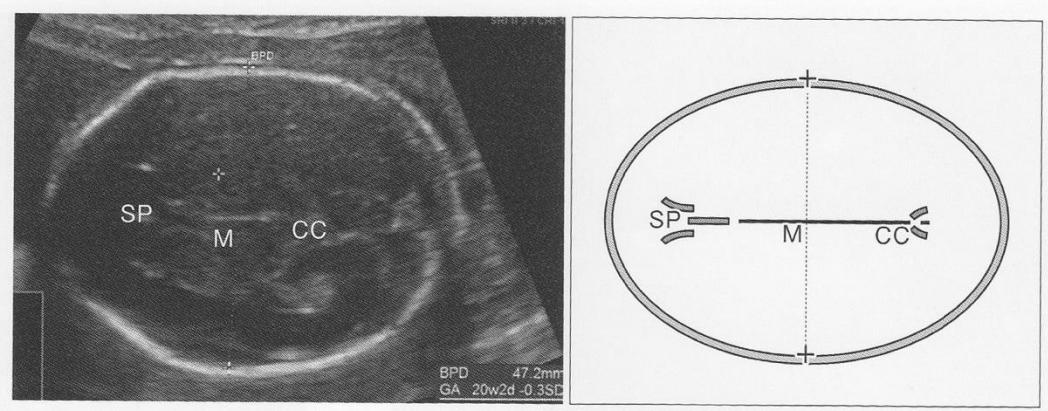
- The prognosis is also poor in early pregnancy.

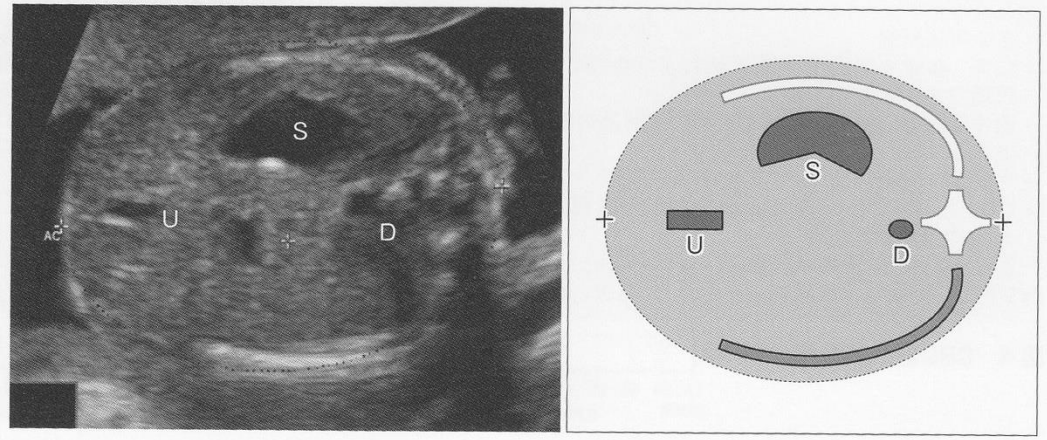


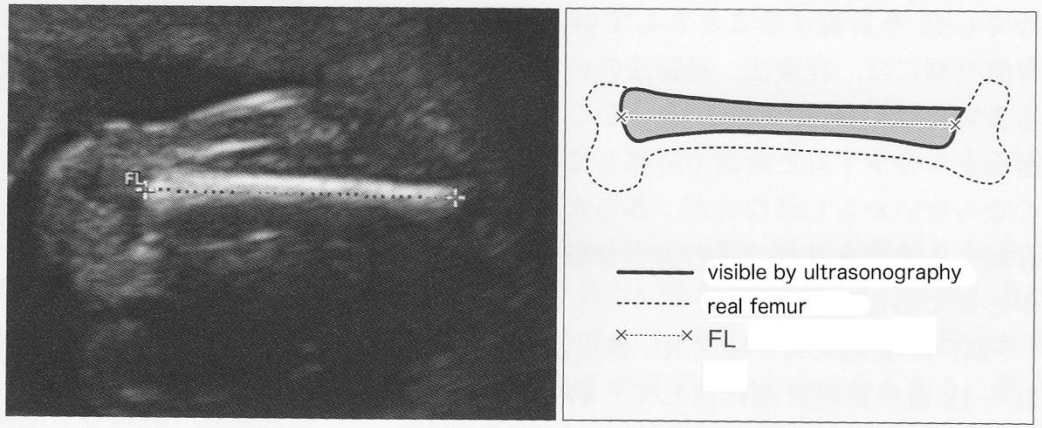












Fetal Measurement

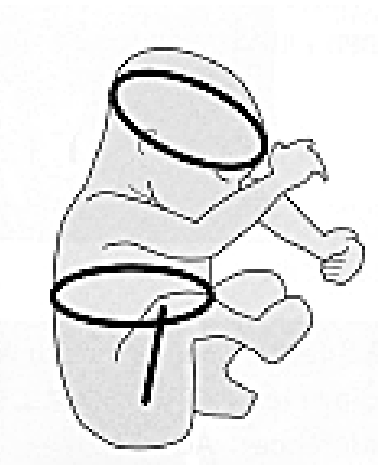
CRL（Crown Rump Length）

8^{th} week+0～12^{th} week+0

BPD（Biparietal diameter）

12^{th} week+0～16^{th} week+0

* The midline is bilateral symmetry and the septum pellucidum and quadrigeminal cistern are depicted.



Definitions for early- and late-onset fetal growth restriction (FGR) in absence of congenital anomalies, based on international Delphi consensus

Early FGR: *GA < 32 weeks, in absence of congenital anomalies*	*Late FGR:* *GA ≥ 32 weeks, in absence of congenital anomalies*
AC/EFW < 3rd centile *or* UA-AEDF *Or* 1. AC/EFW < 10th centile *combined with* 2. UtA-PI > 95th centile *and/or* 3. UA-PI > 95th centile	AC/EFW < 3rd centile *Or at least two out of three of the following* 1. AC/EFW < 10th centile 2. AC/EFW crossing centiles > 2 quartiles on growth centiles* 3. CPR < 5th centile *or* UA-PI > 95th centile

*Growth centiles are non-customized centiles. AC, fetal abdominal circumference; AEDF, absent end-diastolic flow; CPR, cerebroplacental ratio; EFW, estimated fetal weight; GA, gestational age; PI, pulsatility index; UA, umbilical artery; UtA, uterine artery.

Ultrasound Obstet Gynecol 2020; 56: 298–312

FGR

Low birth weight < 2,500g, very low birth weight < 1,500g, very low birth weight < 1,000g.

*Susceptible to complications such as intracranial hemorrhage, RDS, and infection.

Causes:

symmetrical FGR:

- **Smoking** placental dysfunction due to vasoconstriction caused by nicotine and CO, cellular damage caused by cyanide.
- **Alcohol** aldehyde, a metabolite of ethanol, etc., impairs organ differentiation, alcohol (alcohol passes through the placenta for long periods of time and impairs fetal cell proliferation, etc.),
- **chromosomal anomaly**

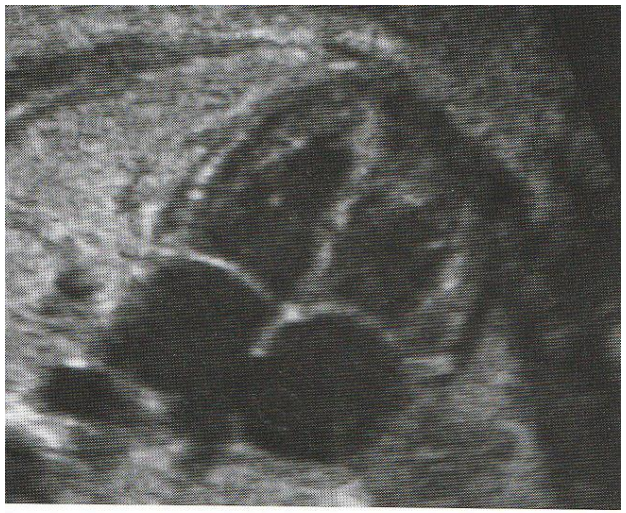
asymmetrical FGR:

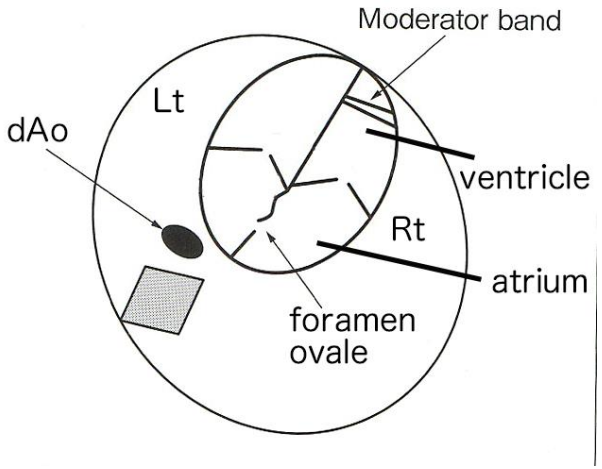
- **HDP** impairs blood flow resulting in poor placentation.

heart

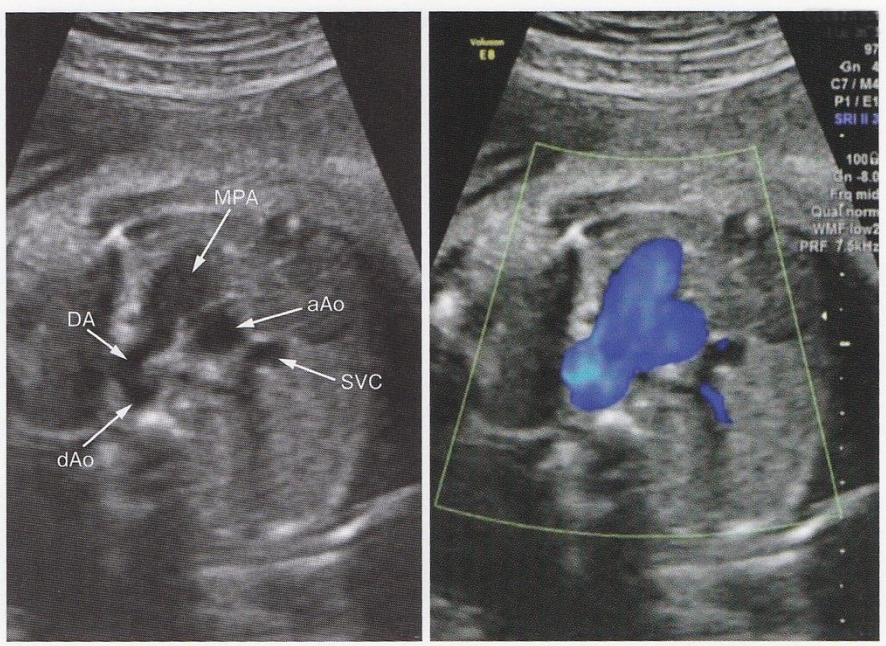
- The frequency of congenital cardiac diseases is about 1%.

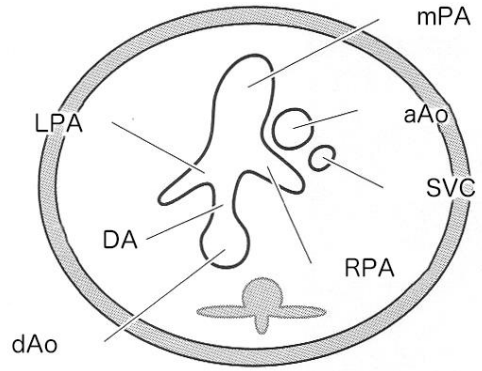
Screening of cardiac anomaly



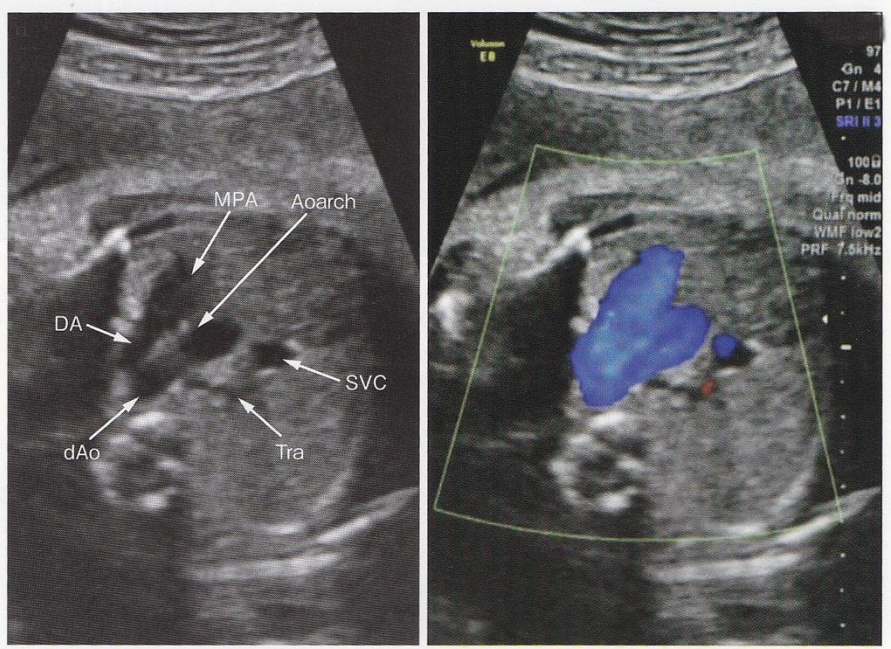


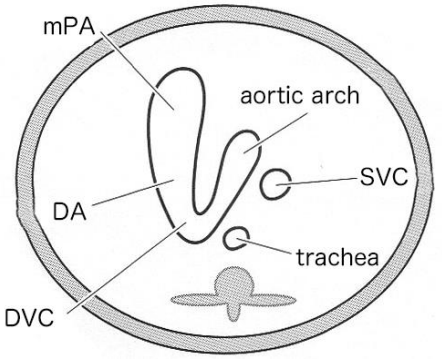
four chamber view





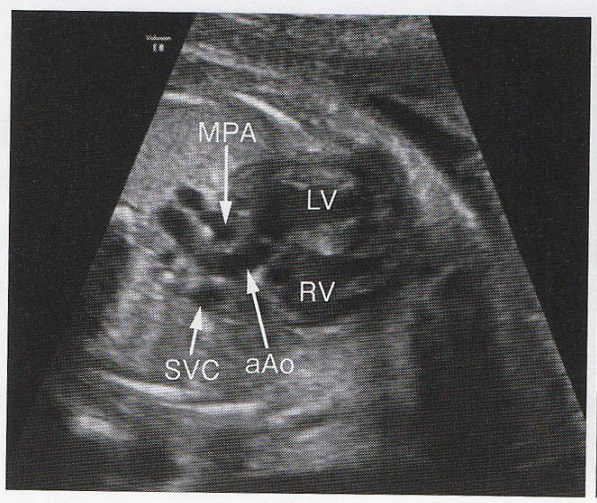
three vessel view

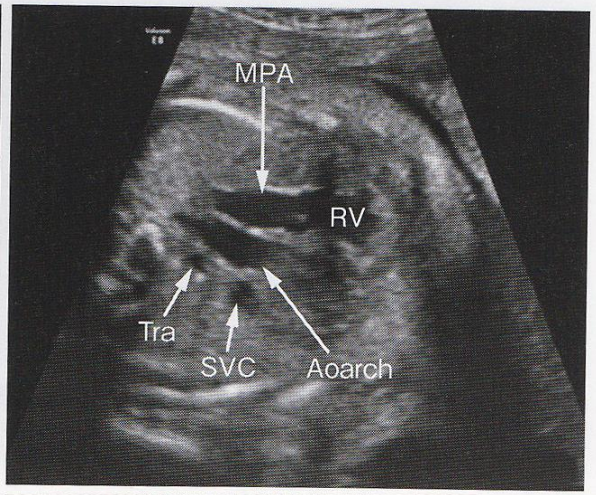


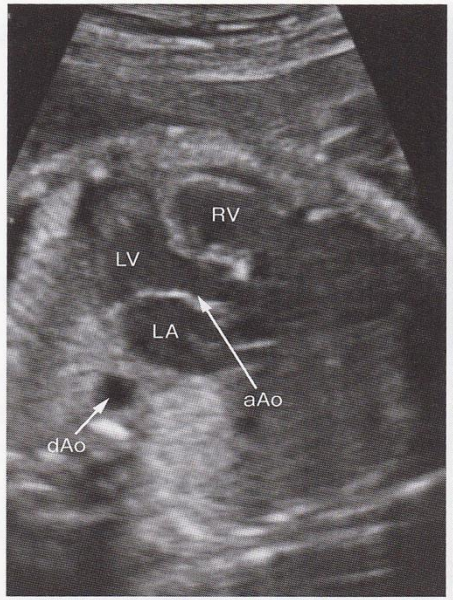


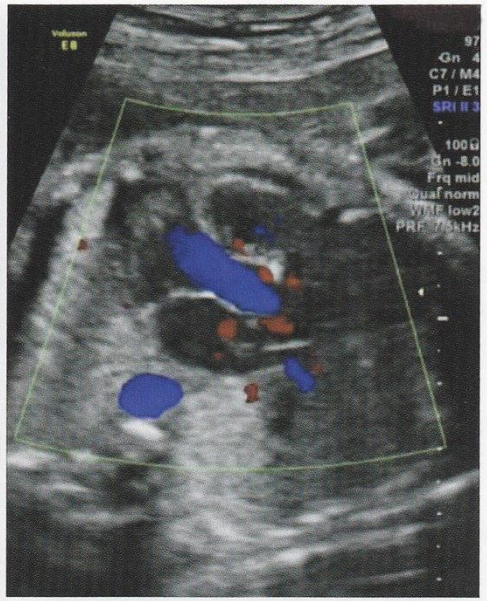
three vessel trachea view

Screening of cardiac anomaly

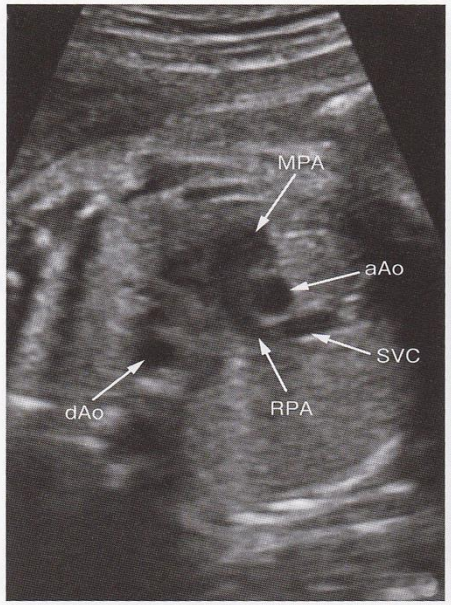


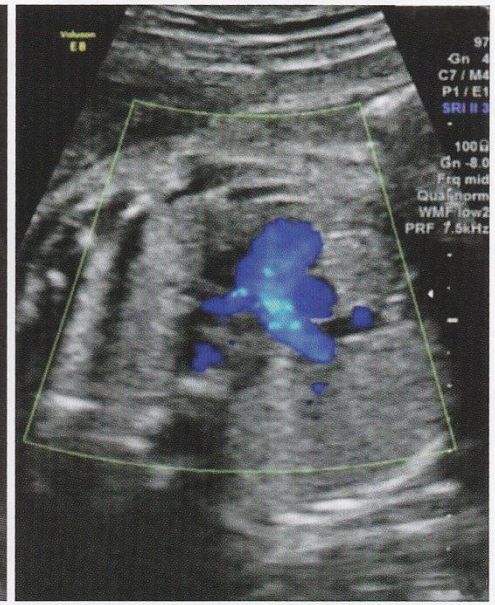


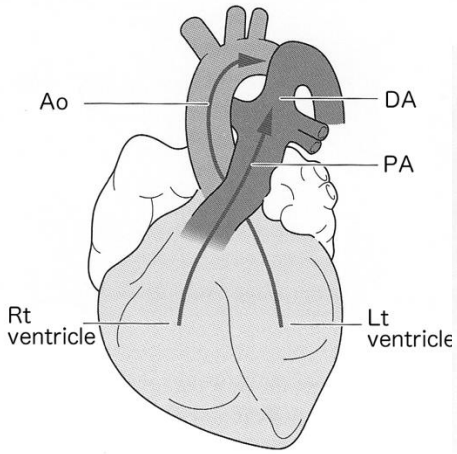


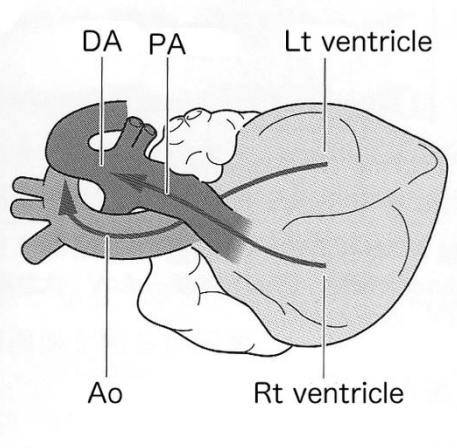


left ventricular outflow tract









right ventricular outflow tract

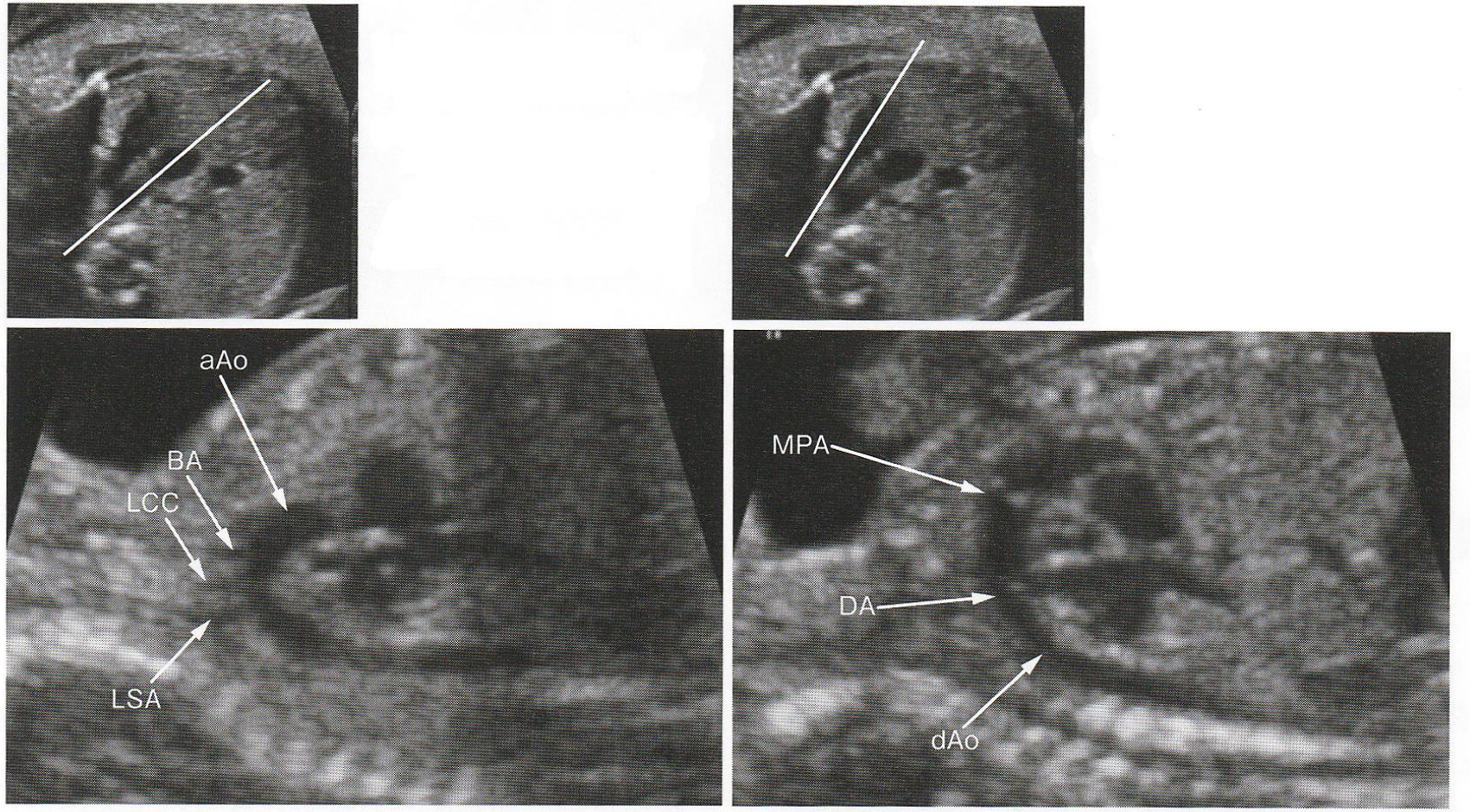
Screening of cardiac anomaly (Aortic Arch)

A)
3 vessel view - 3 vessel trachea view - ascending Ao section

B)
3 vessel view - 3 vessel trachea view - main pulmonary A section

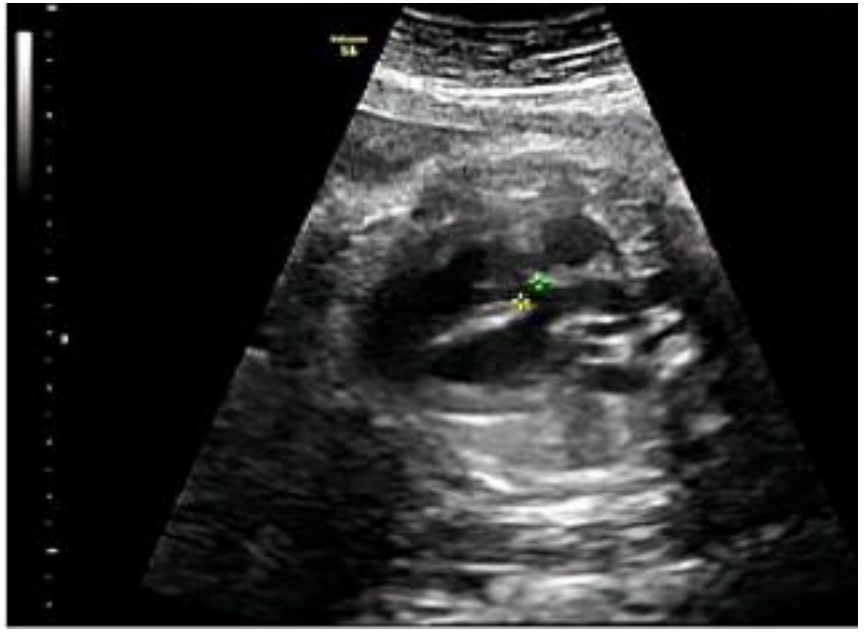
A)
aAo: ascending Ao
BA: brachiocephalic A
LCC: Lt common carotid A
LSA: Lt subclavian A
***You can see three neck vessels.**

B)
MPA: main pulmonary A
DA: ductus arteriosus
dAo: descending Ao

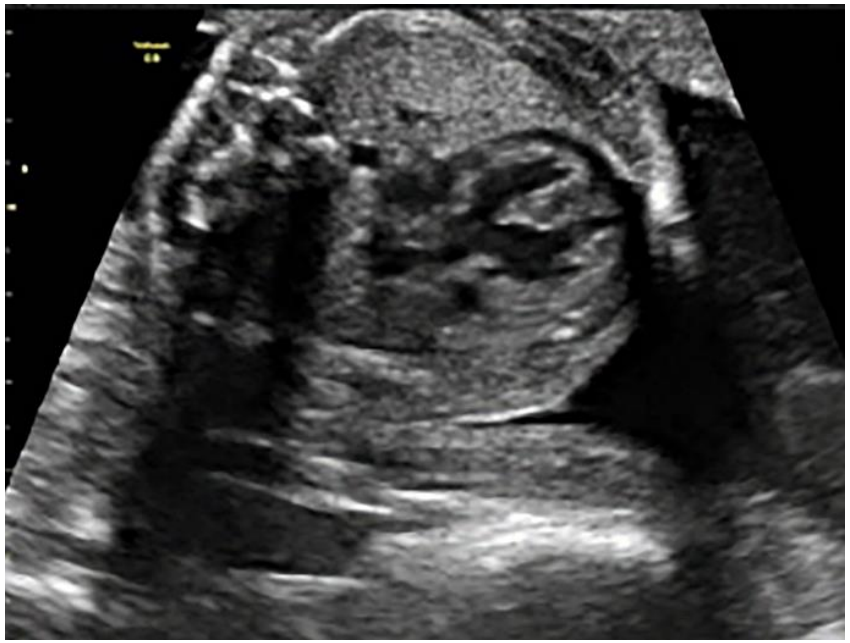


Tetralogy of Fallot (TOF)

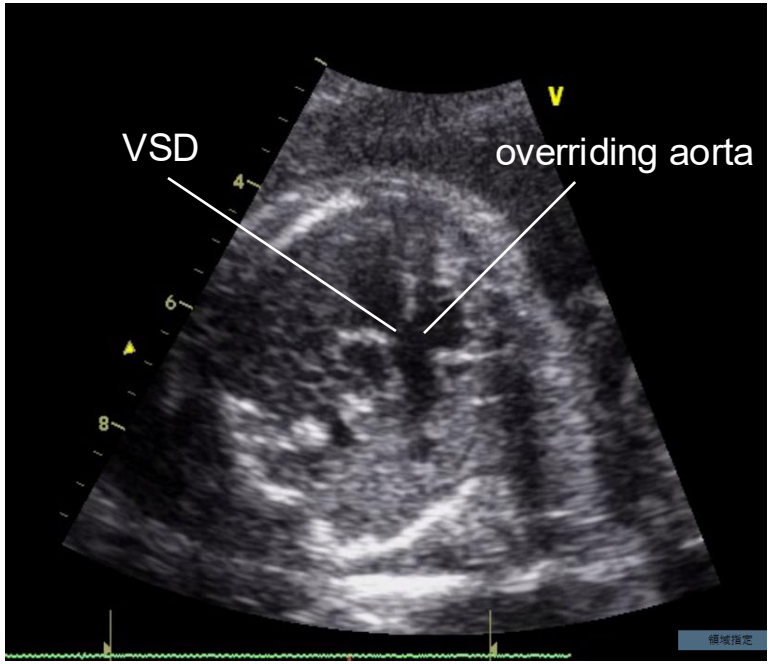
- pulmonary stenosis (PS)
- VSD
- over riding aorta
- right ventricular hypertrophy



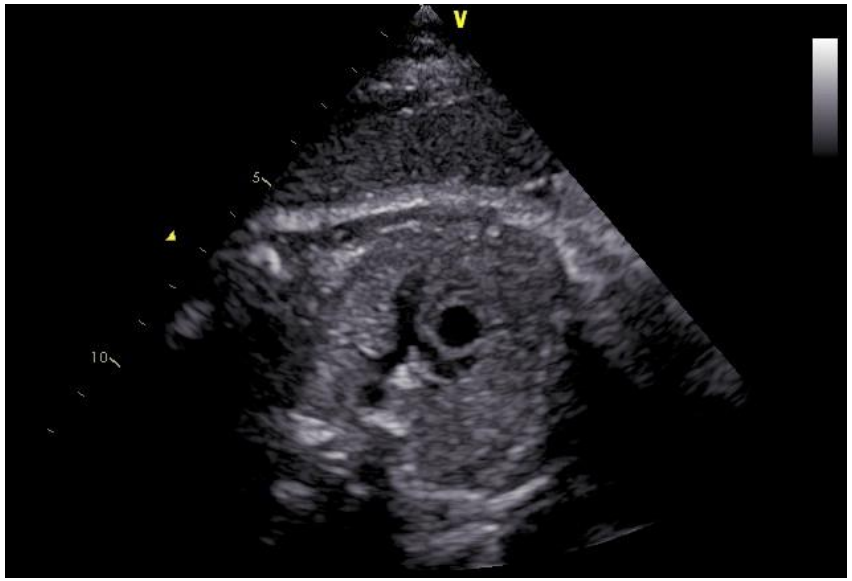
Ventricular Septal Defect (VSD)



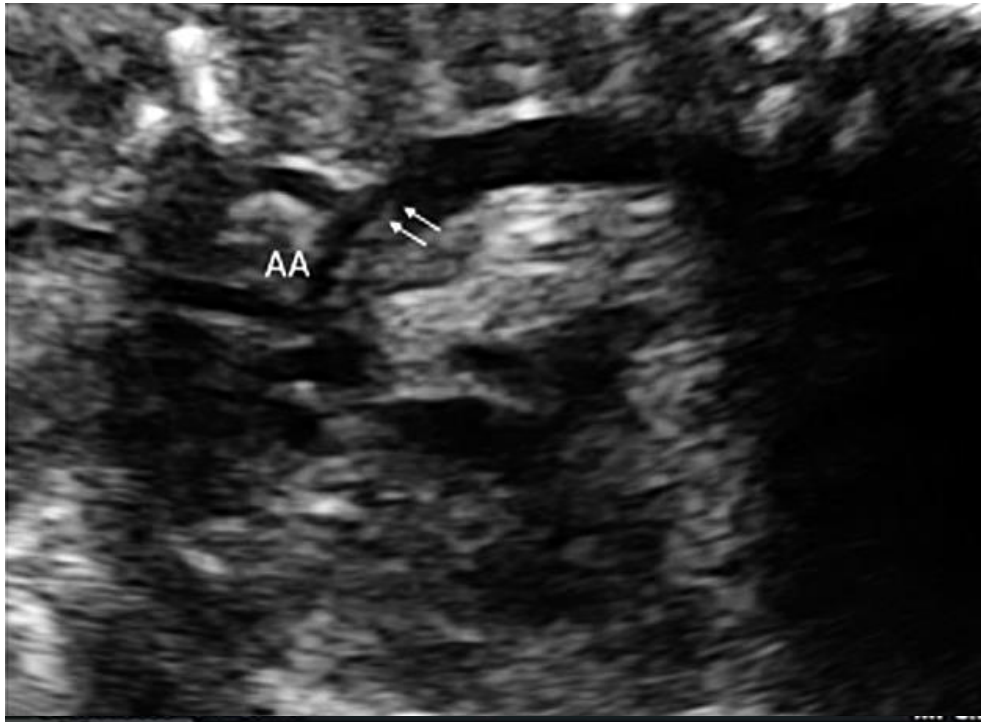
Right ventricular hypoplasia



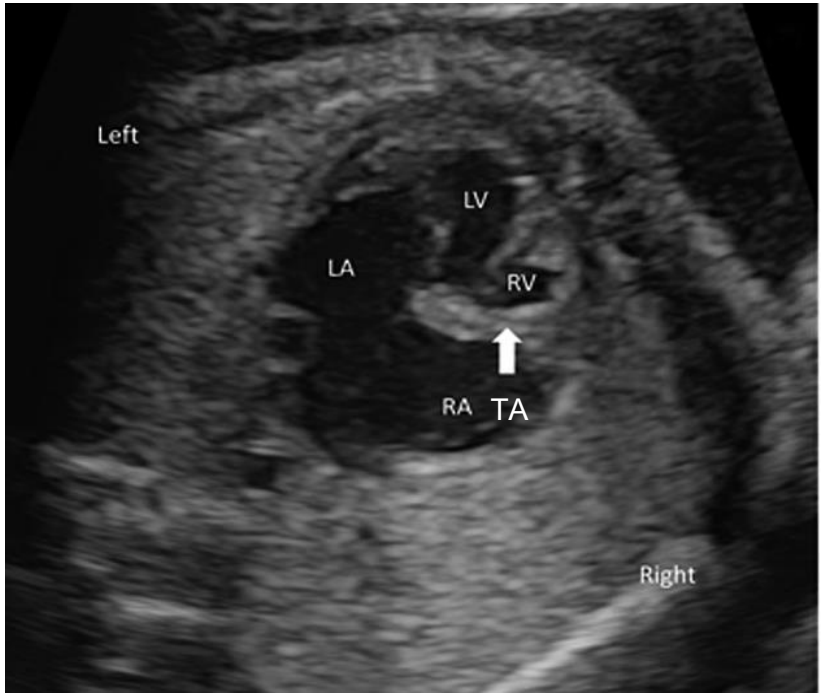
Over riding aorta



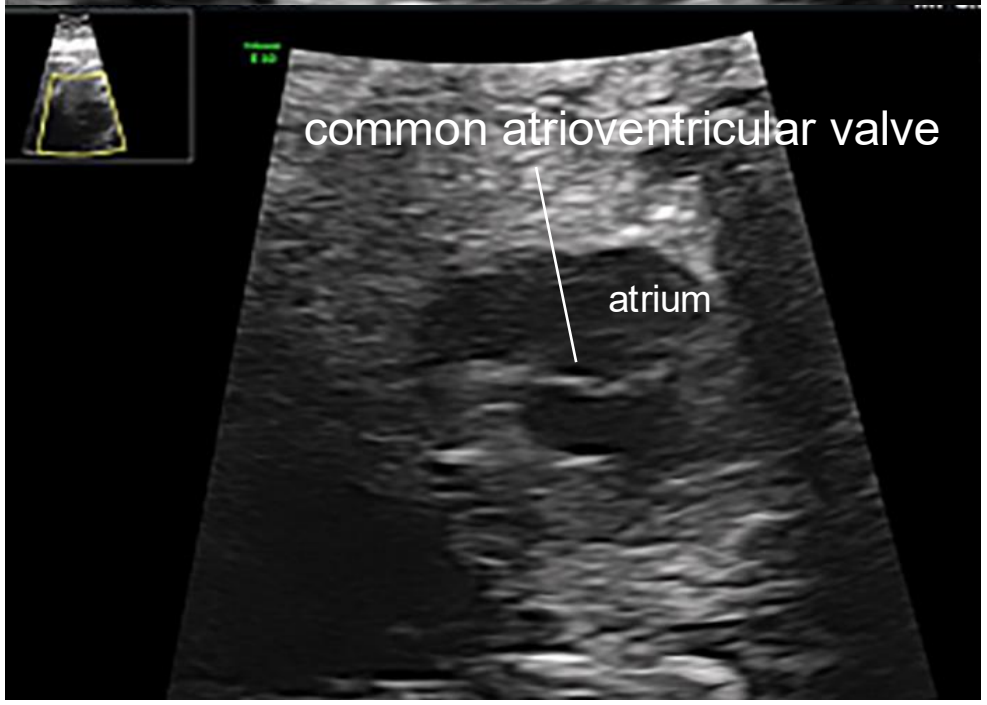
Pulmonary Stenosis (PS)



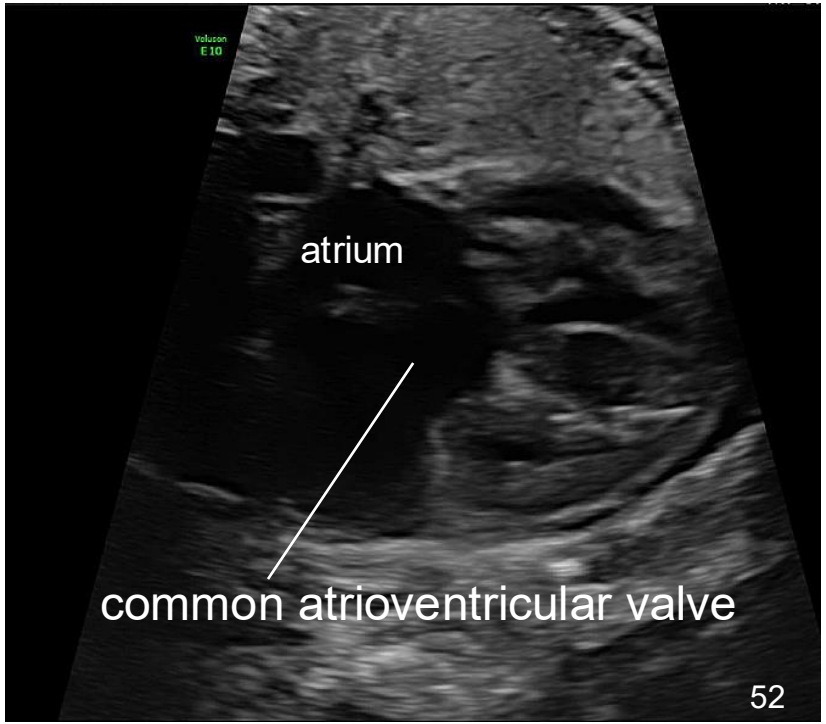
coarctation of aorta (CoA)



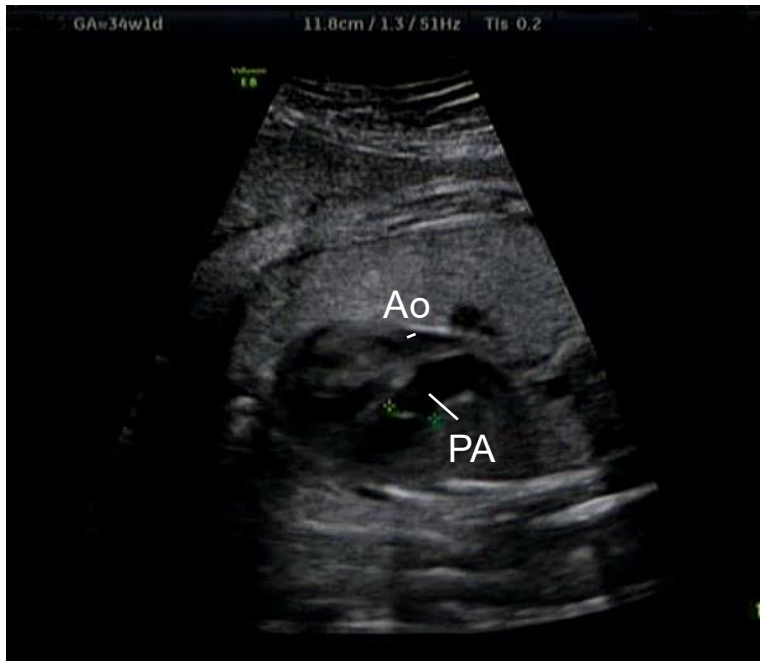
Tricuspid Atresia (TA)

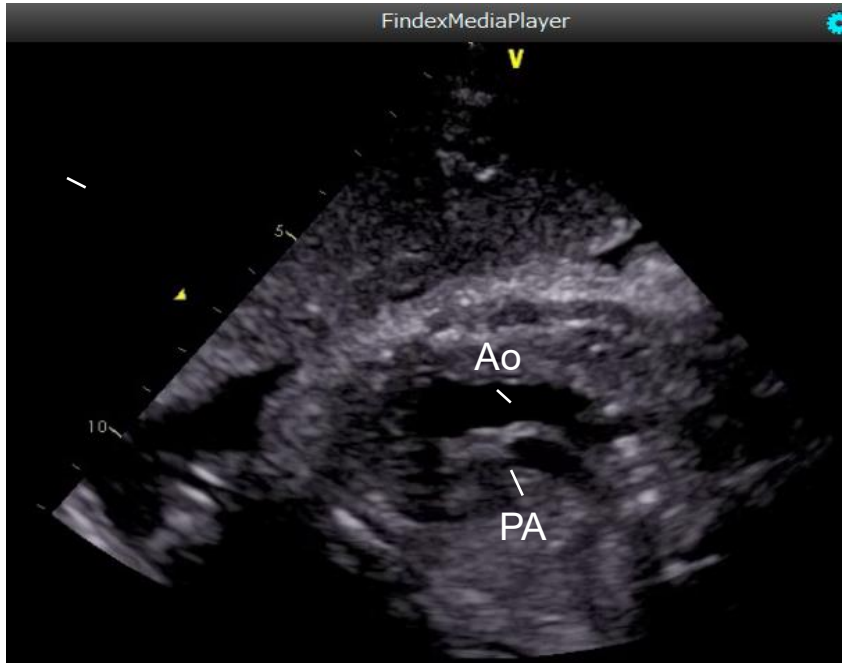


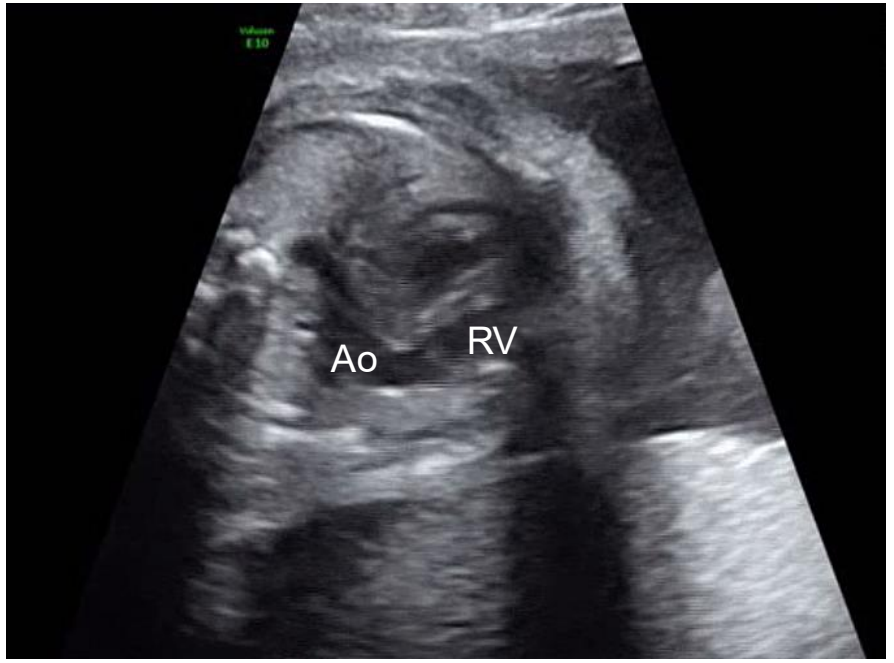
Atrio-Ventricular Septal Defect (AVSD)

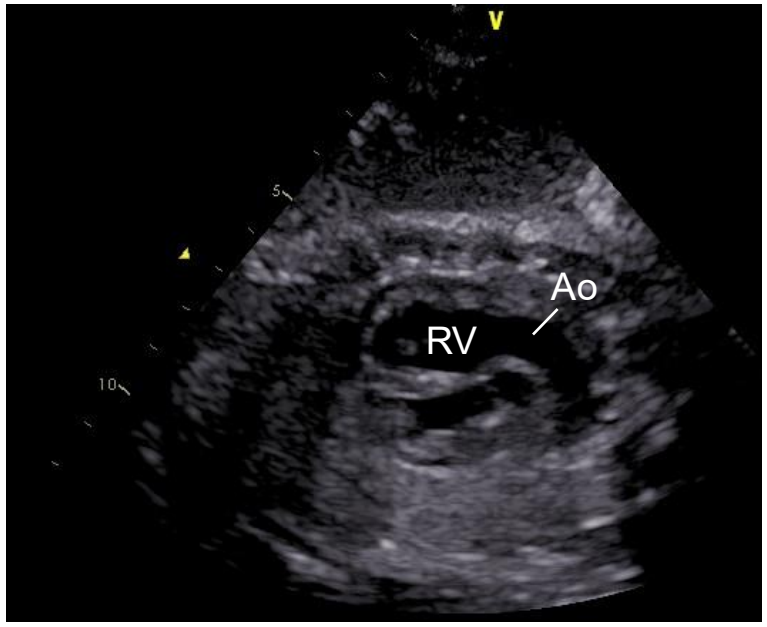


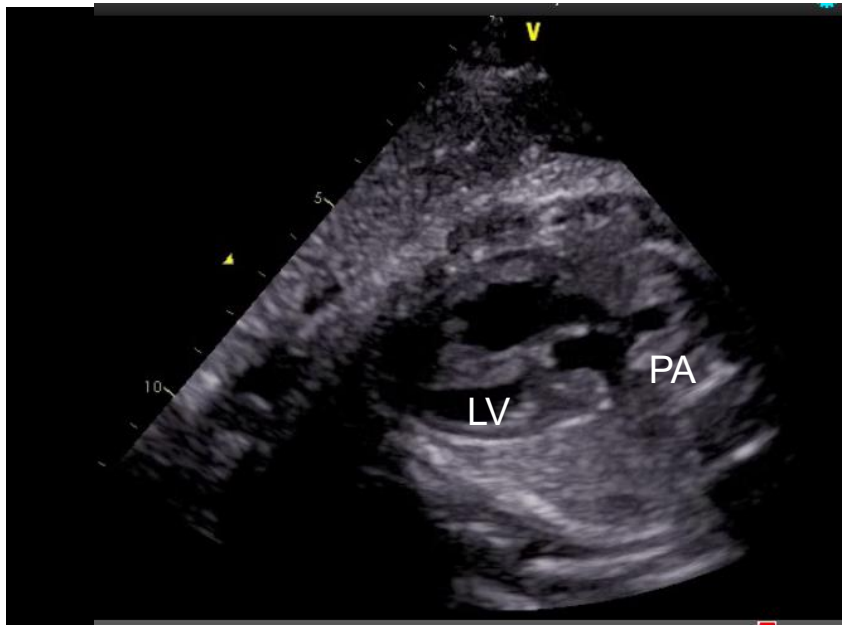
complete transposition of great arteries (TGA)

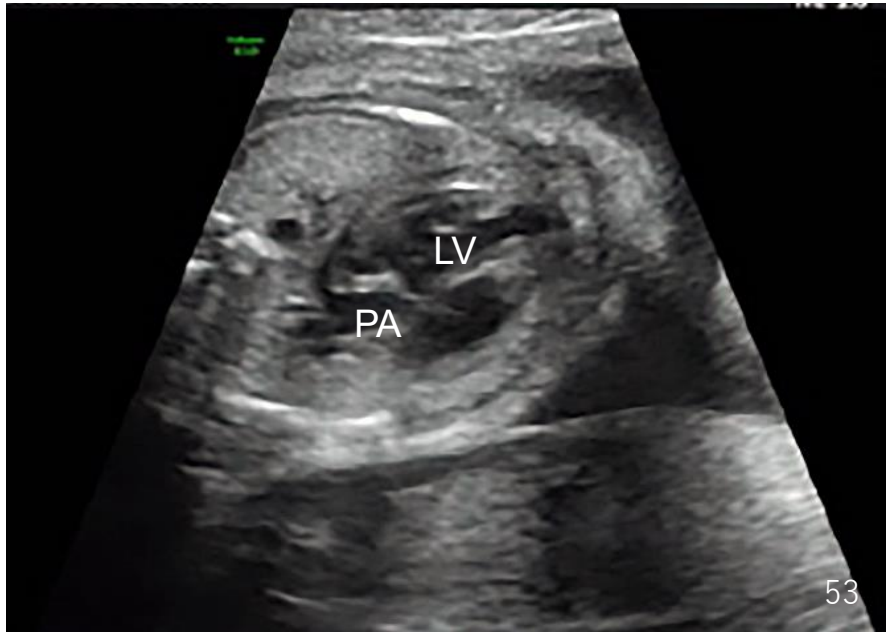


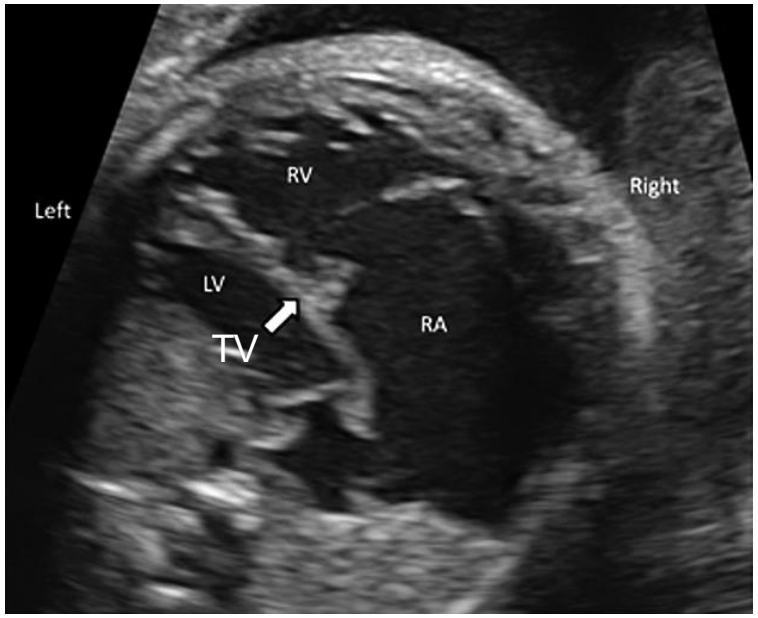




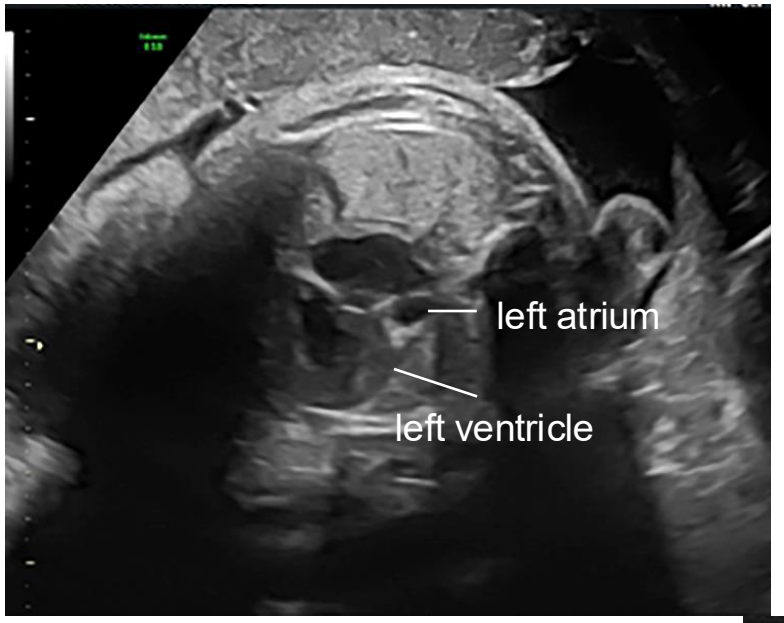




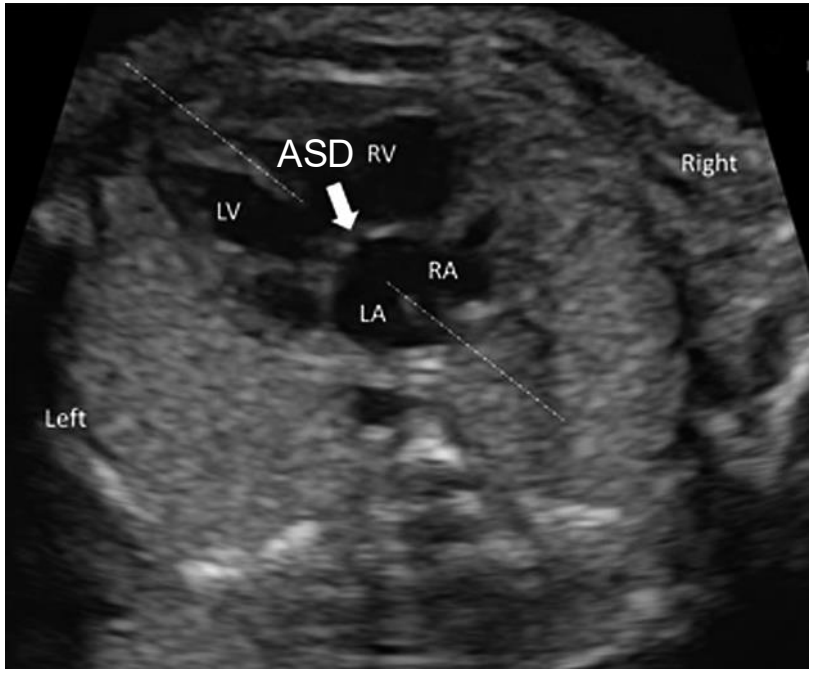




Ebstein's anomaly



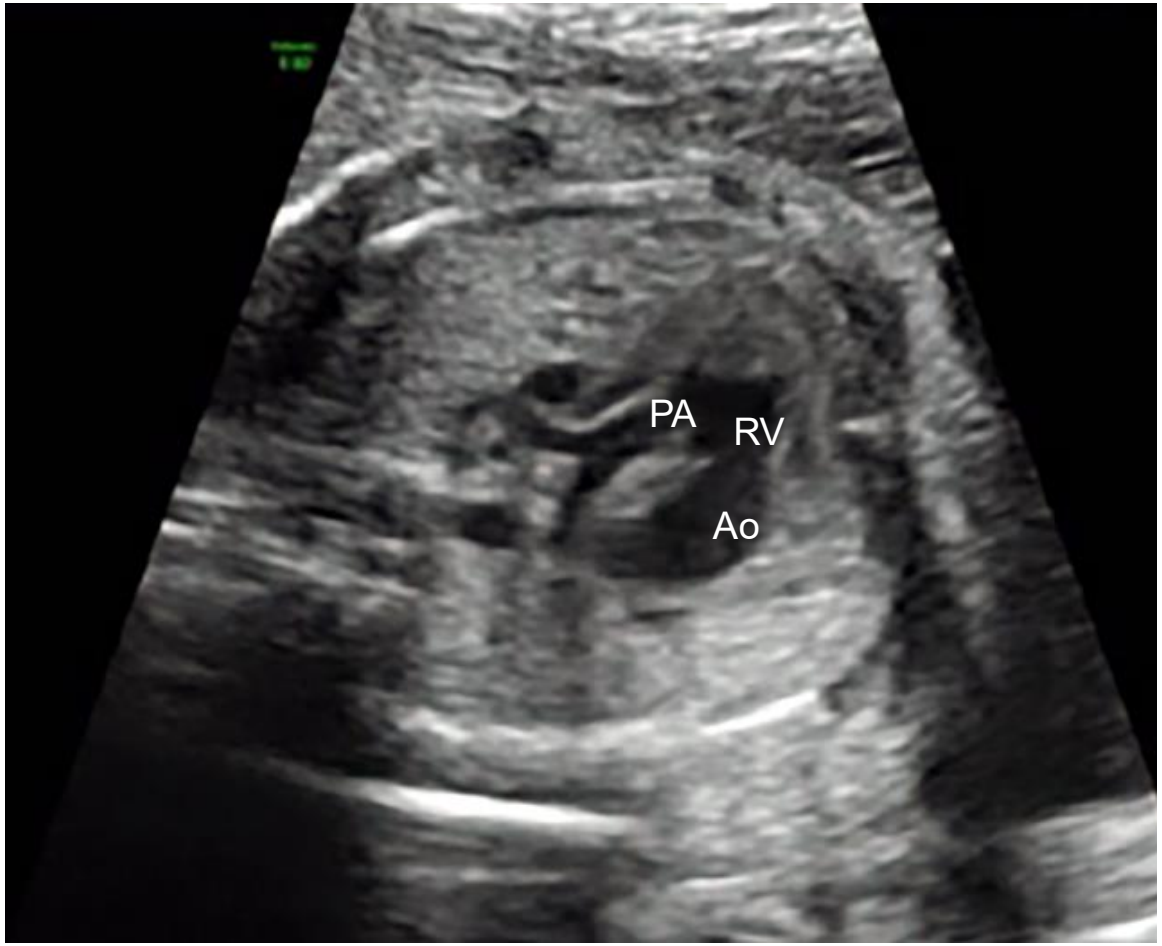
hypoplastic left heart syndrome (HLHS)



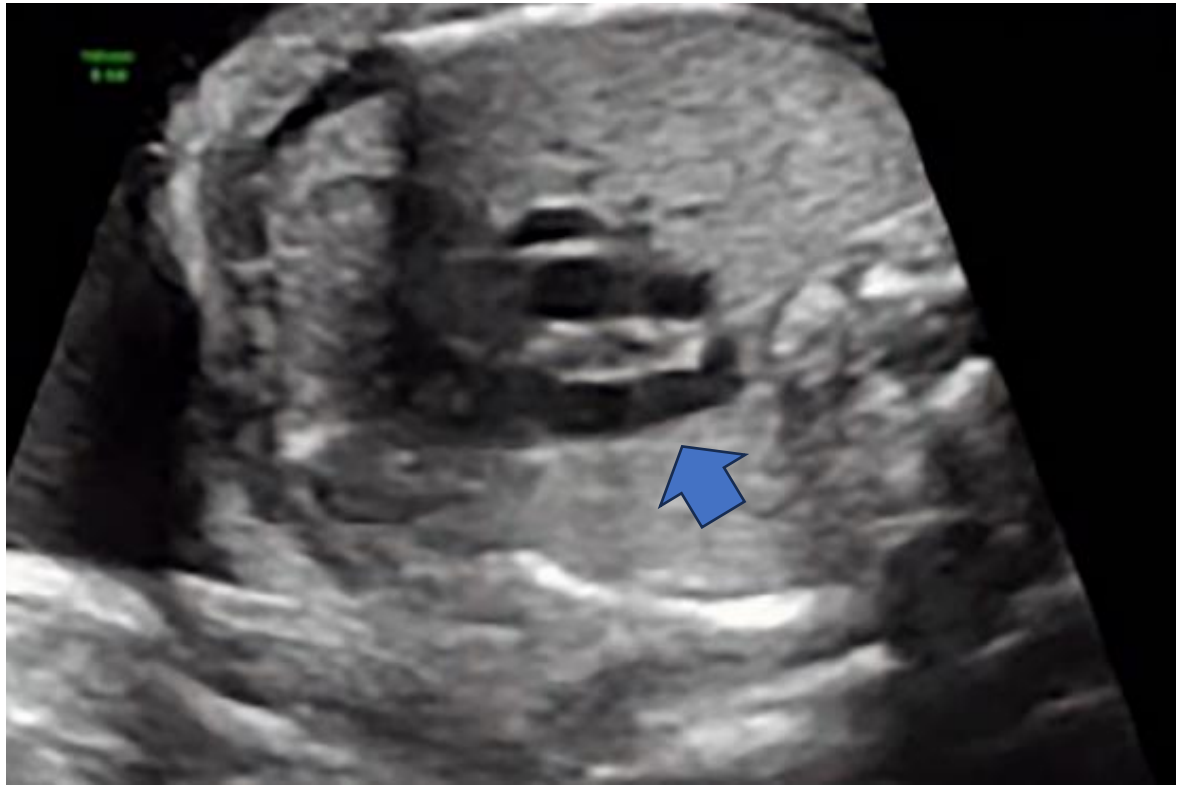
atrial septal defect (ASD)

Total Anomalous Pulmonary Venous Drainage (TAPVD)

double outlet right ventricle (DORV)

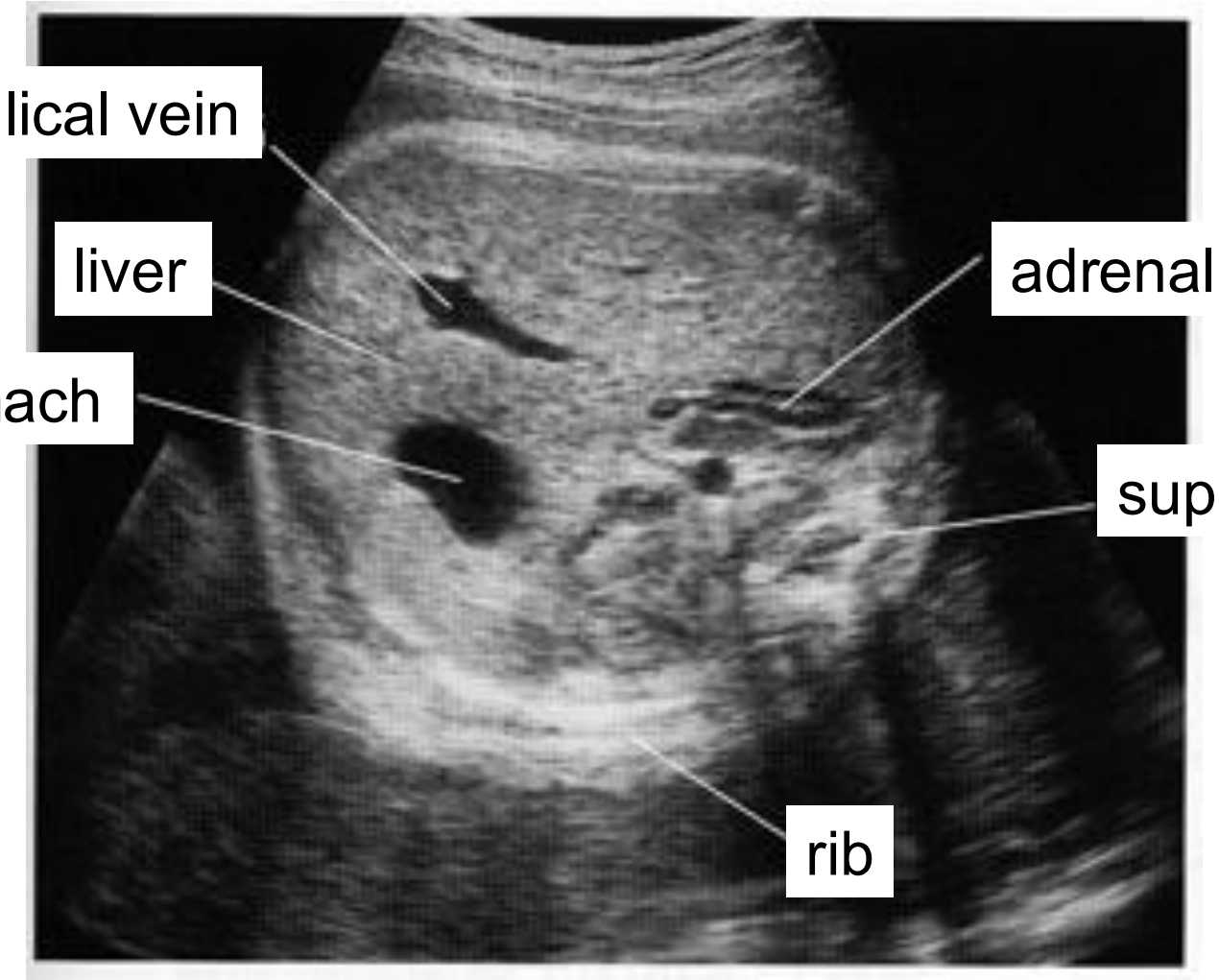


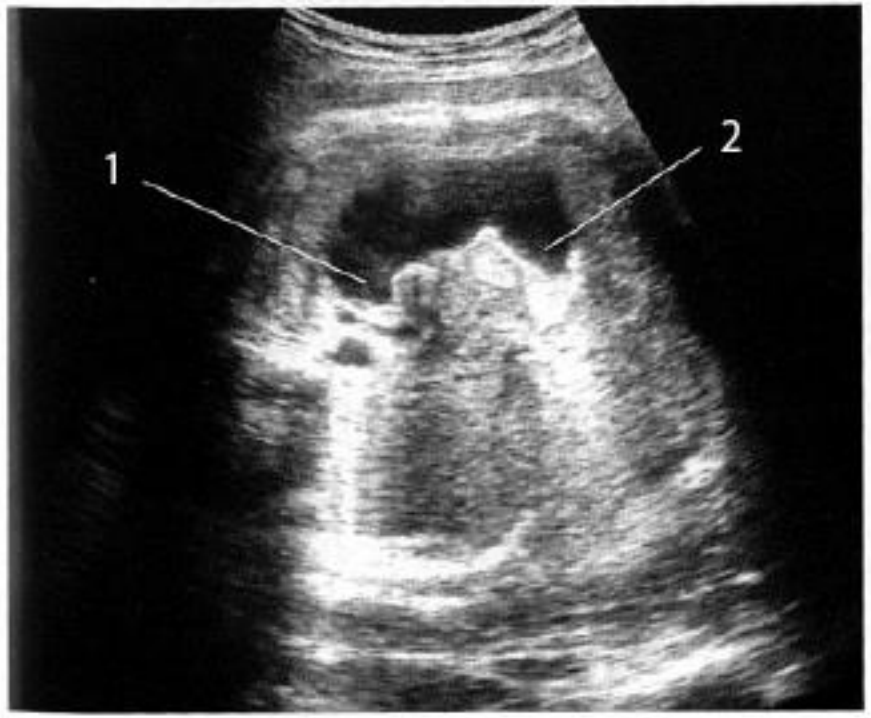
vascular ring



Abdomen

Upper abdomen （40th weeks gestation）



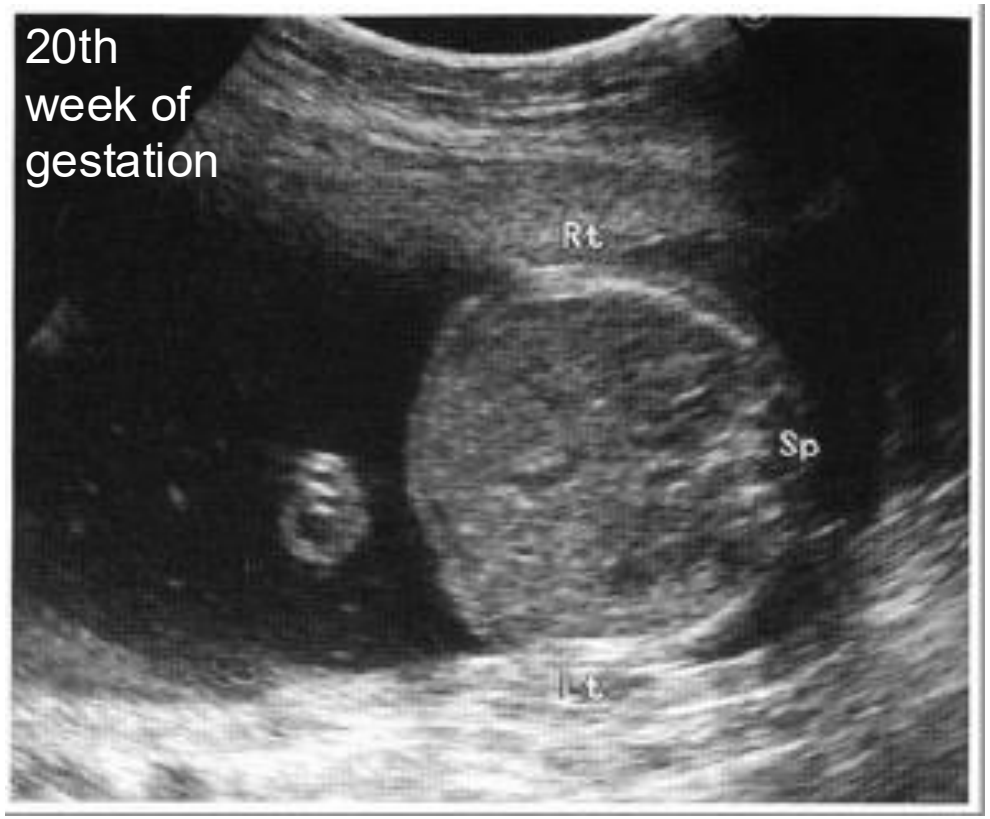


abdominal echo of normal fetus

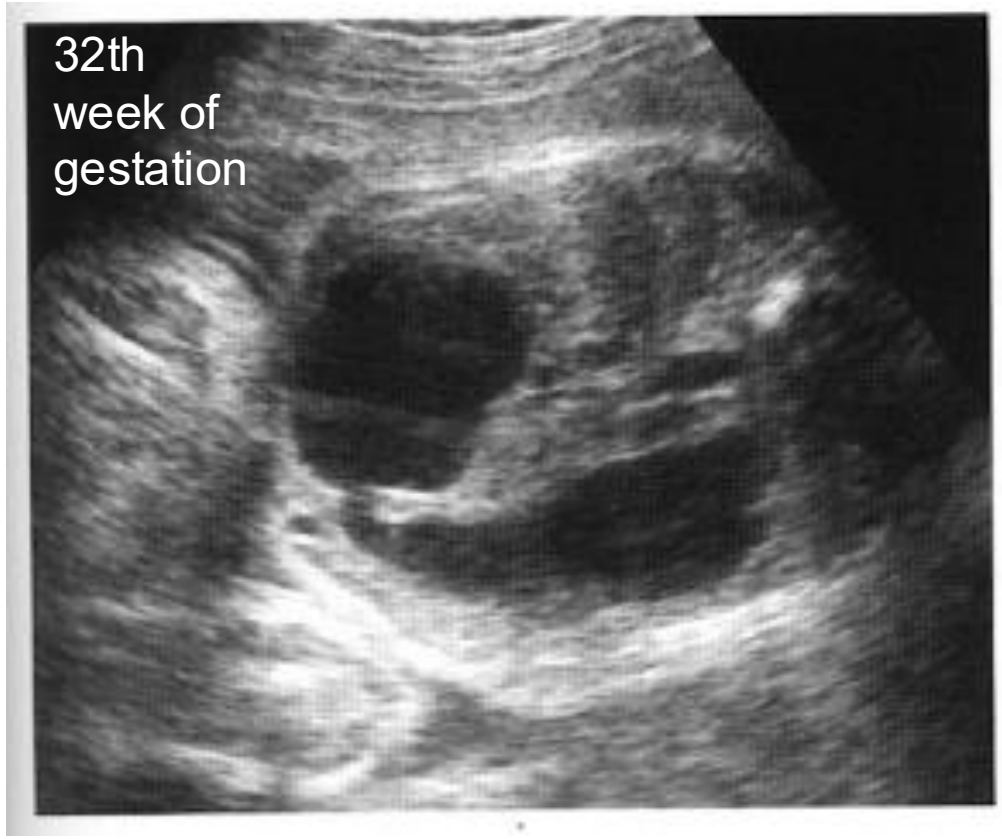
1: gastroduodenal region
2: gastropyloric region

gastrointestinal obstruction

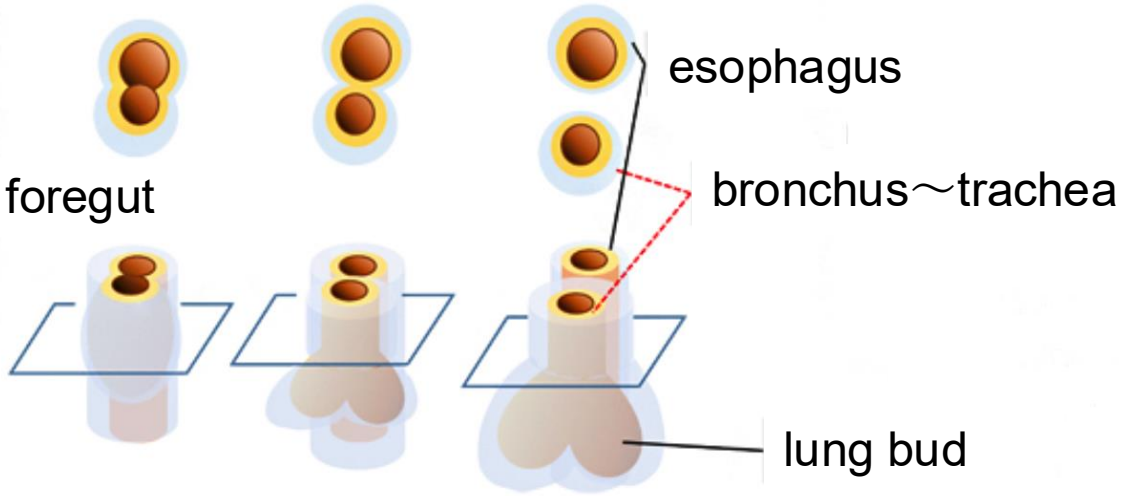
Enlargement of gastrointestinal tract： mid-term (>15mm) and late-term (>20mm)

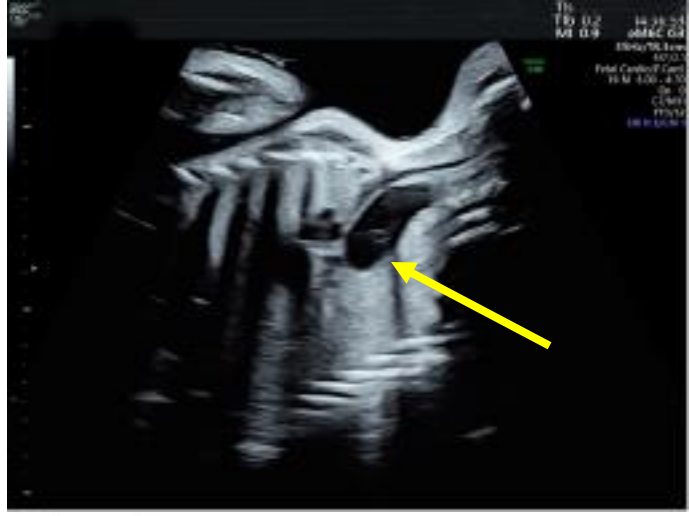


Esophageal atresia
extremely small gastric vesicle, polyhydramnion, FGR (21+)

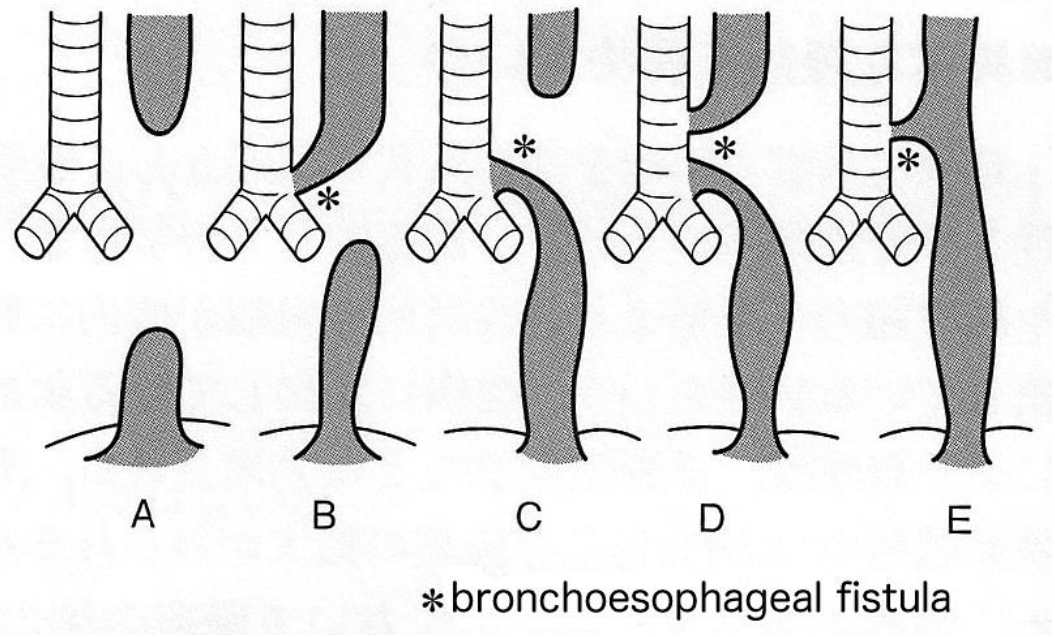


Duodenal atresia
double bubble sign (gastric vesicle and duodenal enlargement) (21+)



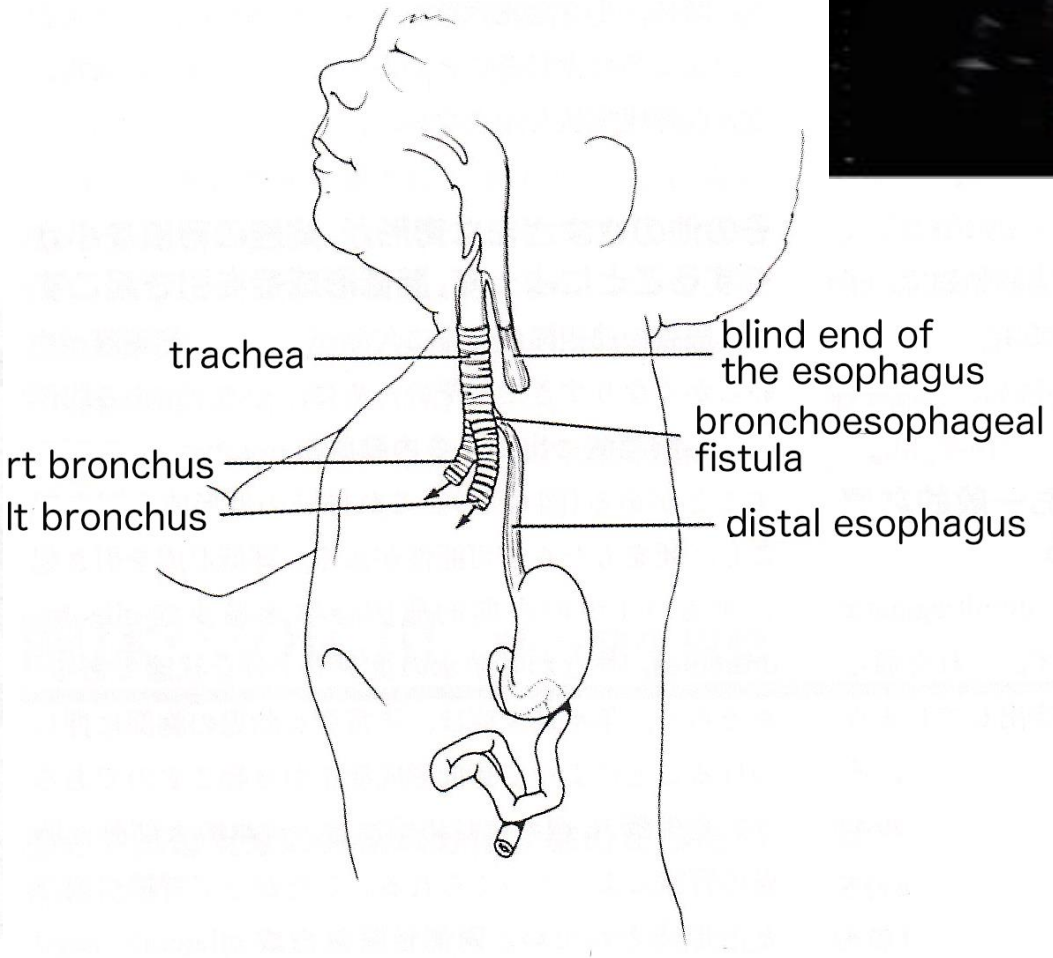


Pouch sign



Gross classification of esophageal atresia

Gross C is most common in the fetal esophageal atresia.

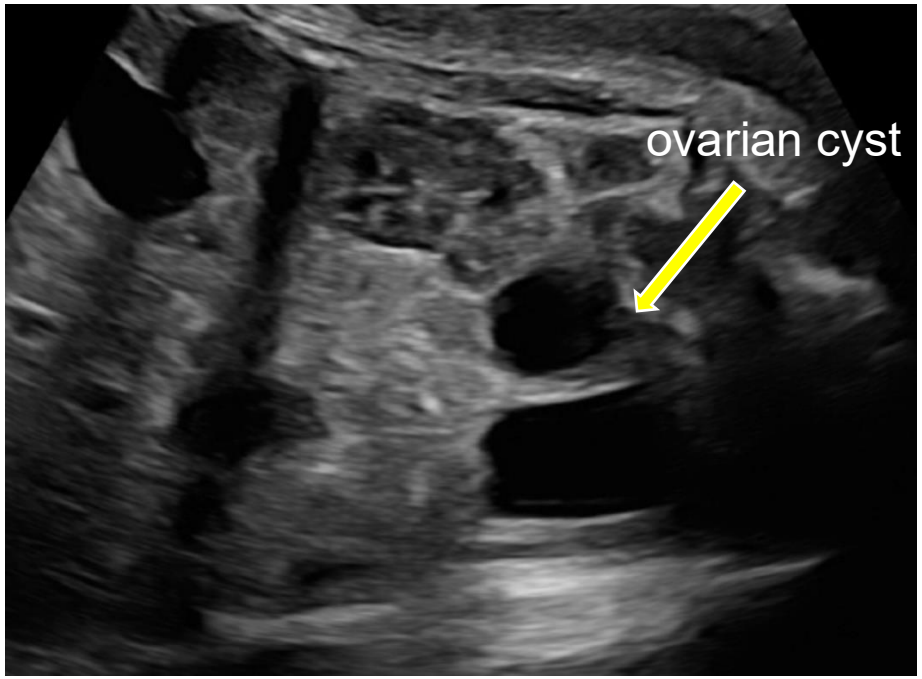


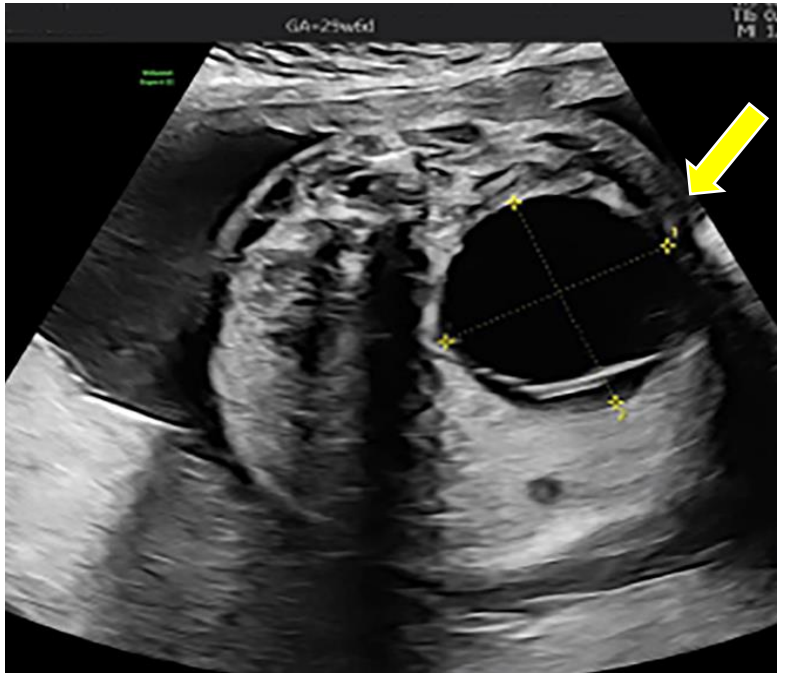
Esophageal atresia of Gross C

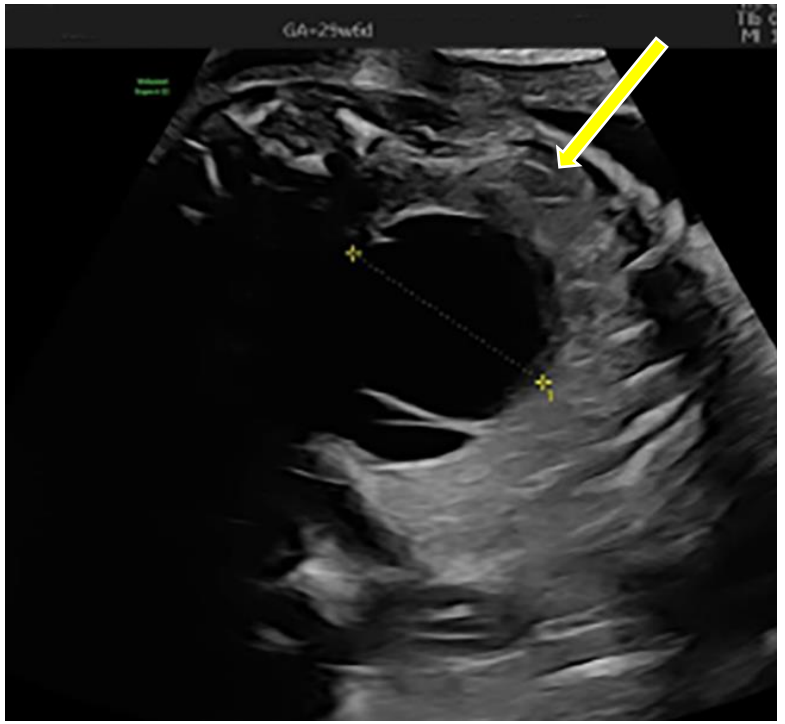
abdominal

cyst

Ovarian cyst

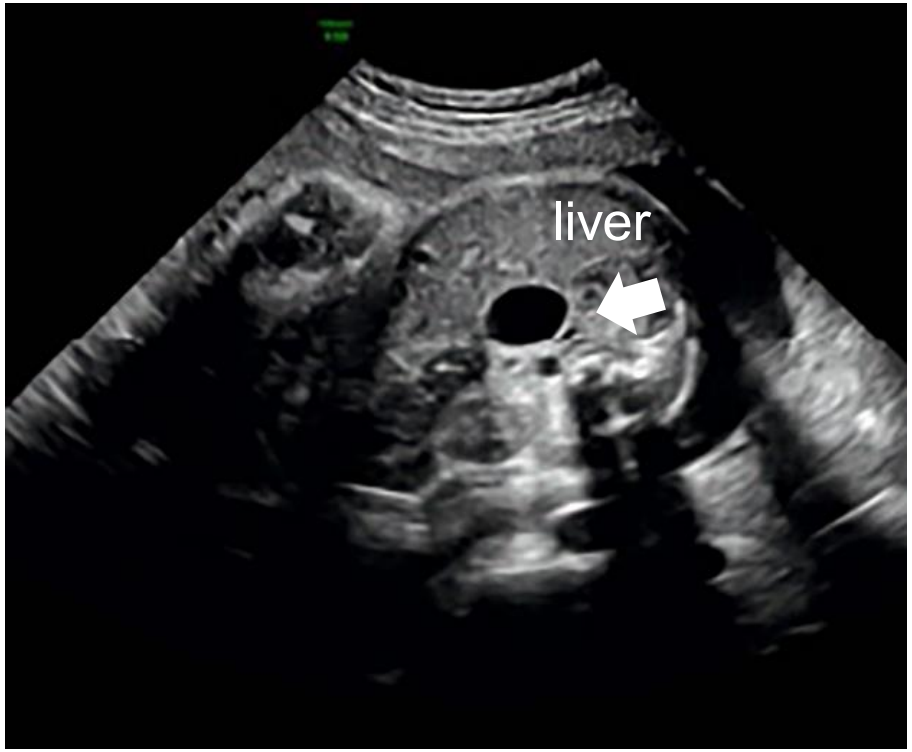


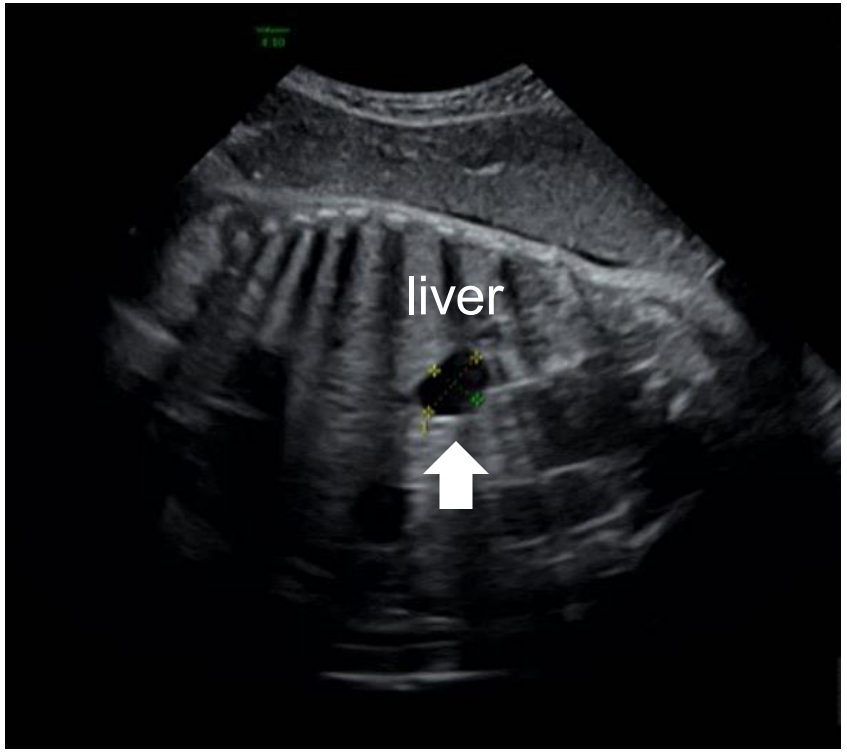




29th week gestation

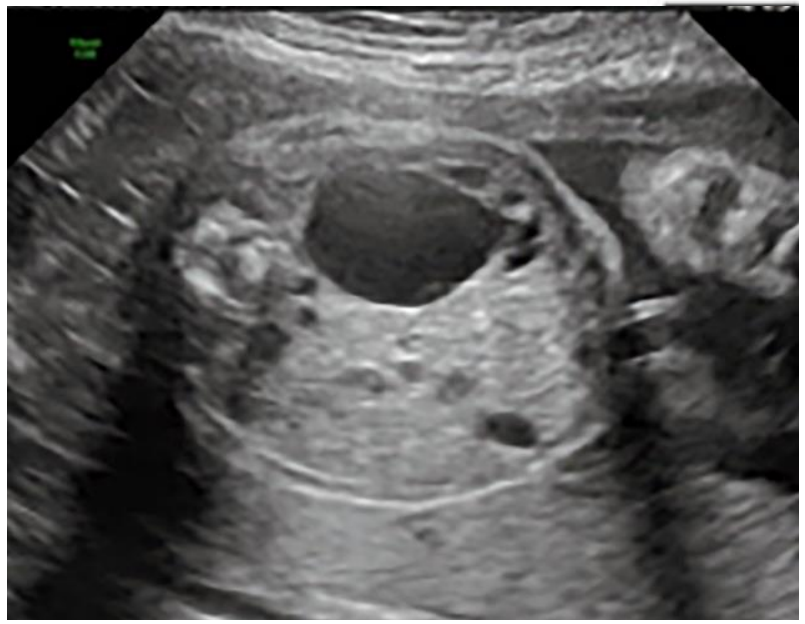
Congenital biliary atresia



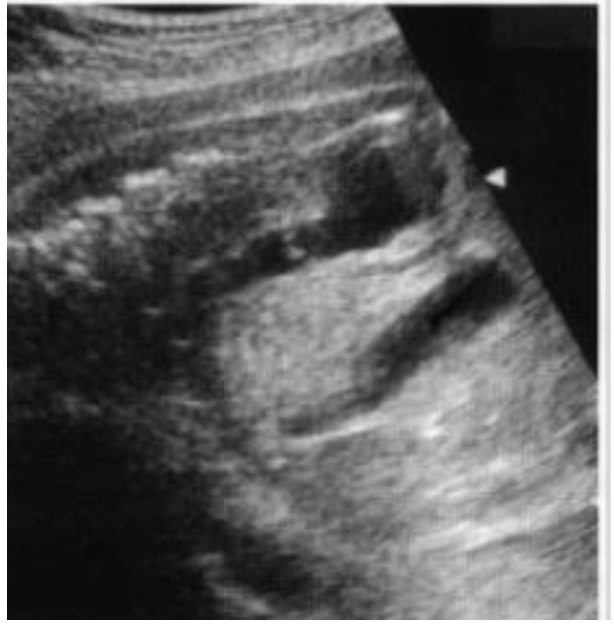


Hydronephrosis

- **Cause:**
  - ➢Ureteropelvic junction stenosis (prognosis is good).
  - ➢Vesicoureteral junction stenosis (prognosis depends on the ureteral diameter)

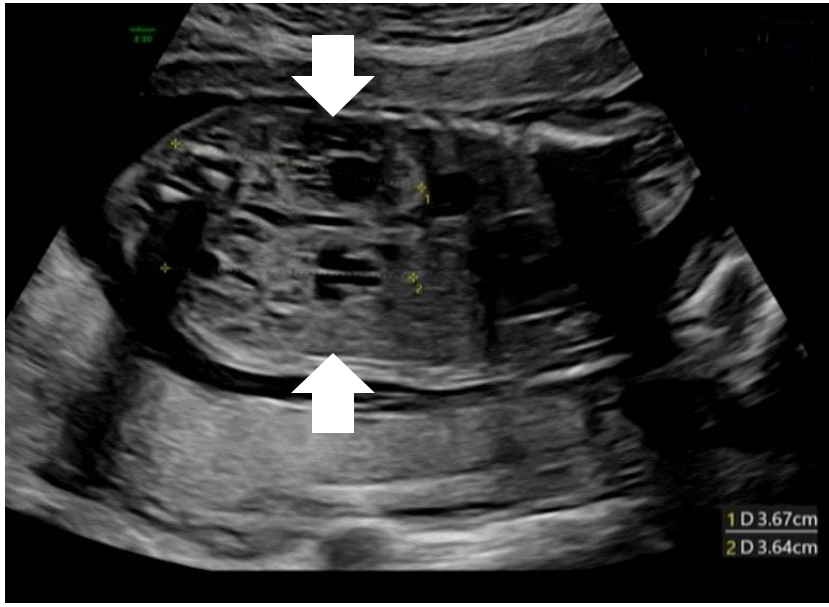


It hydronephrosis
29th weeks gestation



Vesicoureteral junction stenosis

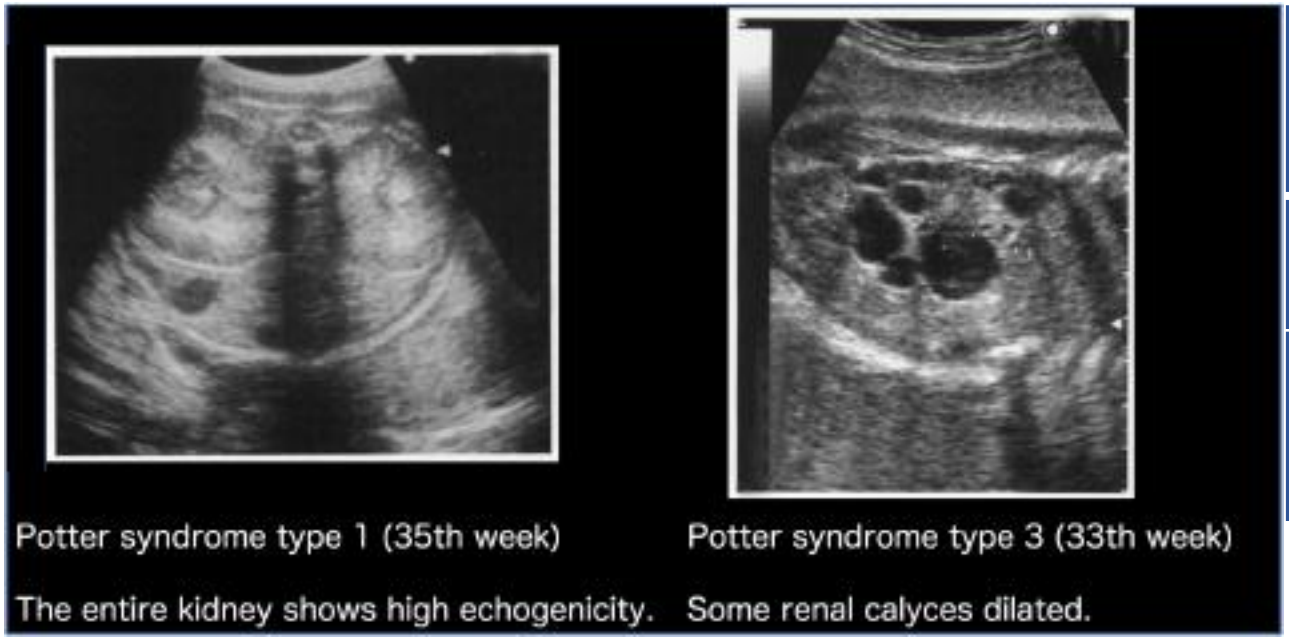
- However, the differential diagnosis of multiple dysplastic kidney (MCDK) is important because the prognosis of MCDK is not good.



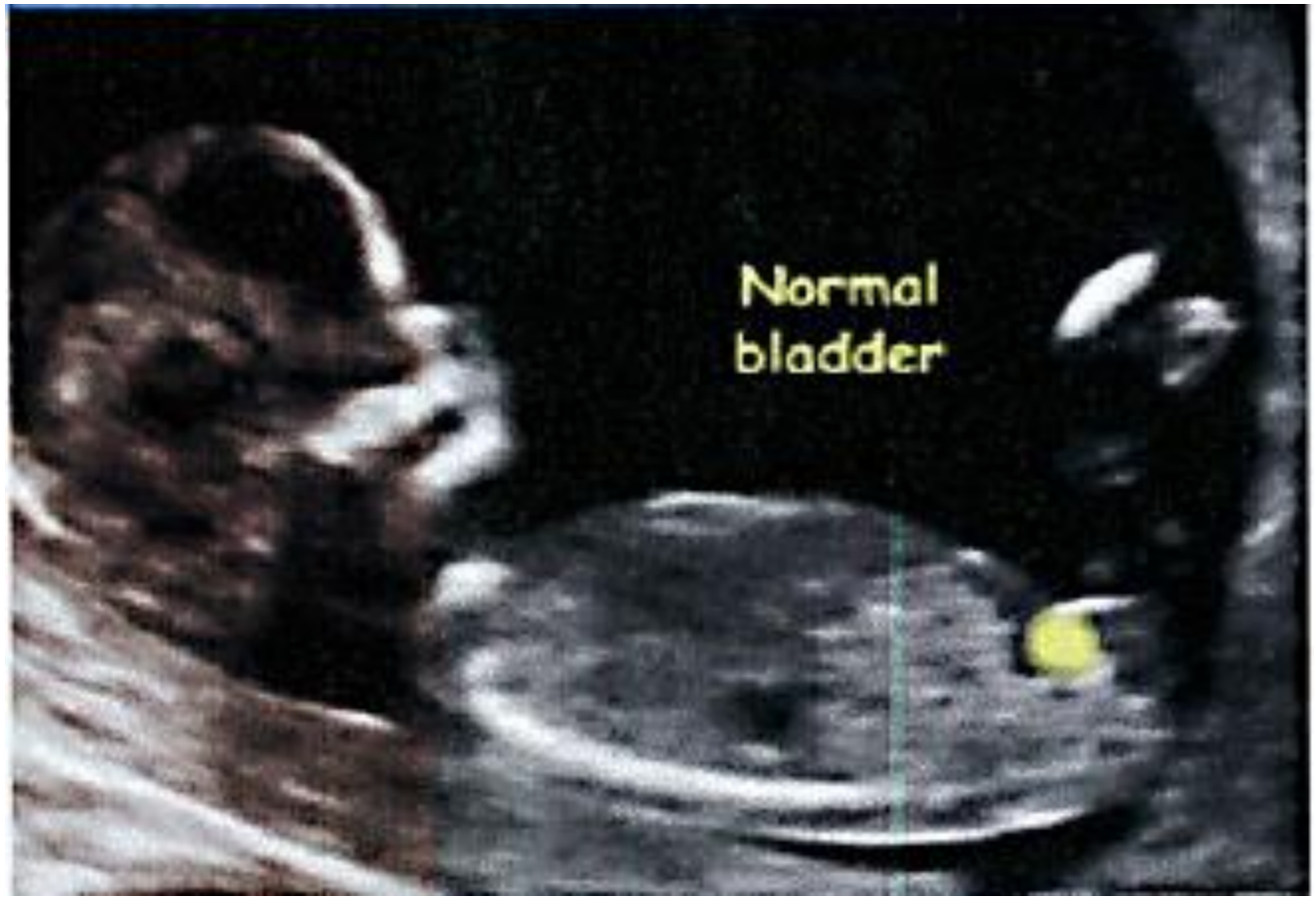
Polycystic kidney
18 weeks of gestation

Multiple dysplastic kidney (MCDK) （Potter syndrome）

- **Potter type 1:** Symmetrical enlargement of the entire kidney due to microcystic dilation of the renal tubules. The prognosis is very poor if there is a family history (autosomal recessive inheritance) or if there is oligohydramnion.
- **Potter type 3 (MCDK):** Kidney is occupied by cysts of various sizes. Unilateral cases have a good prognosis; however, bilateral cases are fatal because of renal failure oligohydramnion. (Autosomal dominant inheritance)



Potter type 1	infantile polycystic kidney disease (IPKD) autosomal recessive polycystic disease (ARPKD)
Potter type 2	multicystic dysplastic kidney (MCDK) sporadic
Potter type 3	adult polycystic kidney disease (APKD) autosomal dominant polycystic disease (ADPKD)

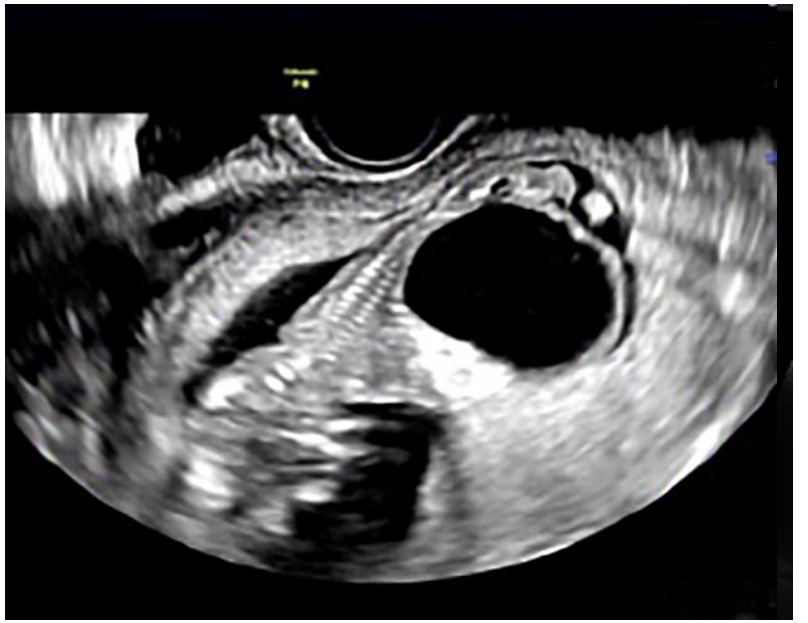


normal bladder

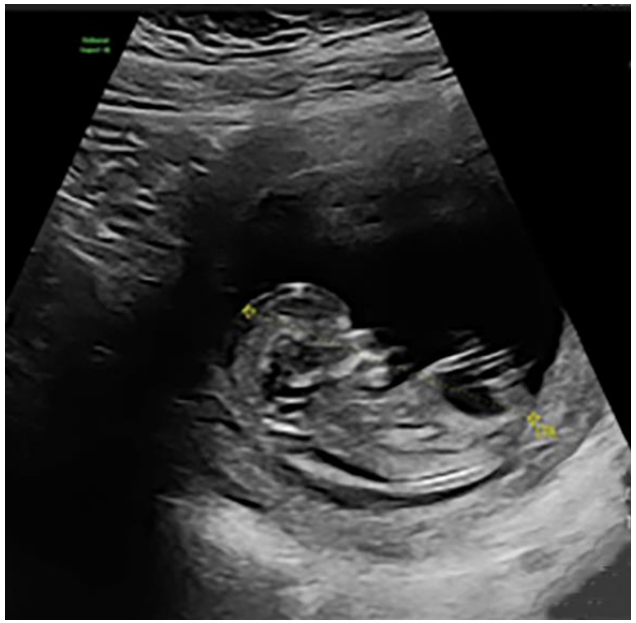
Giant bladder /

Prune-Berry syndrome

- Fetal bladder diameter at 13 weeks gestation is less than 6 mm; amniotic membrane produces amniotic fluid until 15 weeks.

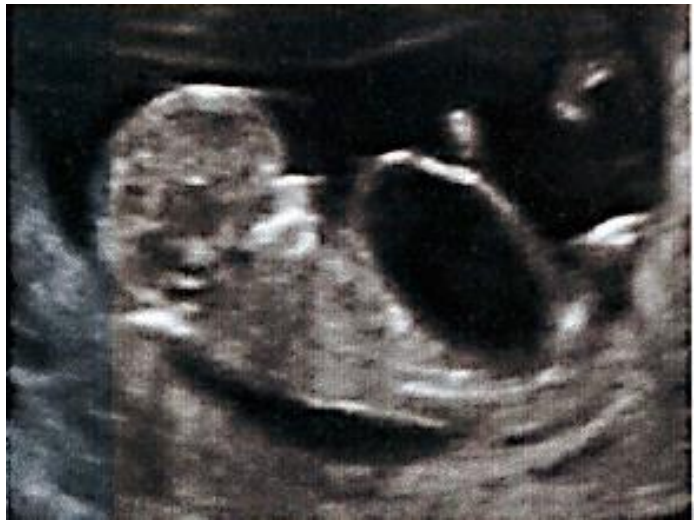


8th weeks gestation



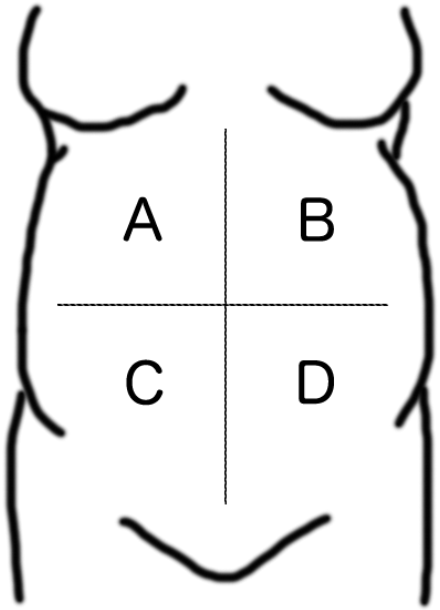
12th weeks gestation

- If the bladder diameter is 7-15 mm, 20% have a chromosomal abnormality (13 and 18 trisomies). In the case of normal chromosomes (80%), 90% of the fetuses improve spontaneously. As a result, 8% requires cysto-amniotic cavity shunt.
- If the bladder length is greater than 15 mm, chromosomal abnormalities are present in 10% of cases, and if the chromosomes are normal, obstructive uropathy is the most likely cause.

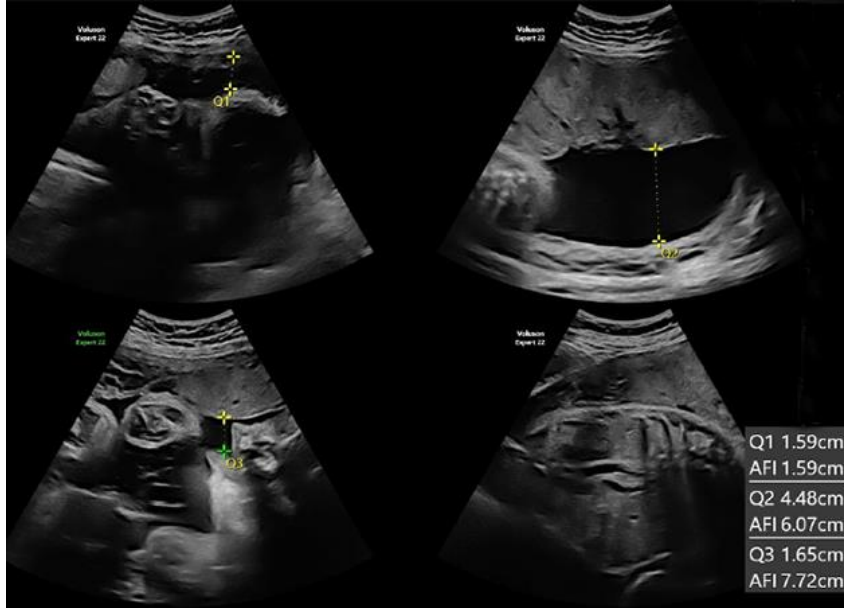


11th weeks gestation

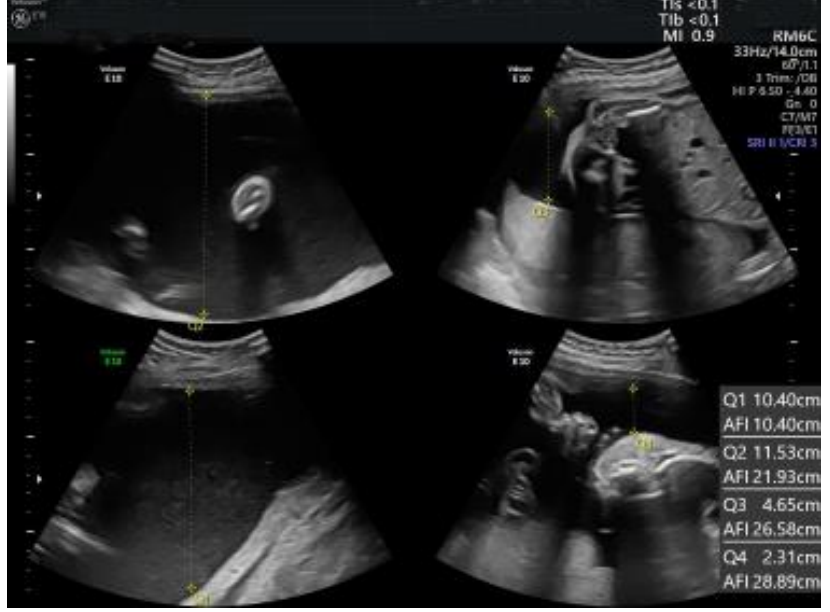
Amnion



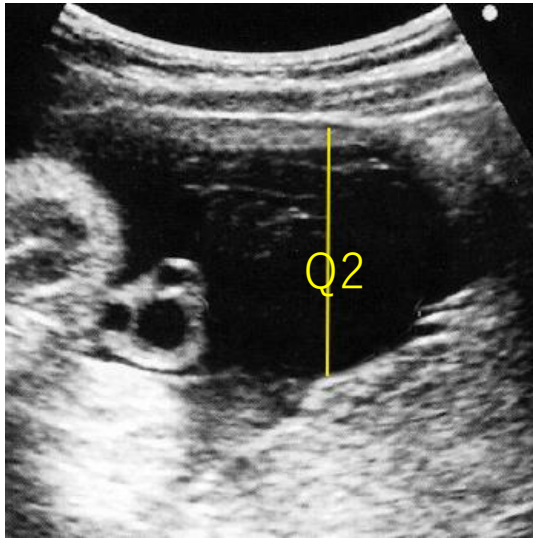
AFI = A + B + C + D



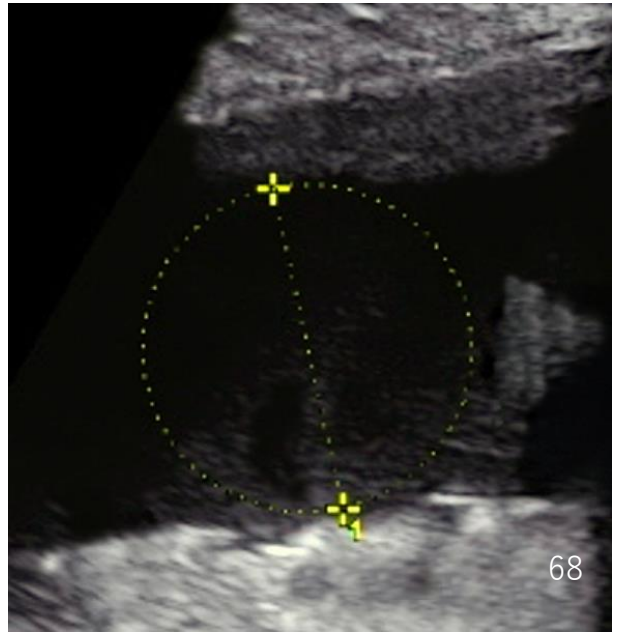
Amniotic Fluid Index (AFI)
(normal range: 5≤ ≥20)
AFI = 7.72, MVP = 4.48



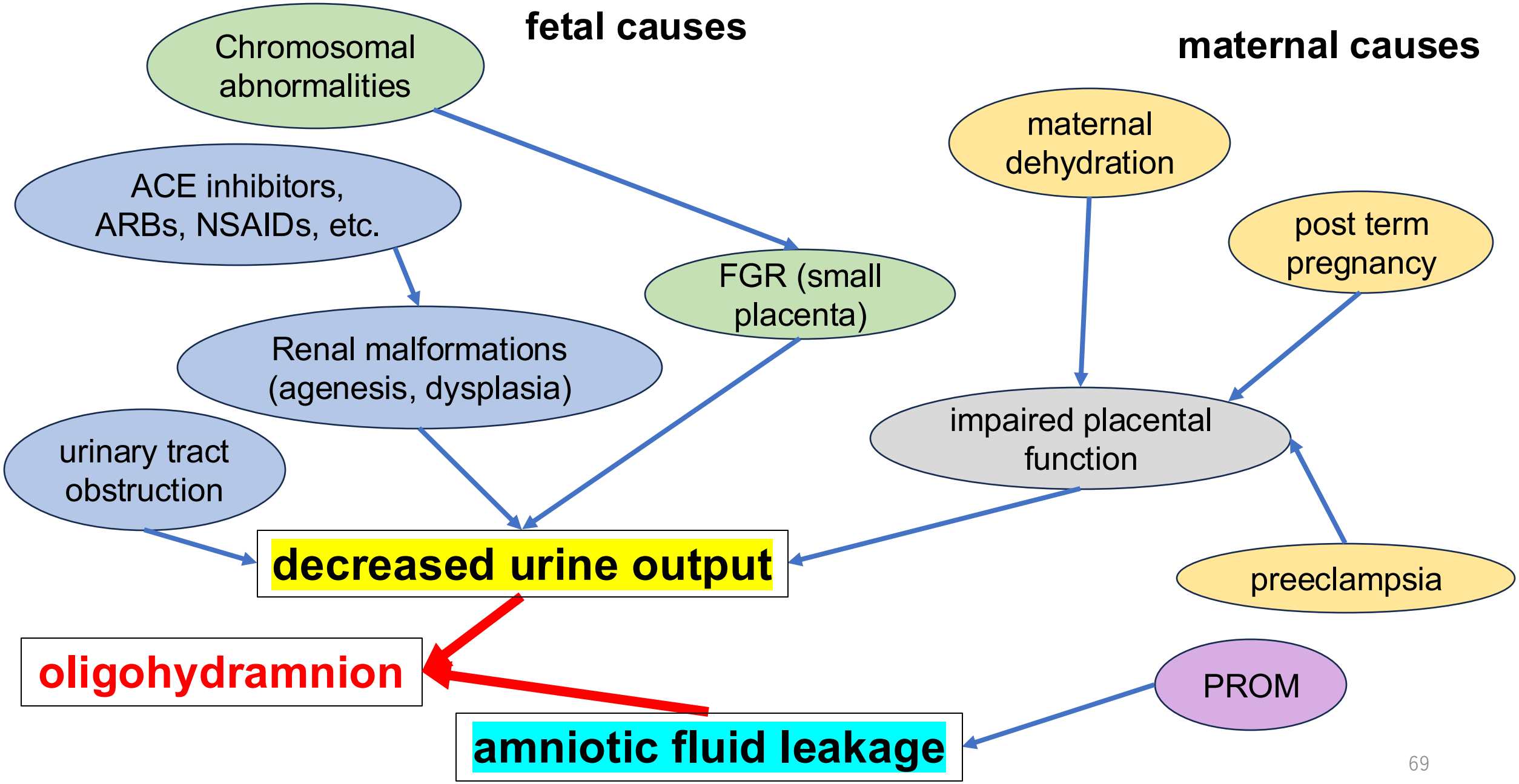
polyhydramnion
AFI = 28.89, MVP = 11.53

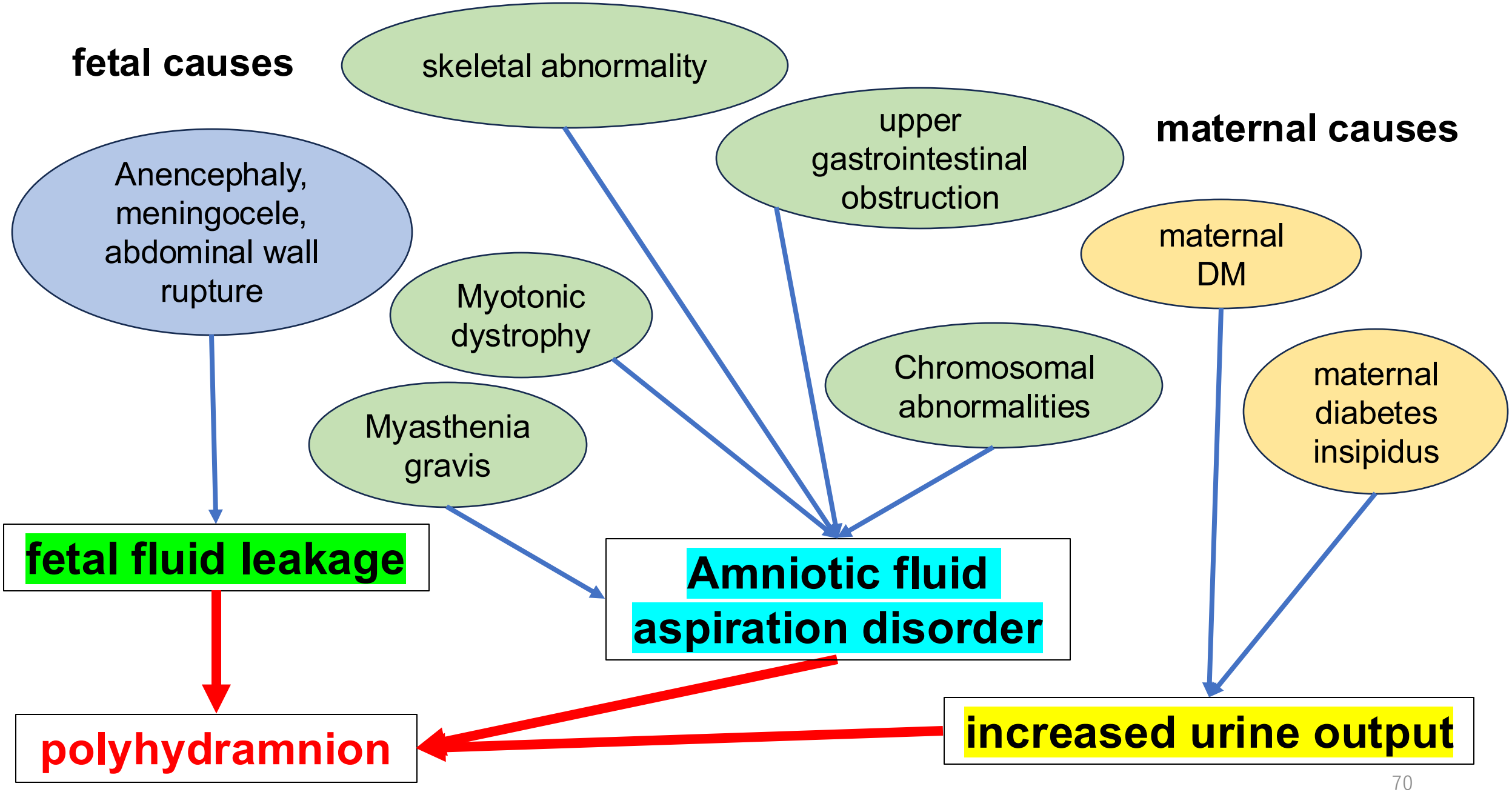


Maximal Vertical Pocket (MVP) = Q2
(normal range: 2≤ ≥8)



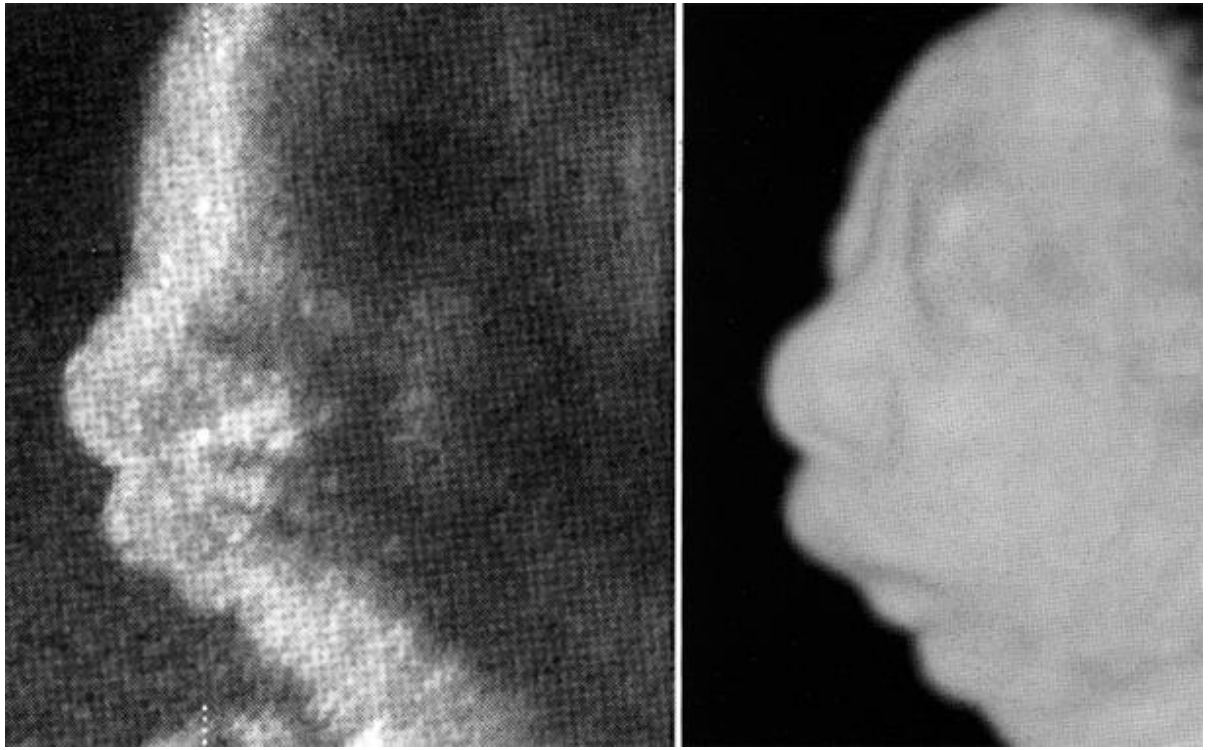
Amniotic Fluid Pocket (AP)
(normal range: 2≤ ≥8)


fetal causes
maternal causes
Chromosomal abnormalities
ACE inhibitors, ARBs, NSAIDs, etc.
Renal malformations (agenesis, dysplasia)
urinary tract obstruction
FGR (small placenta)
maternal dehydration
post term pregnancy
impaired placental function
preeclampsia
decreased urine output
oligohydramnion
amniotic fluid leakage
PROM


fetal causes
skeletal abnormality
upper gastrointestinal obstruction
maternal causes
Anencephaly, meningocele, abdominal wall rupture
Myotonic dystrophy
maternal DM
Chromosomal abnormalities
maternal diabetes insipidus
Myasthenia gravis
fetal fluid leakage
Amniotic fluid aspiration disorder
polyhydramnion
increased urine output

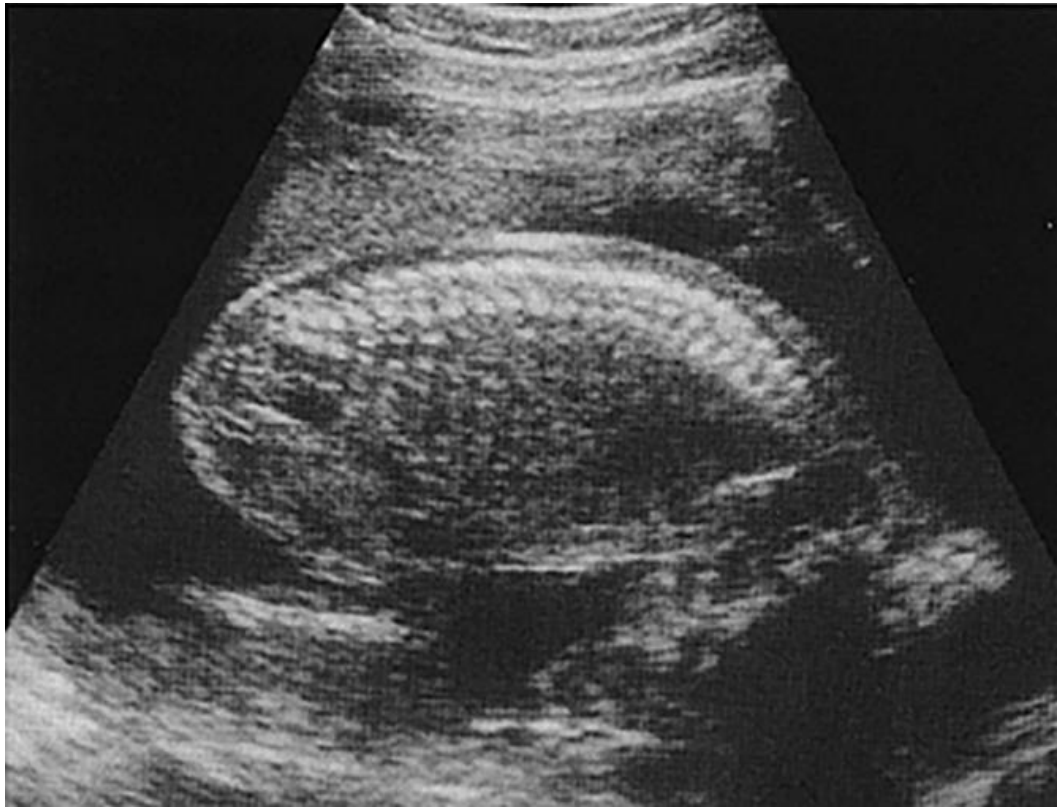
Abnormal Jaw

- **Micrognathia**：Pena-Shokar syndrome・Treacher-Collins syndrome・Pierre Robin syndrome
- Micrognathia can cause polyhydramnion and respiratory failure.

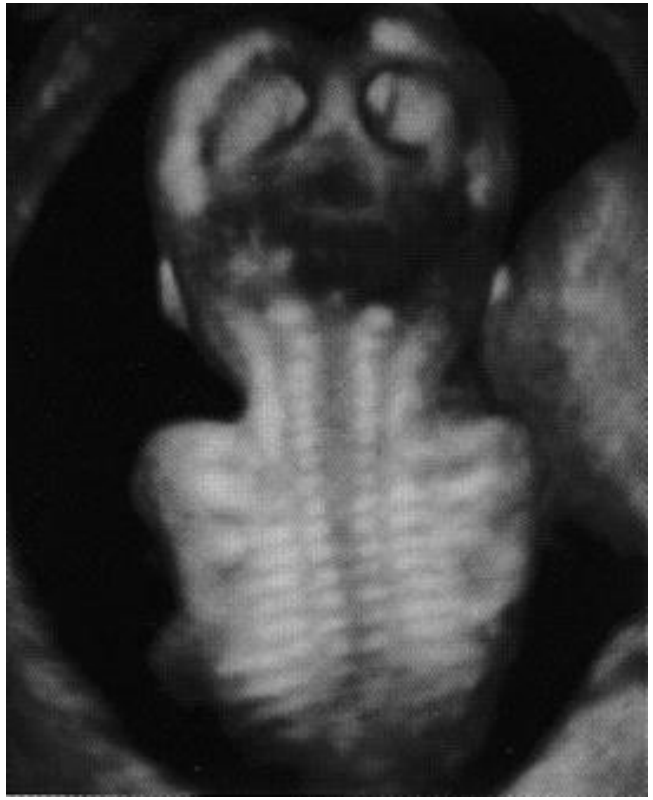


micrognathia（30th weeks gestation）

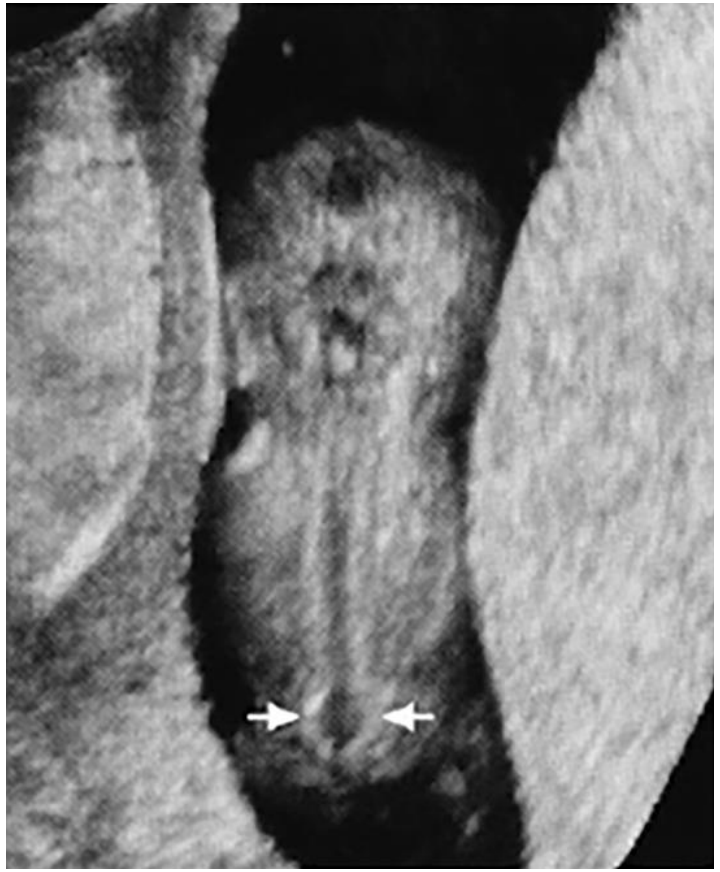
Spine



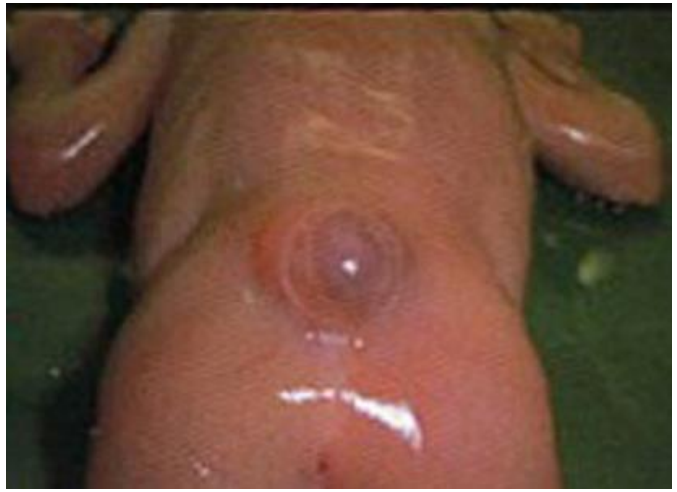
normal spine（21th week of gestation）



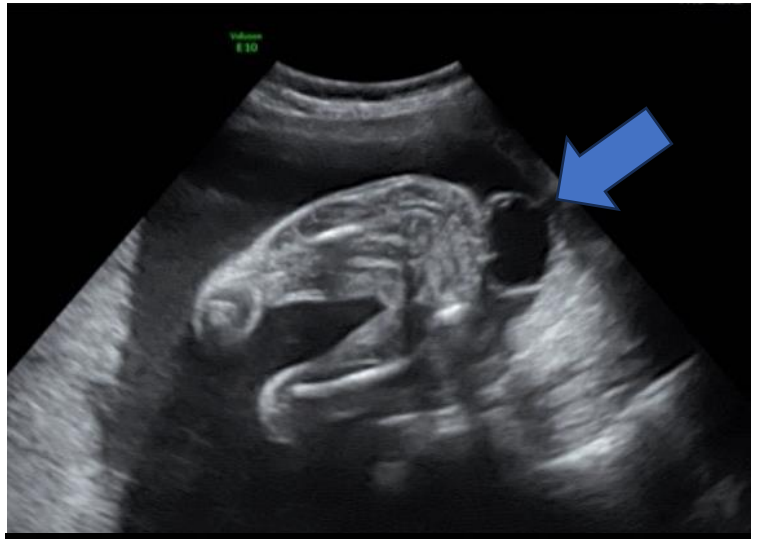
26th week of gestation

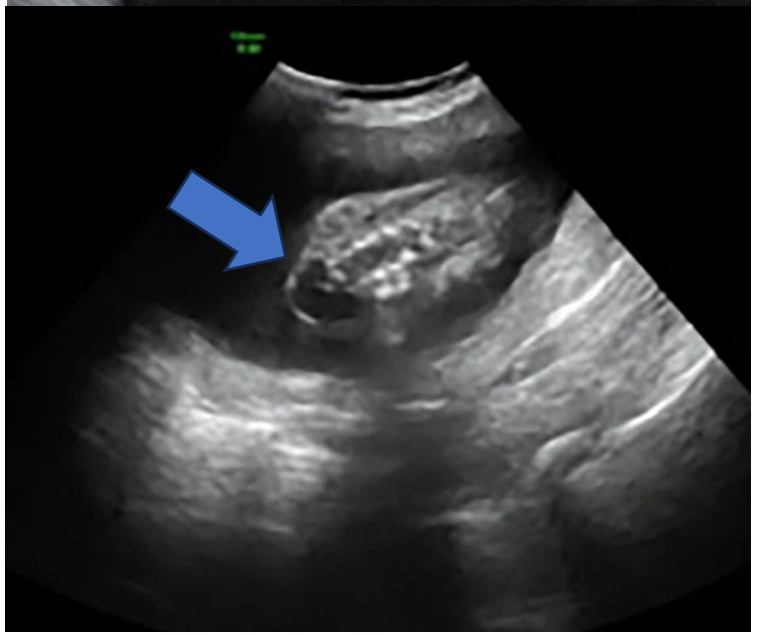


9th spina bifida



18th spina bifida





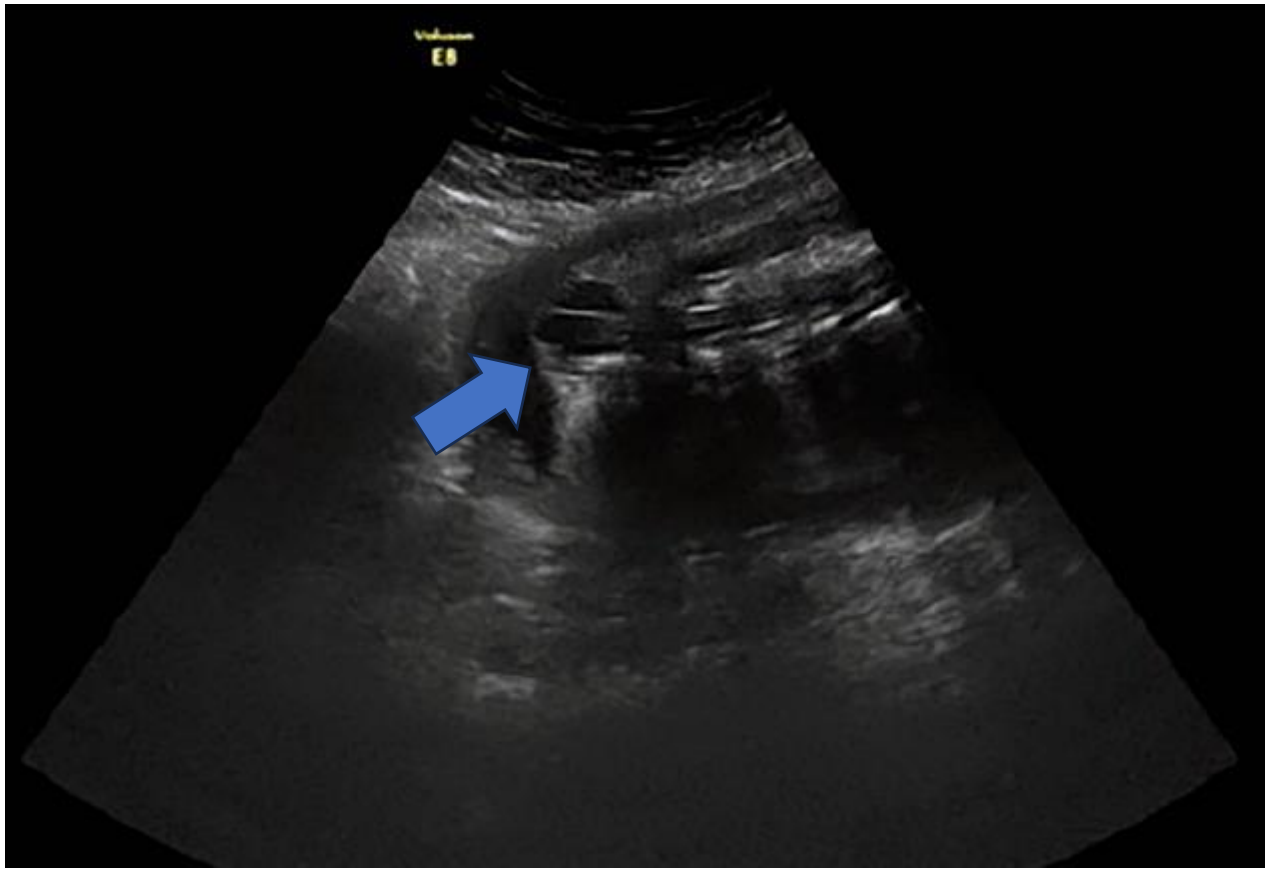
26th spina bifida

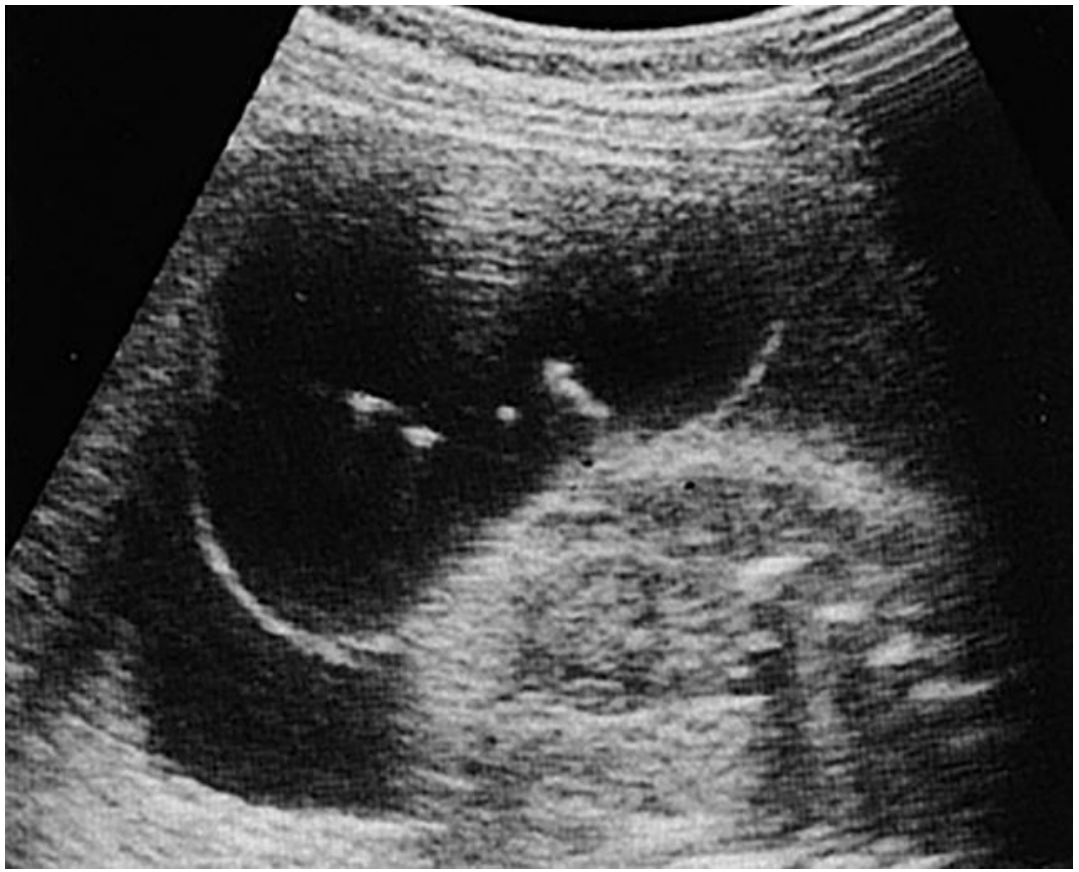
Spina Bifida

Causes: Chromosomal abnormalities, genetic abnormalities, diabetes, antiepileptic drugs

Exposed nerves would be damaged. Adequate intake of folic acid supplements since before pregnancy can reduce the risk of spina bifida by 75%.

lumbosacral meningocele

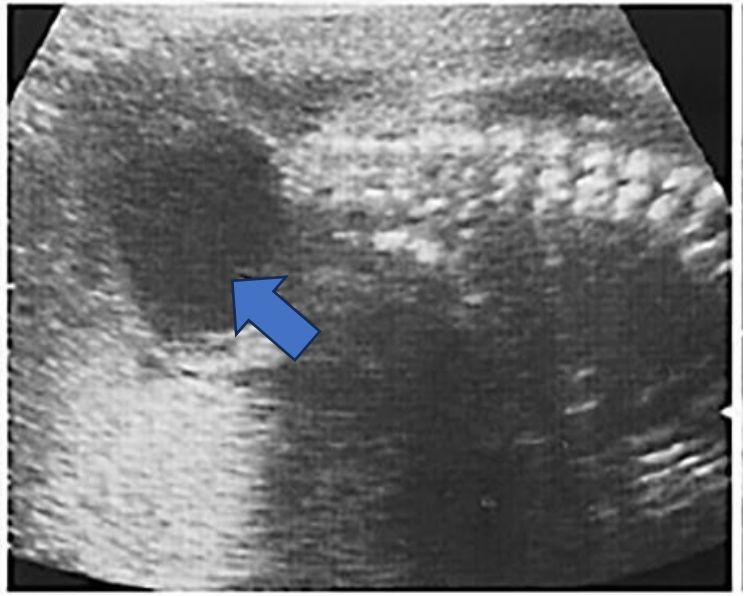


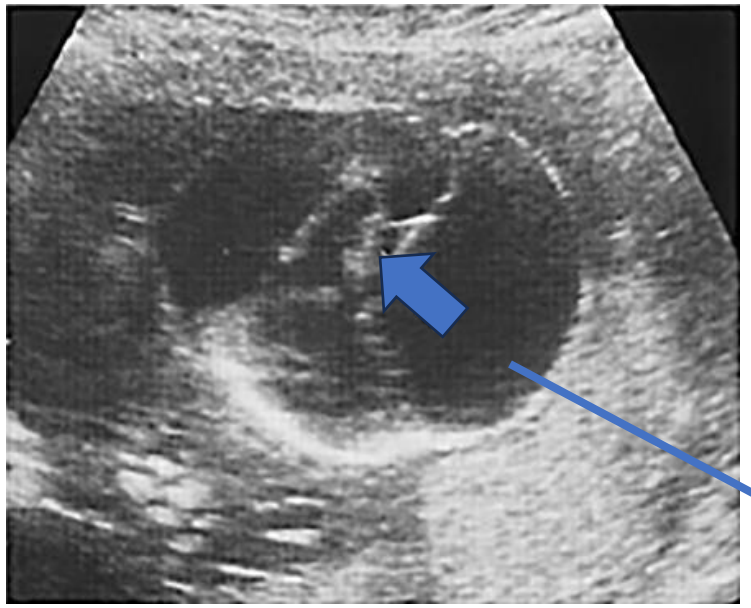


Meningocele : cystic (28 weeks gestation)

Myelomeningocele: The inside of the tumor appears complex because it contains nerve tissue.(28 weeks gestation)

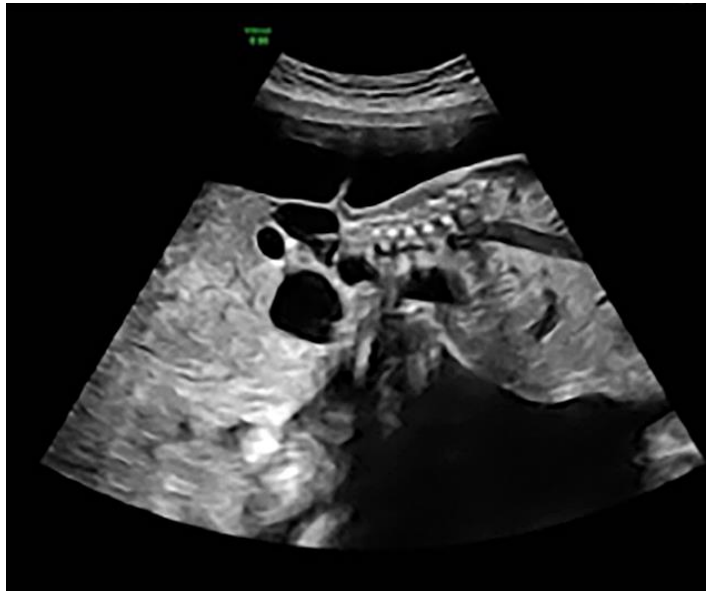
lumbosacral teratoma

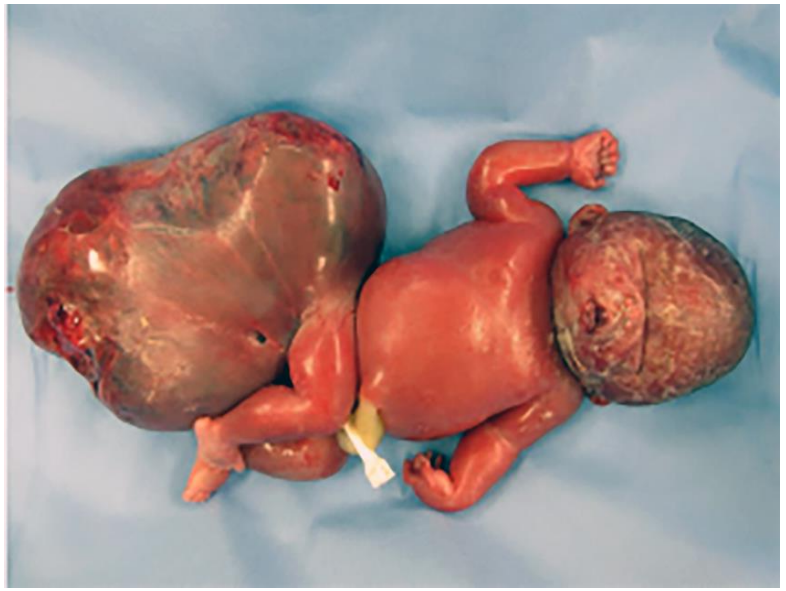




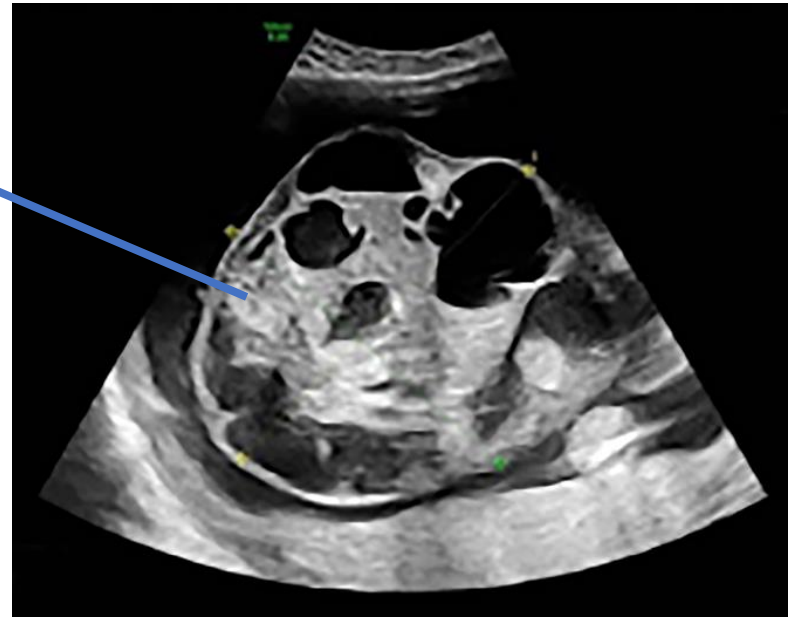
multicystic

cystic: 34 weeks gestation

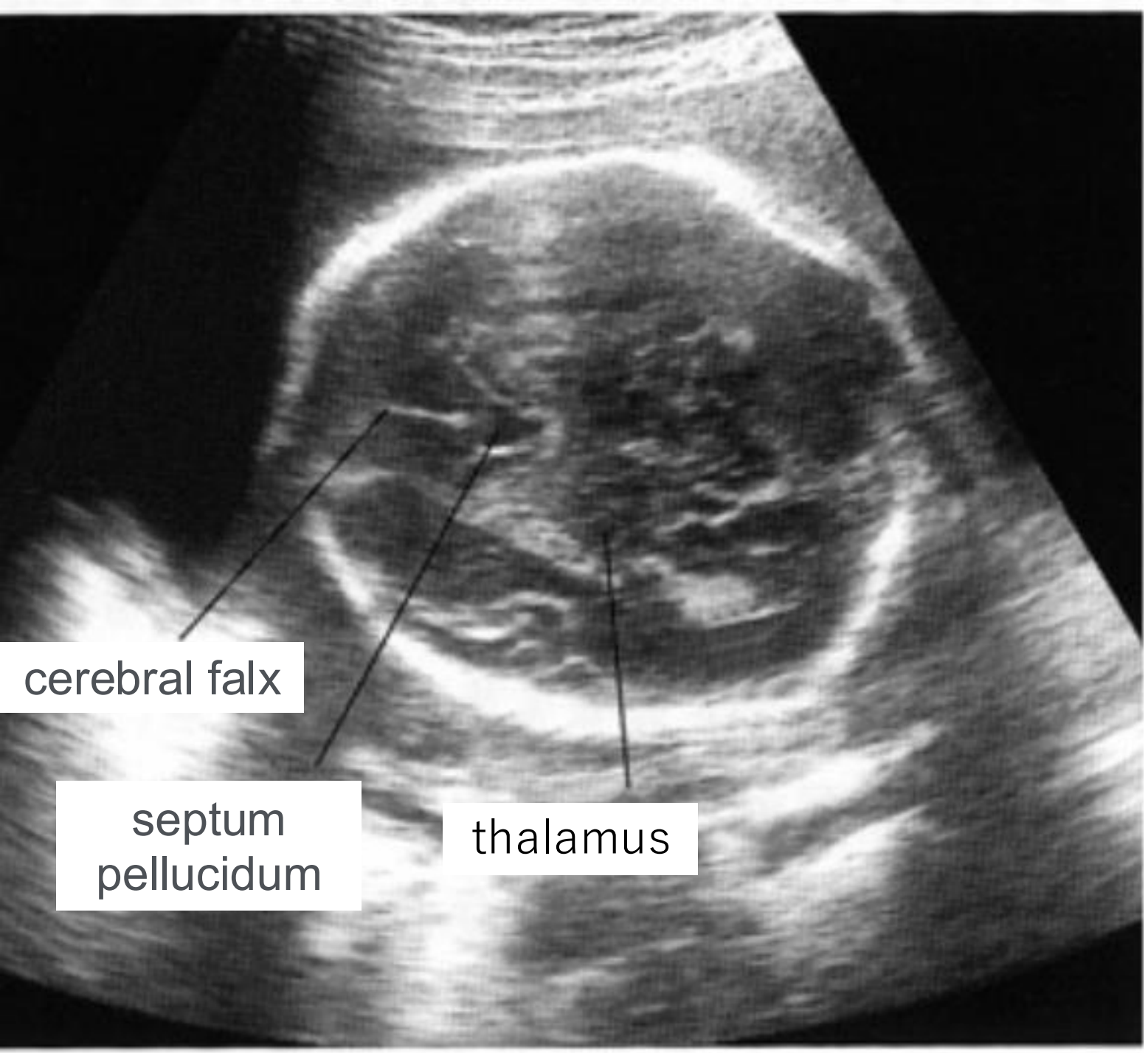


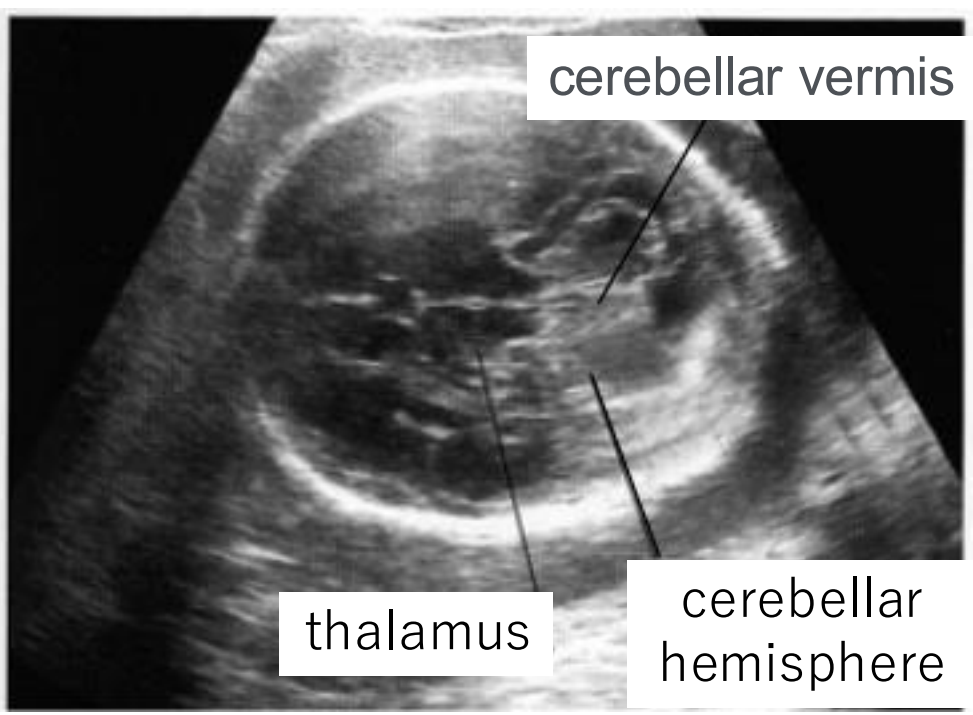


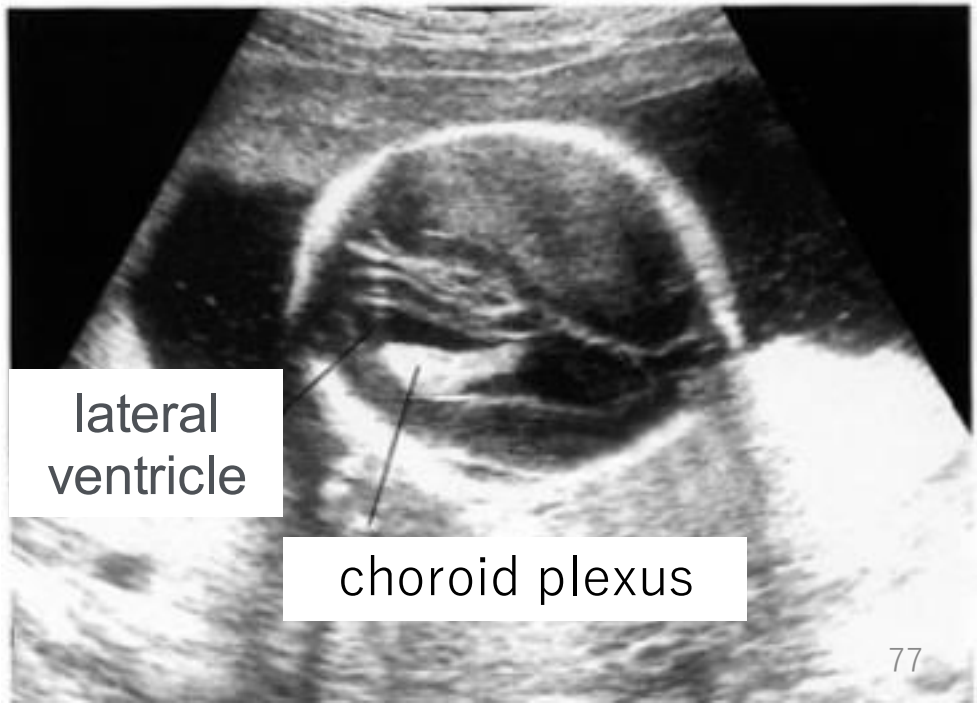
solid
DIC
(w/ or w/o cardiac failure)



Brain (head)

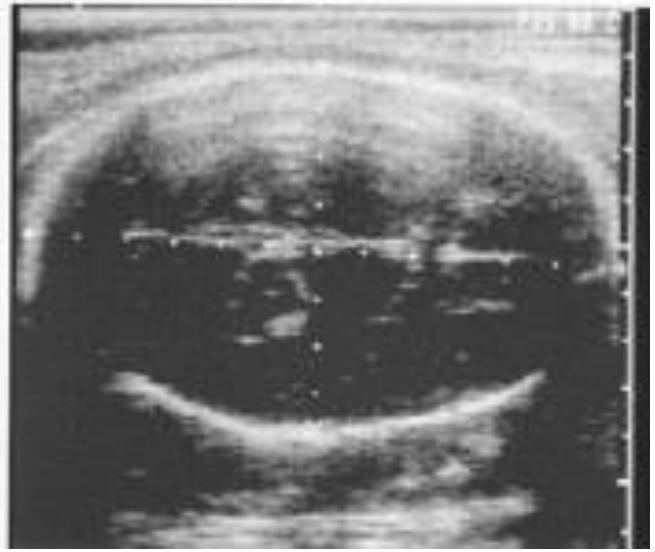

cerebral falx
septum pellucidum
thalamus


cerebellar vermis
thalamus
cerebellar hemisphere

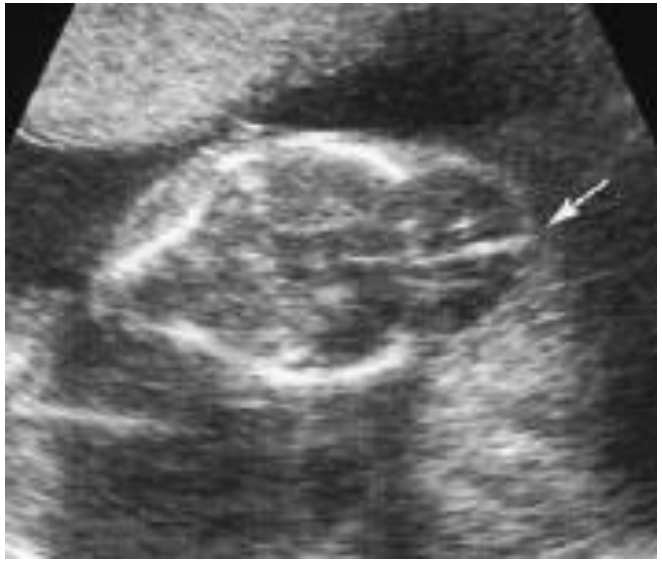

lateral ventricle
choroid plexus

Embryology early in pregnancy (central nervous system)

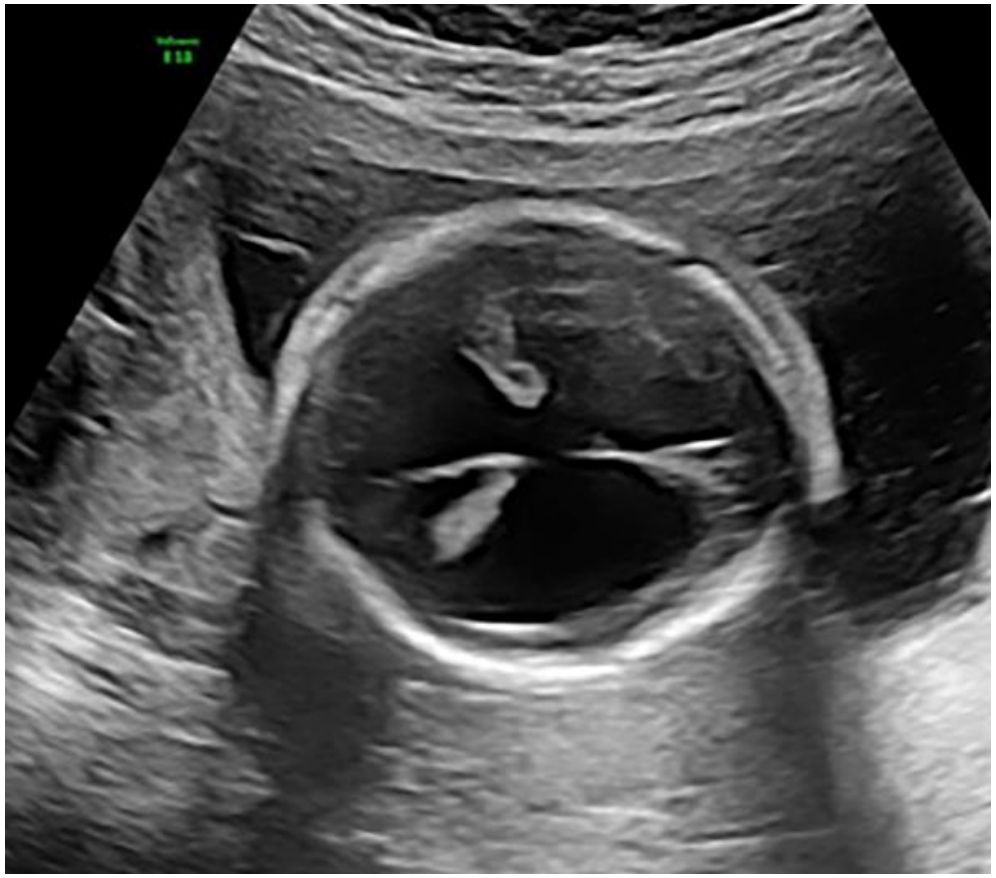
- **Dolichocephaly**：This is found in the pelvic position. When measuring estimated fetal weight, it should be corrected by head circumference.

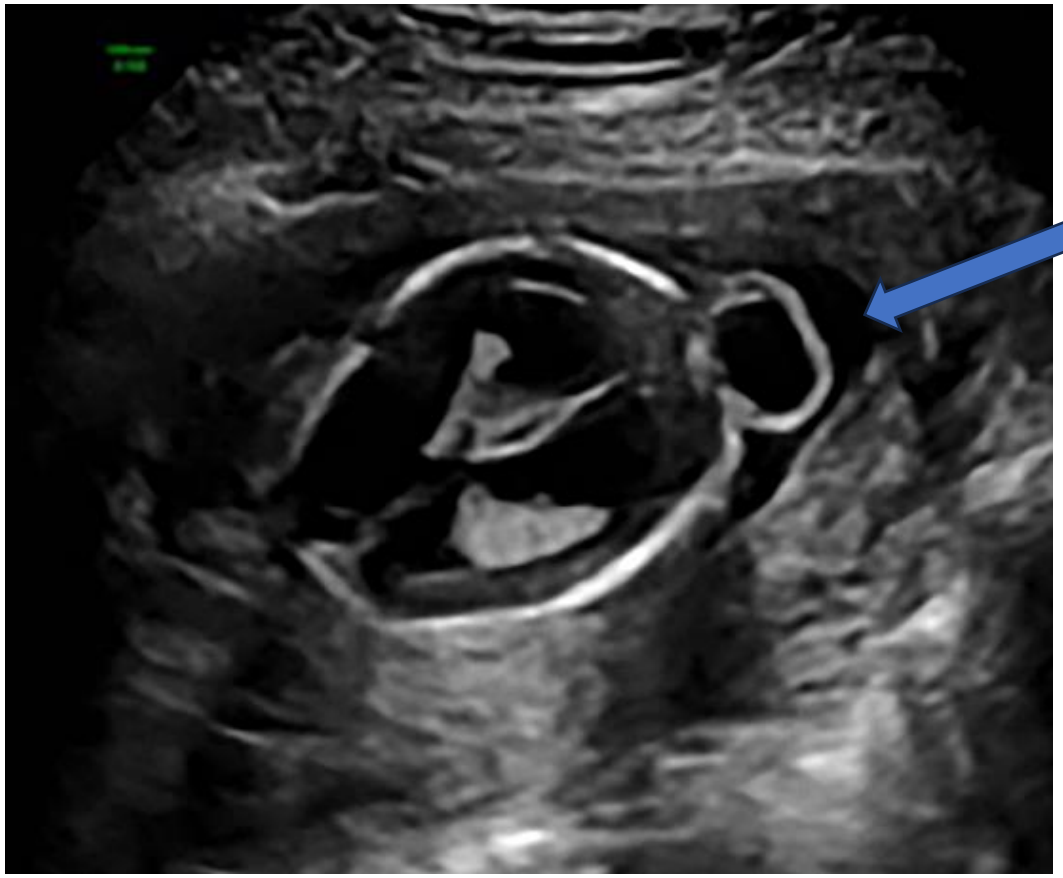


- **Microcephaly** : often based on impaired brain development due to fetal alcohol syndrome or other factors.

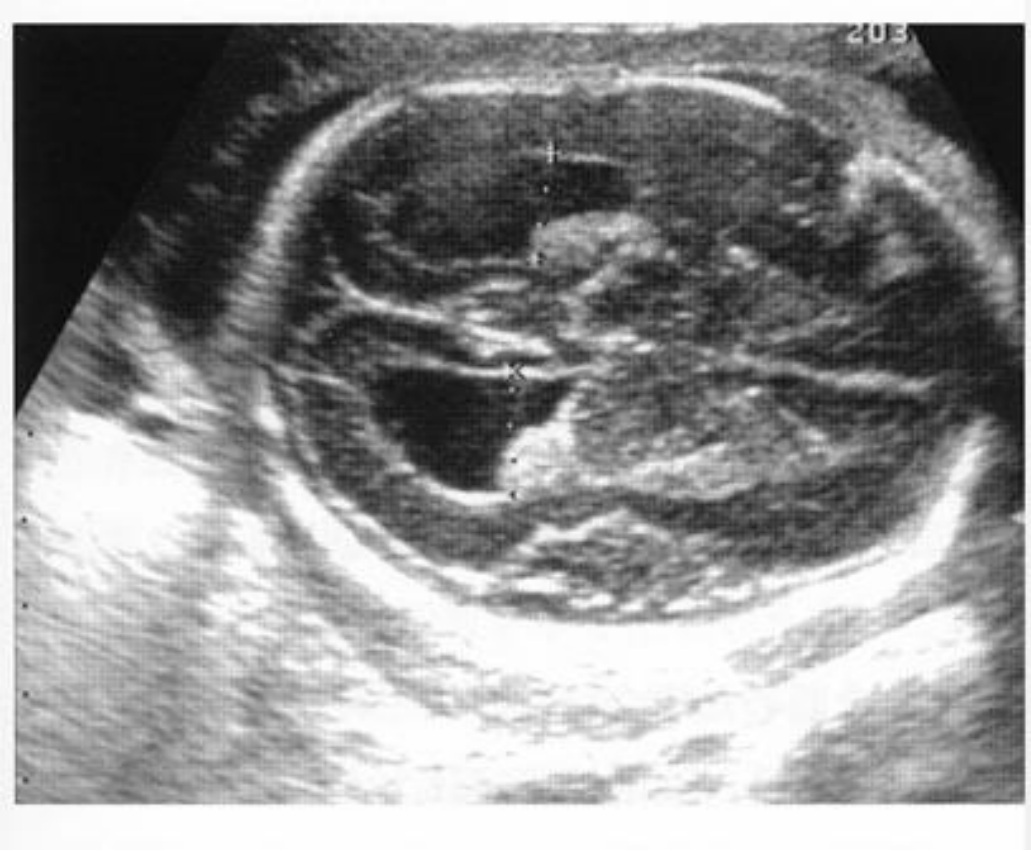


Ventriculomegaly

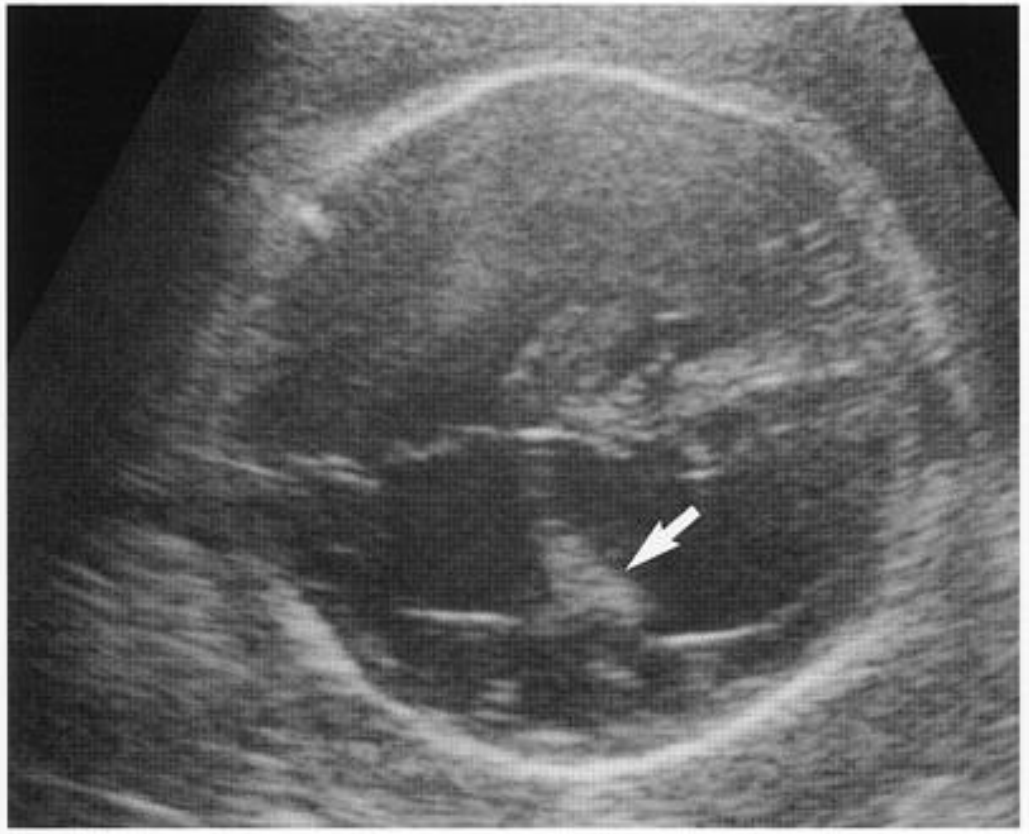




skull defect
encephalocele



mild ventriculomegaly

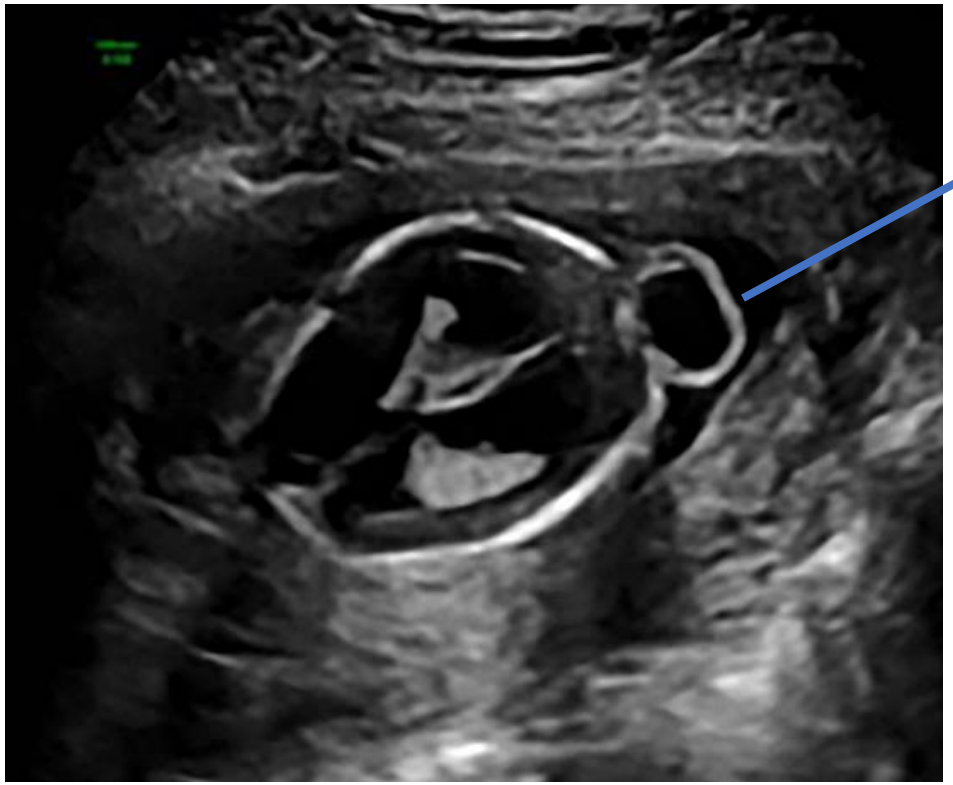


dangling of choroid plexus

- diameter of lateral ventricle（Posterior Horn）≧ 10mm
- **Cause**：chromosomal anomaly, cerebral hemorrhage, fetal viral infection (Toxoplasma, Cytomegalovirus)

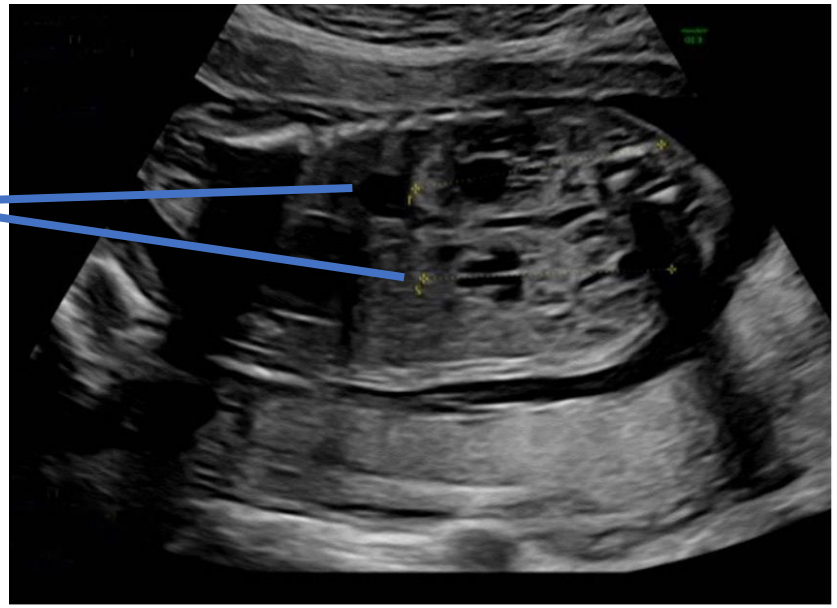
Meckel Gruber syndrome (18th week of gestation)

Encephalocele, Congenital polycystic kidney, Limb abnormalities



encephalocele

polycystic kidney

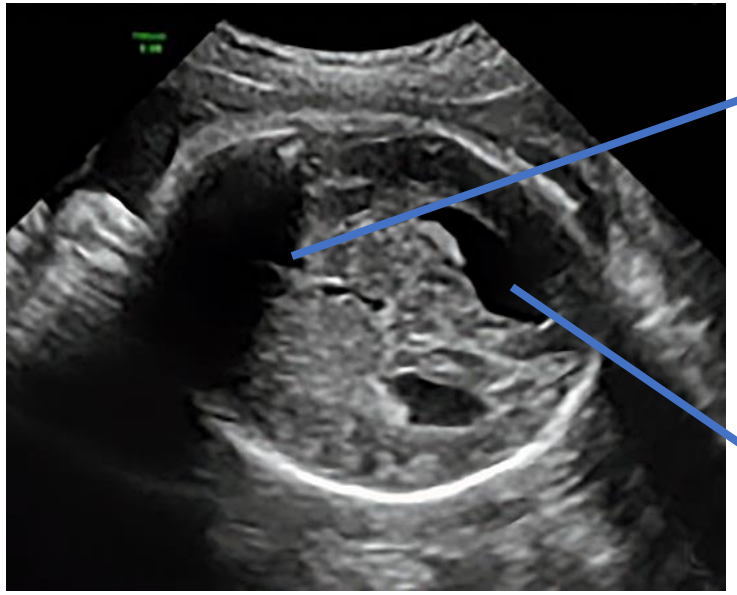


Fetal-specific ventriculomegaly

- Agenesis of corpus callosum
- Chiari type II Malformation
- Dandy-Walker syndrome

Agenesis of corpus callosum

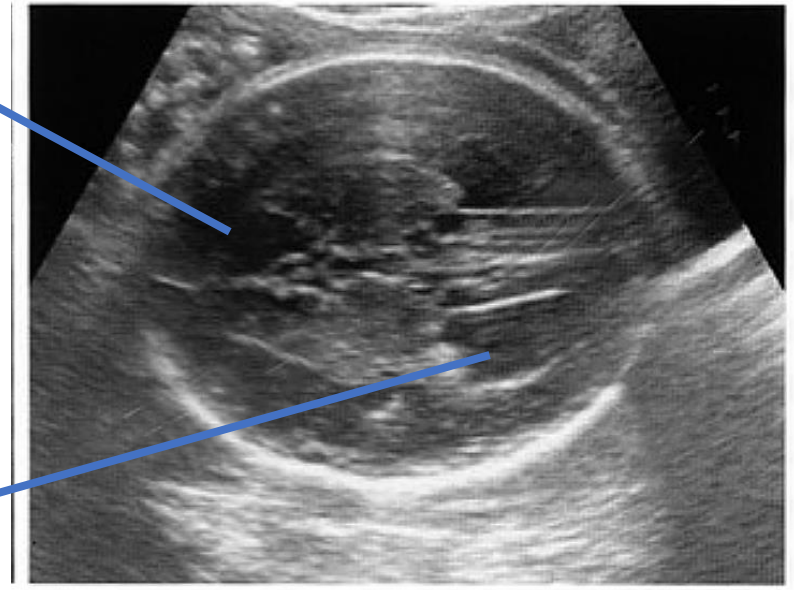
- Possible chromosomal abnormalities (8+, 13+, 18+). May be associated with various malformations. When it is an isolated case, neurological and other symptoms are rare.



disappearance of septum pellucidum

dilated posterior horn

tear drop shape

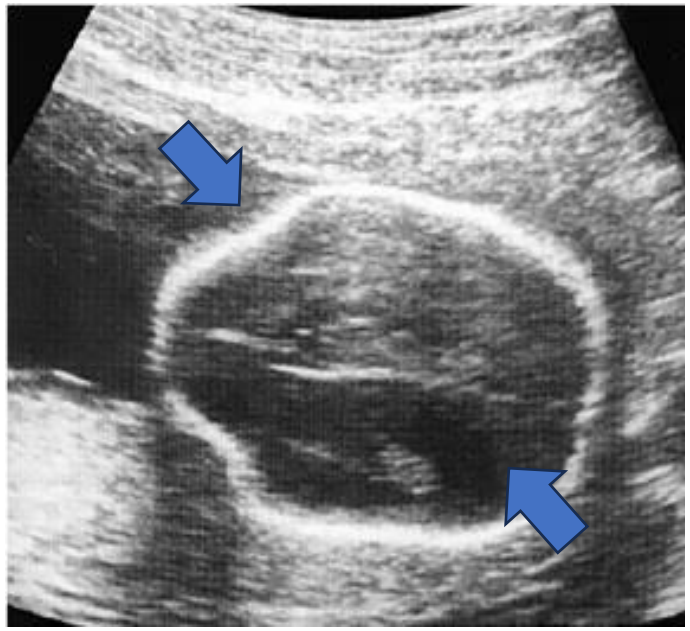


37th week of gestation

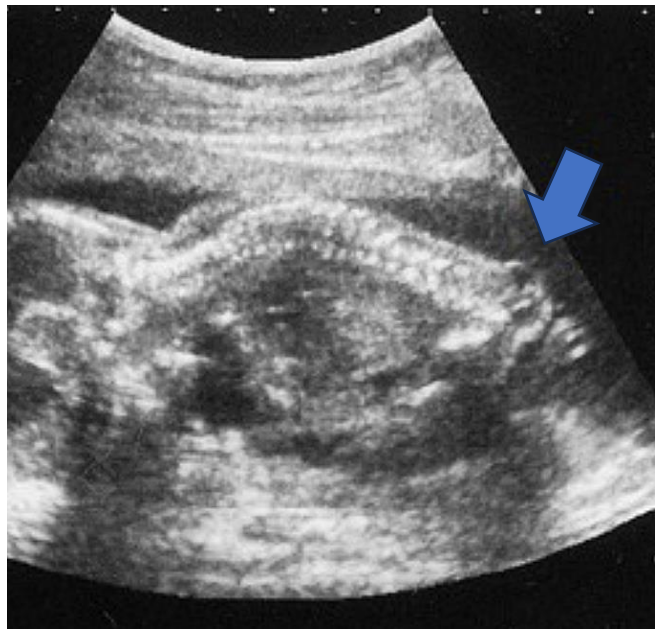
31th week of gestation

Chiari type II Malformation (Chiari malformation occurring in utero)

- Cerebellum and other parts of the brain drop from the cranium into the spinal cavity.
- **Chiari type 2:** In addition to the cerebellar tonsils, the cerebellar vermis and brainstem also drop down. Familial occurrence is seen with myelomeningocele. It is related to chromosomal abnormalities (18+, 13+, 21+)

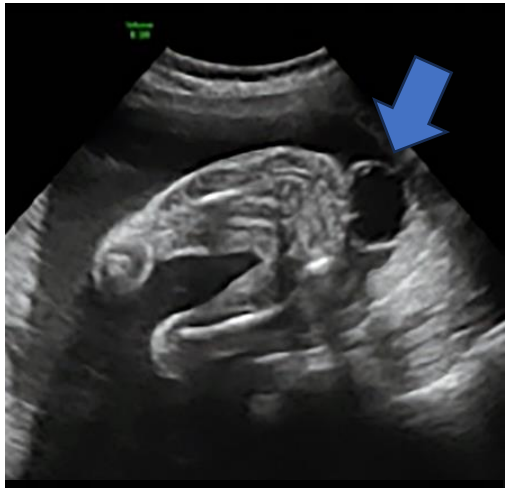


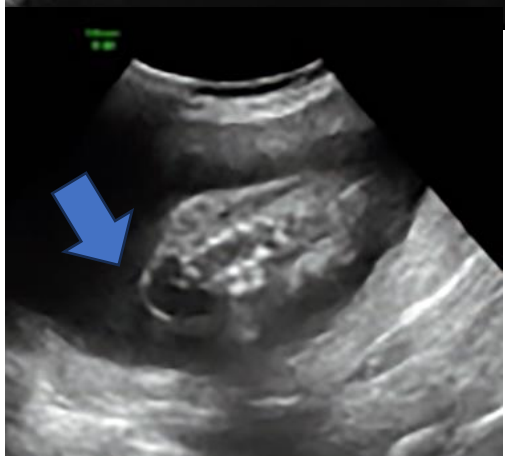
lemon sign

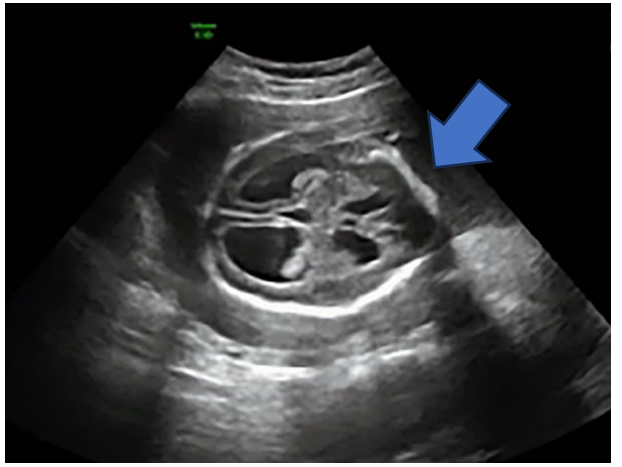


meningocele

16th week of gestation



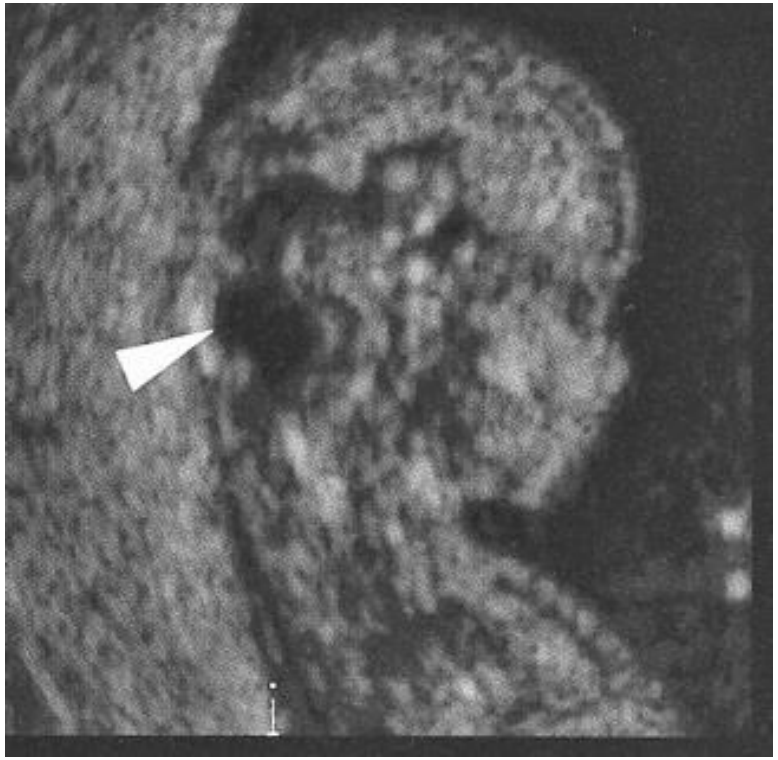




26th week of gestation

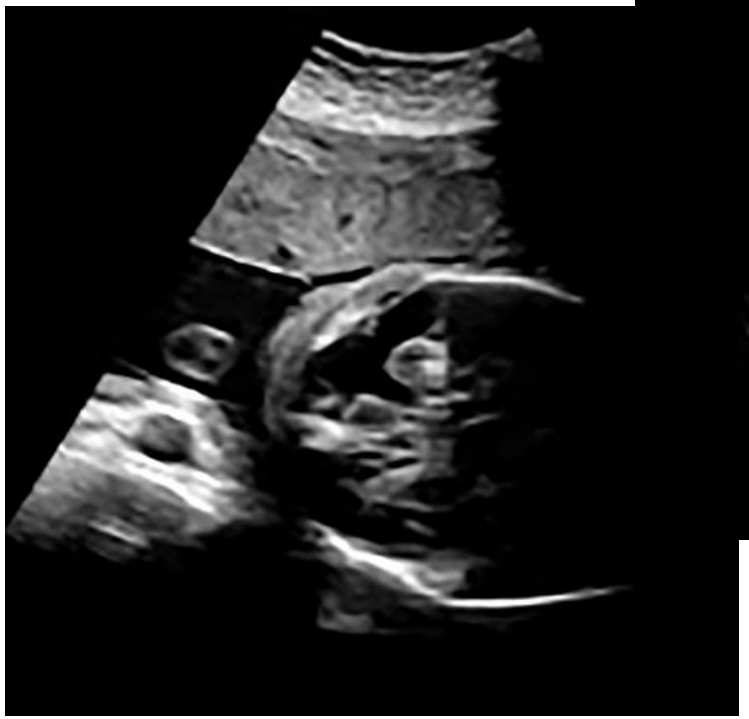
Dandy Walker syndrome

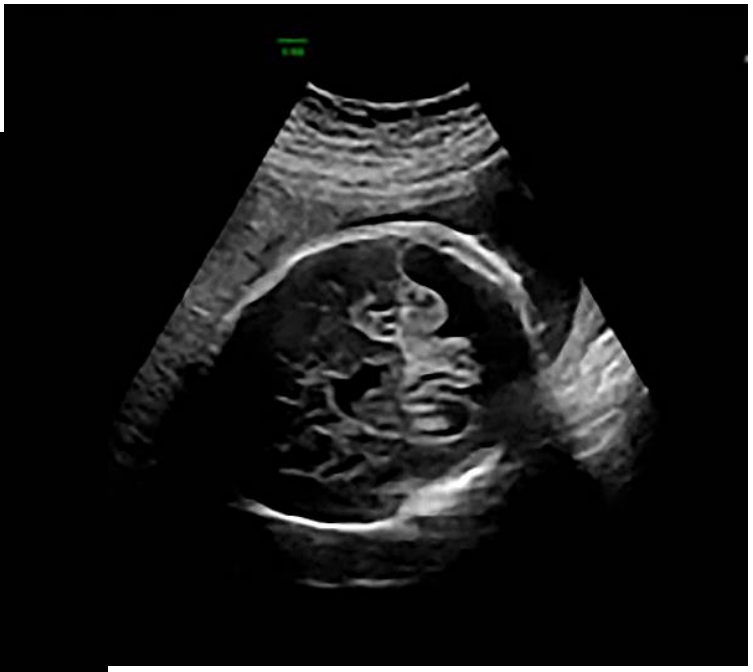
- Cerebellar differentiation is completed by 11 weeks' gestation.
- **Causes of Dandy Walker syndrome**: DM, alcohol drinking, warfarin, CMV, rubella, chromosomal abnormalities



Dilated fourth ventricle: Cerebellar hypoplasia and enlargement of the cisterna magna (18+, 13+)

11 weeks gestation





26 weeks gestation

Chest

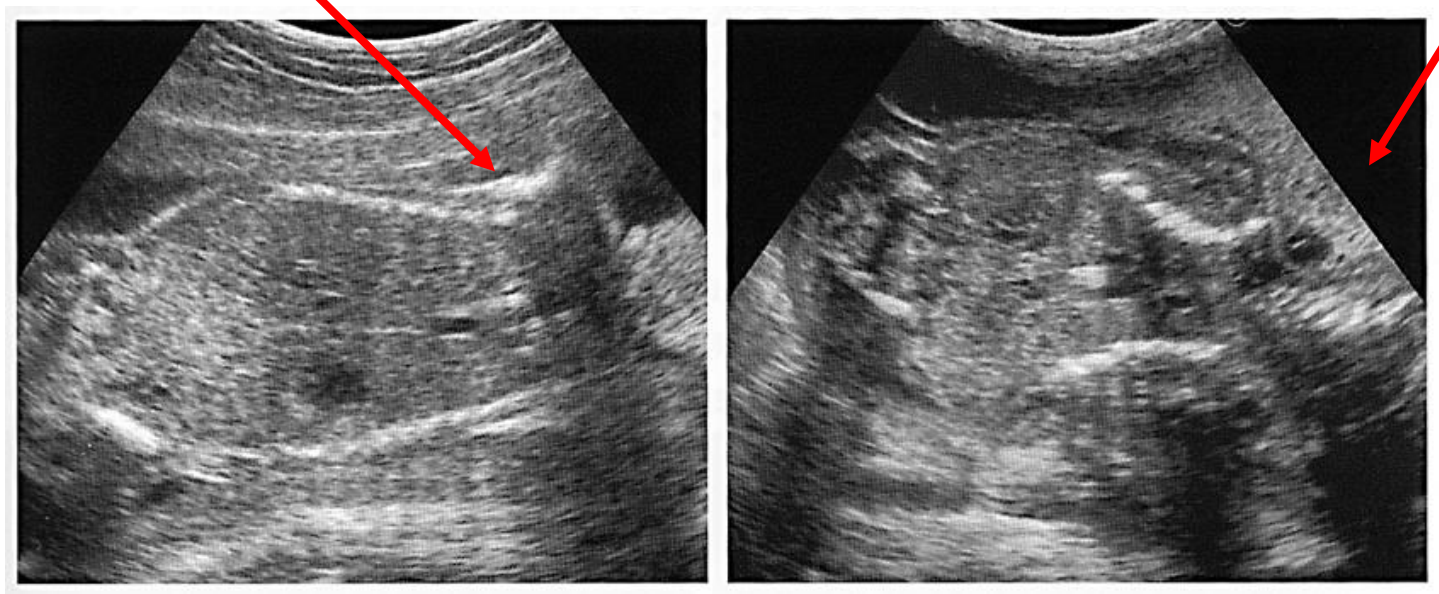
- It is important to prevent postnatal respiratory failure due to lung hypoplasia.

Pulmonary hypoplasia

- oligohydramnion (PROM: premature rupture of membranes), tumor in the thorax, etc.
- Diaphragmatic hernia, congenital cystic adenomatoid malformation, pulmonary sequestration, etc.

- Bell shaped thorax due to skeletal dysplasia

normal thorax



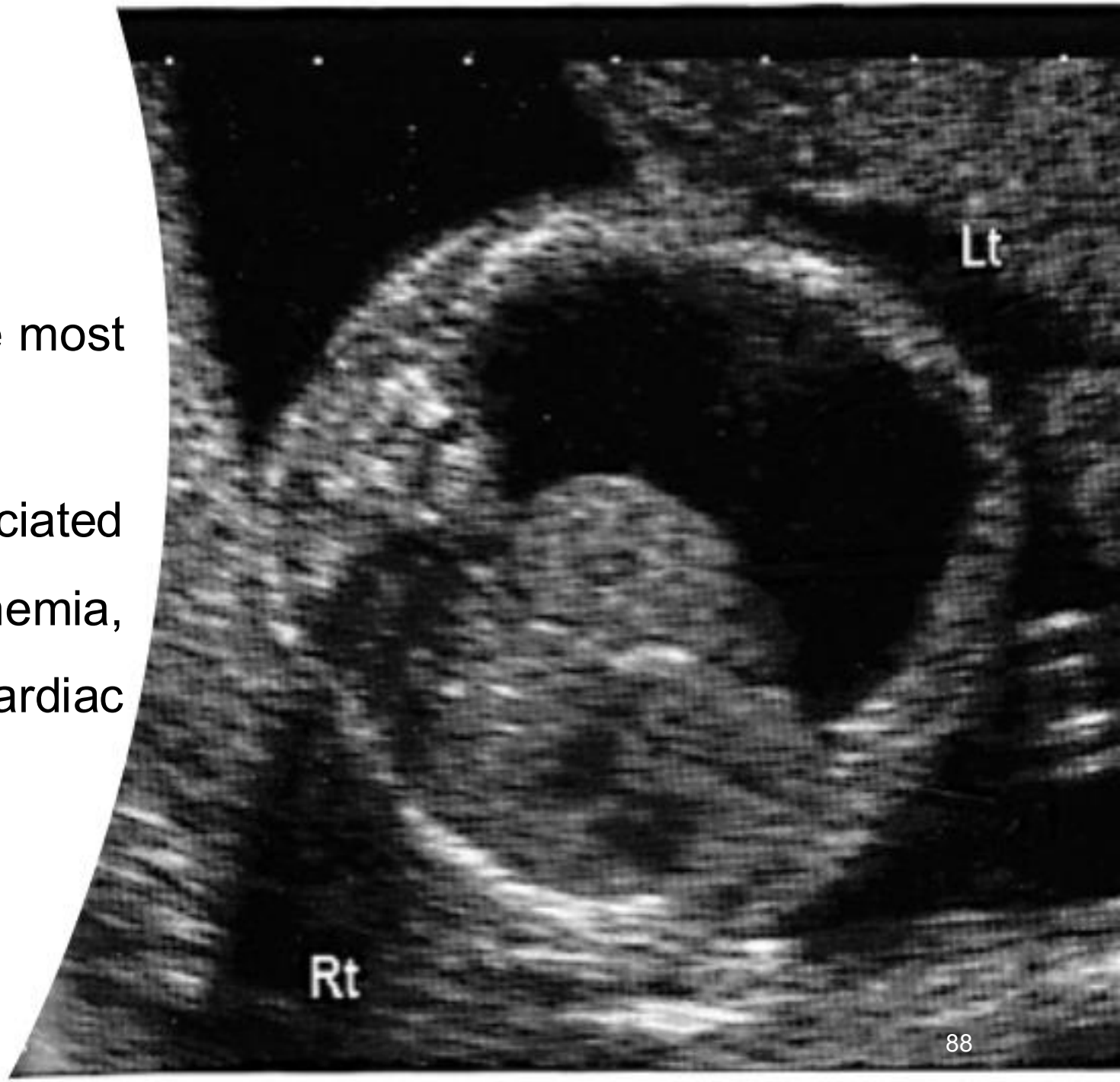
abnormal thorax

Thorax is normal, but various factors cause the lung to be compressed, resulting in the pulmonary hypoplasia.

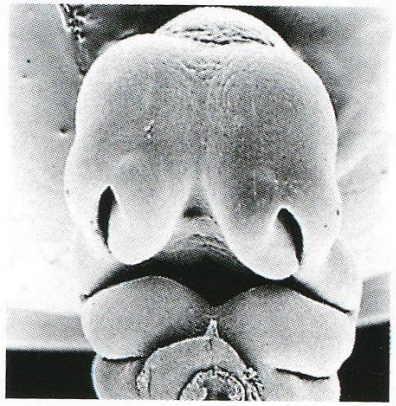
Lung cannot grow due to the congenital thorax hypoplasia, such as in skeletal dysplasia.

Pleural effusion

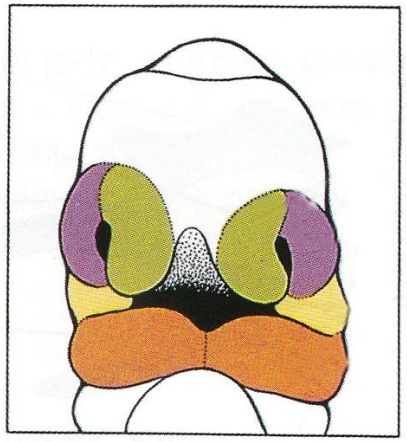
- If it is unilateral, chylothorax is the most common.
- Bilateral pleural effusion is associated with fetal hydrops (infection, anemia, chromosomal abnormalities, cardiac malformations)



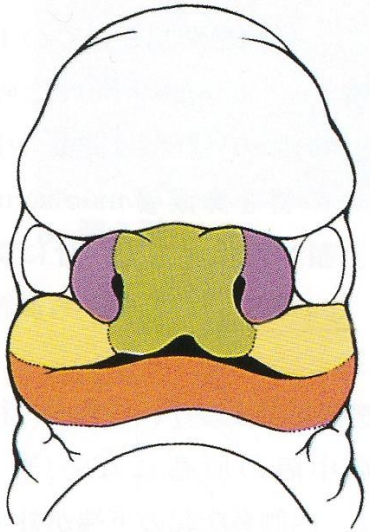
Face



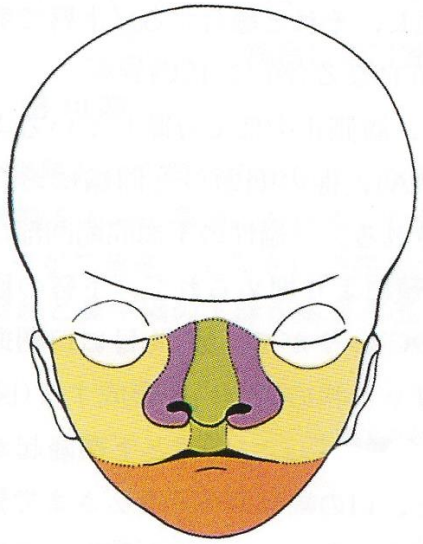
A 6th week of gestation



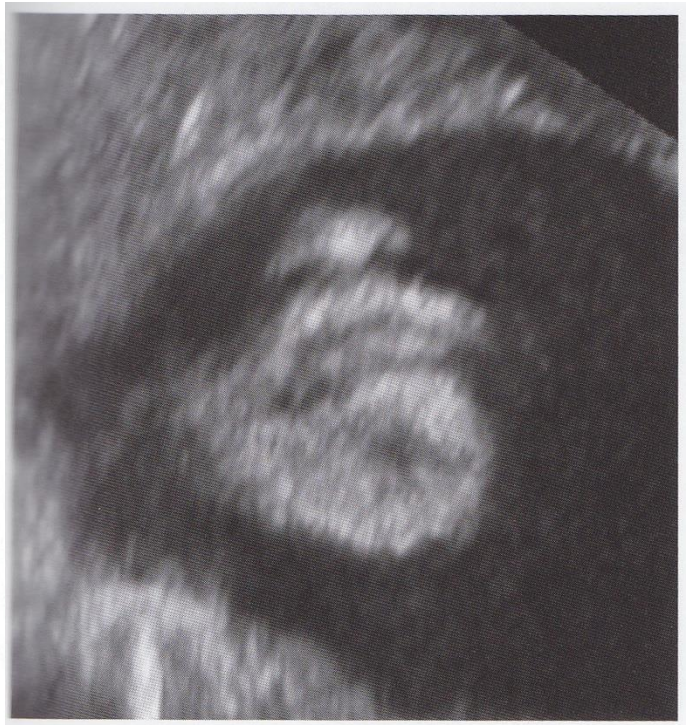
B 6th week of gestation



D 7th week of gestation



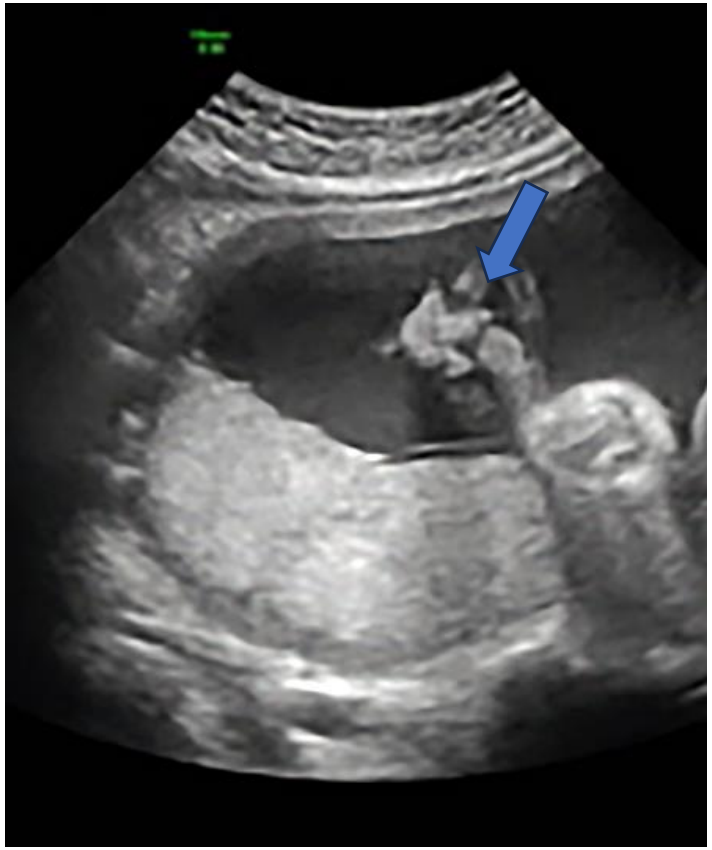
E 10th week of gestation

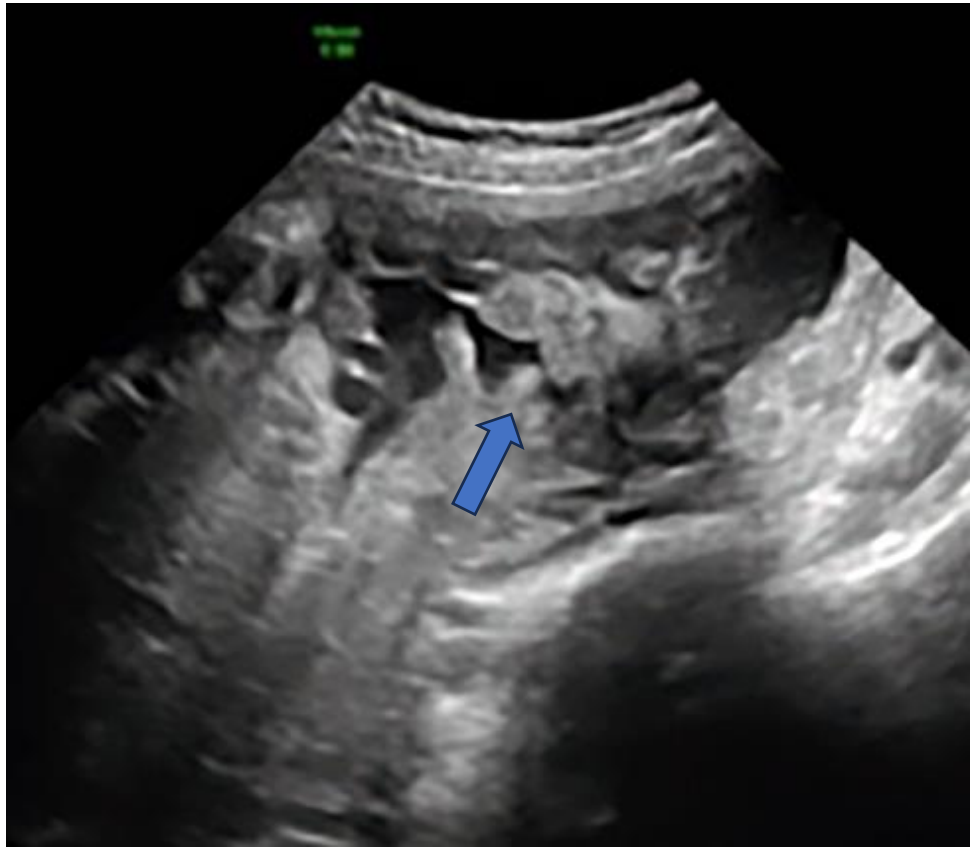


Some cases of cleft palate is caused by a large amount of adrenal corticosteroid.

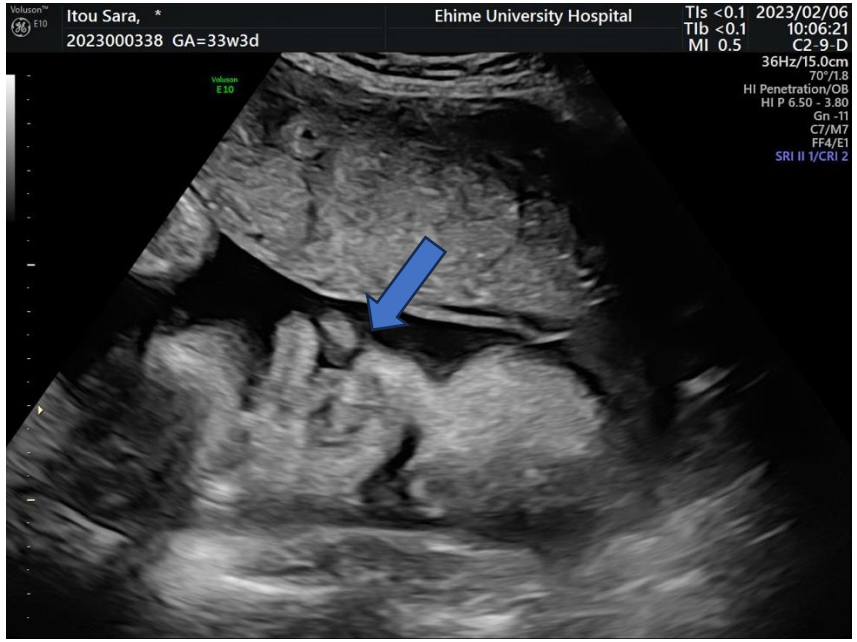
Folic acid is also effective to prevent the cleft palate.

The original facial tissues originate in pairs on the left and right sides, which develop and fuse in the center to form the lips and nose in the central part of the face. Failure of this fusion to occur and leaving a cleft in the center is believed to be the cause of cleft lip and palate.

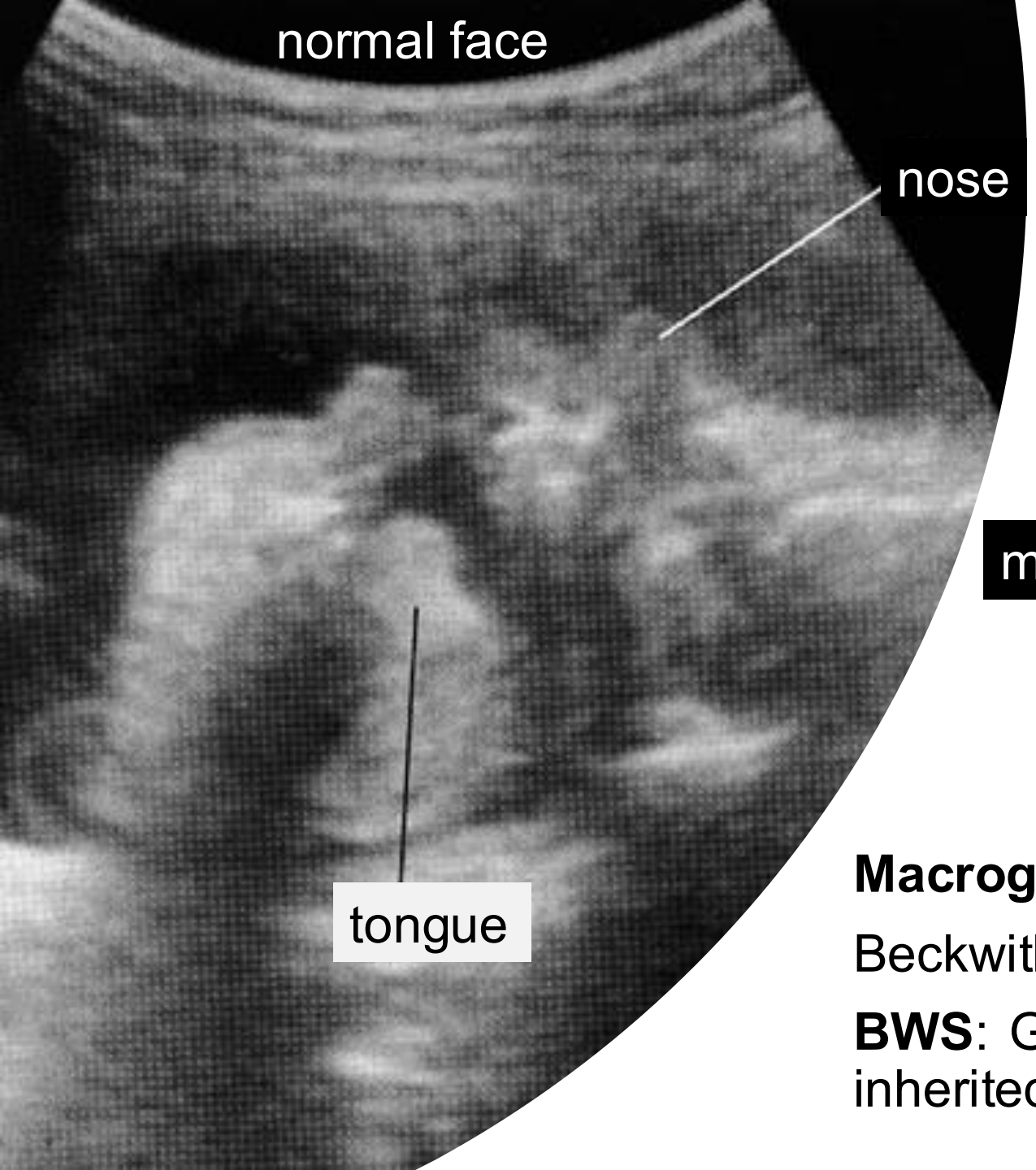


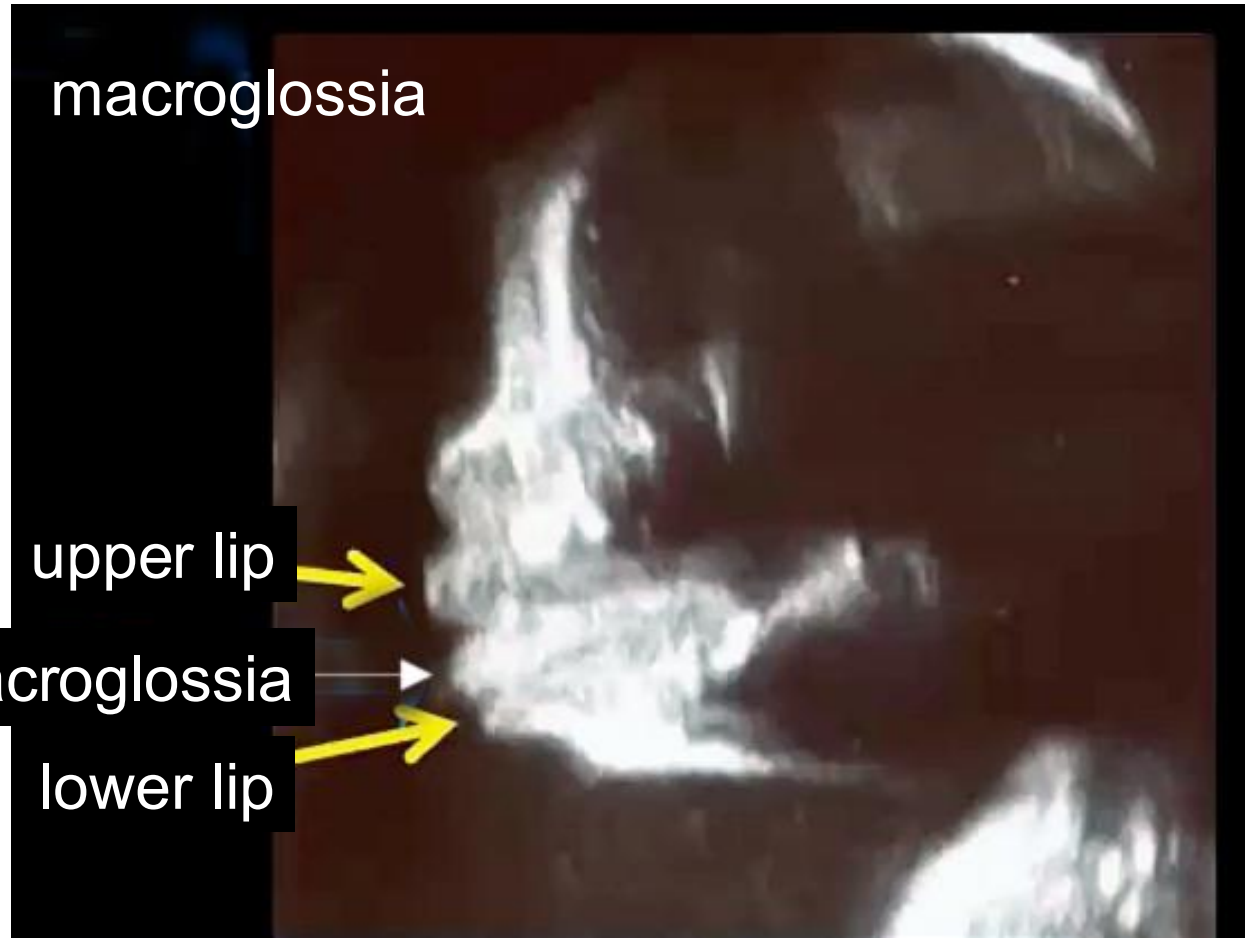


30th week of gestation



33th week of gestation





Macroglossia：

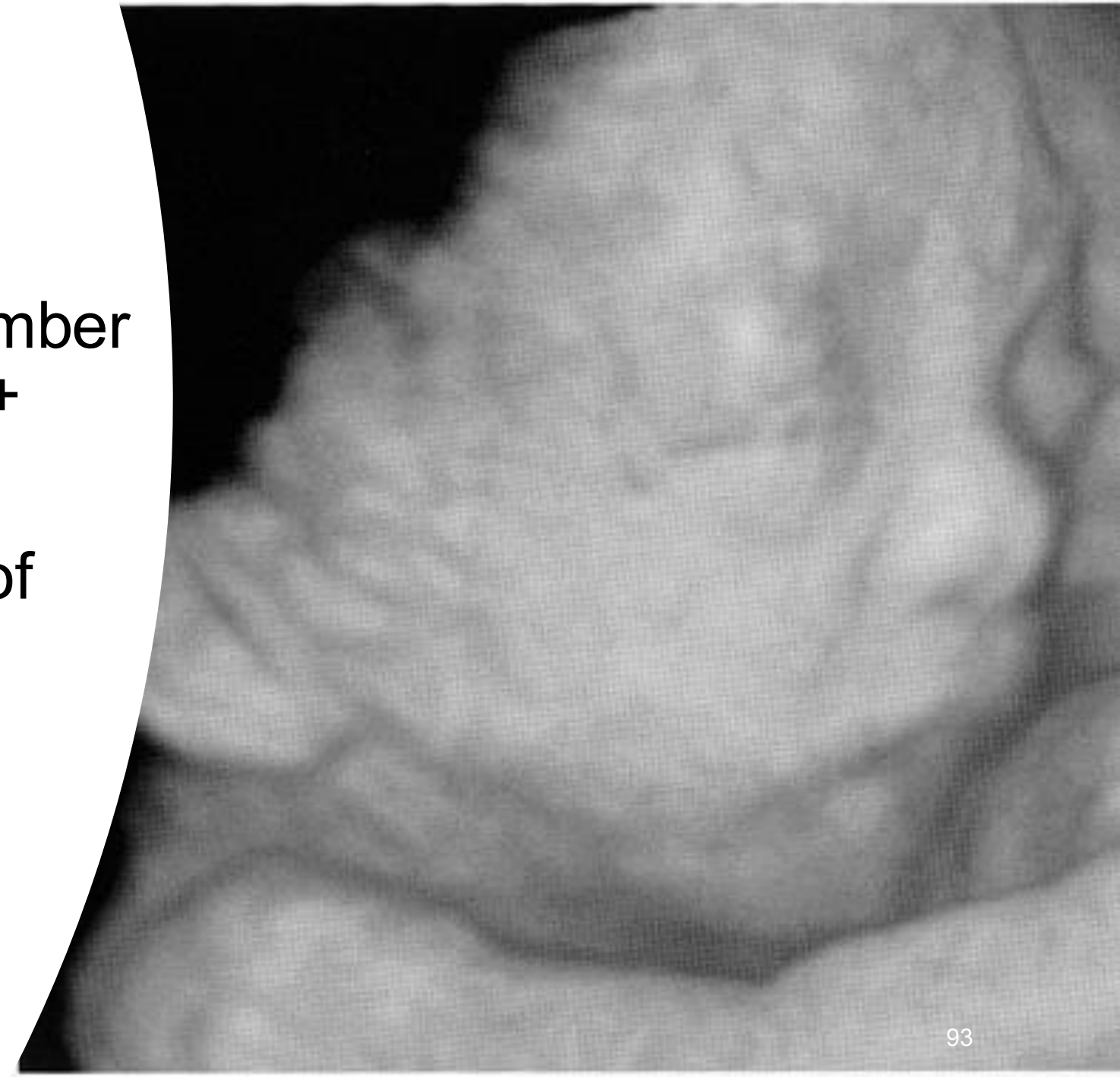
Beckwith-Wiedemann syndrome (BWS), 21trisomy

BWS: Growth-related genes in chromosome 11 are inherited only from the father. (Paternal Disomy)

Auricle

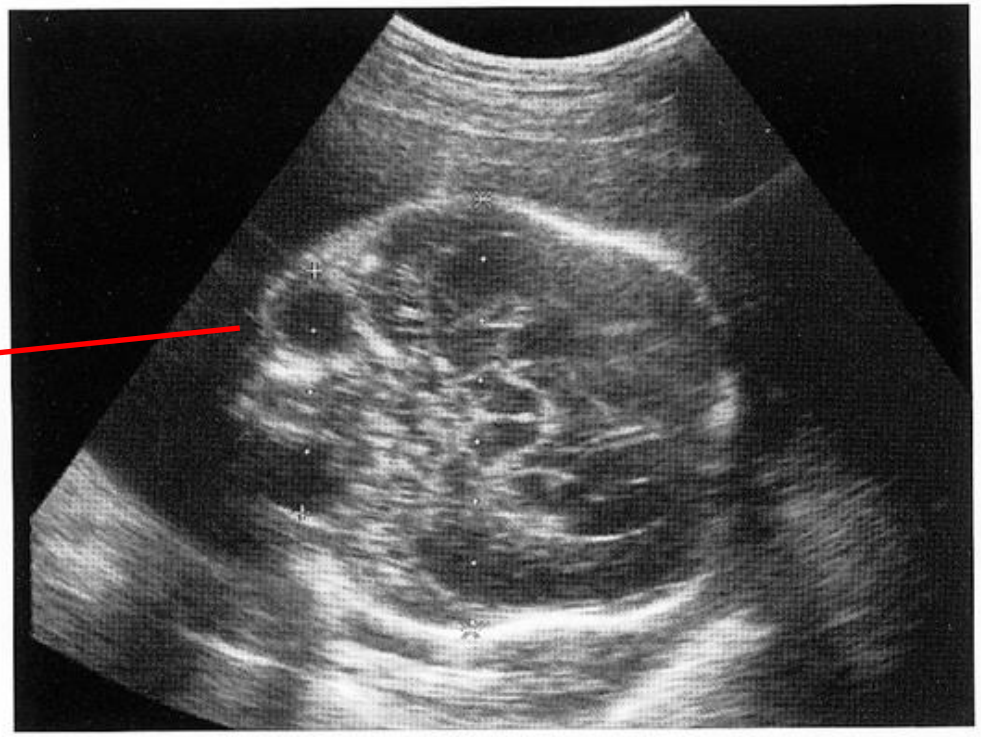
- **Microtia**: chromosome number abnormalities including 21+

- **Low set ears**:(28th week of gestation; 18+, 21+)

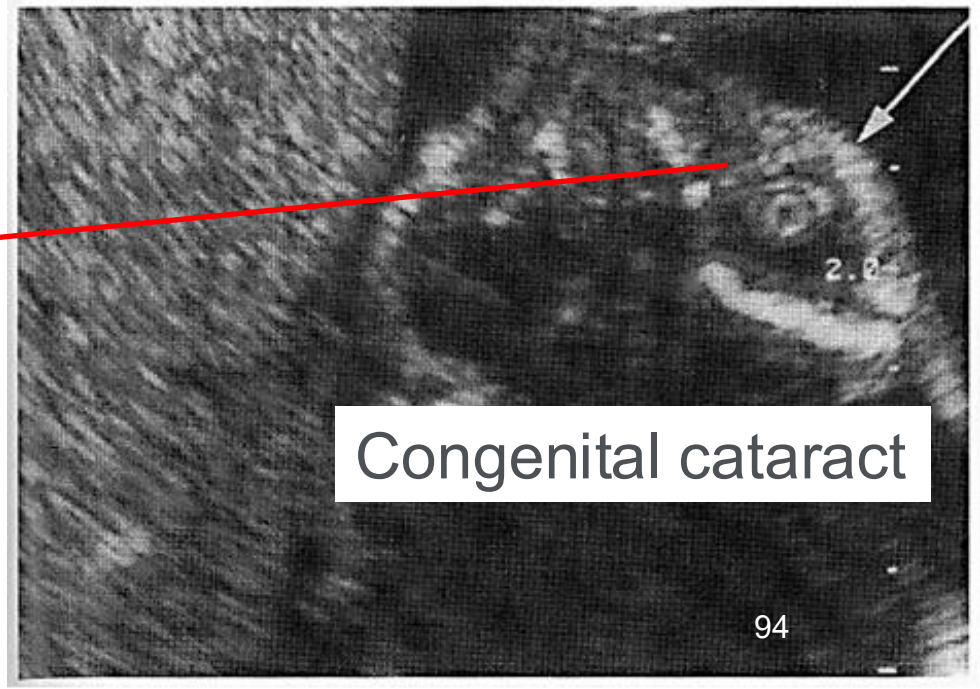


Eyes

- **hypertelorism・hypotelorism：**
  Malformation syndrome



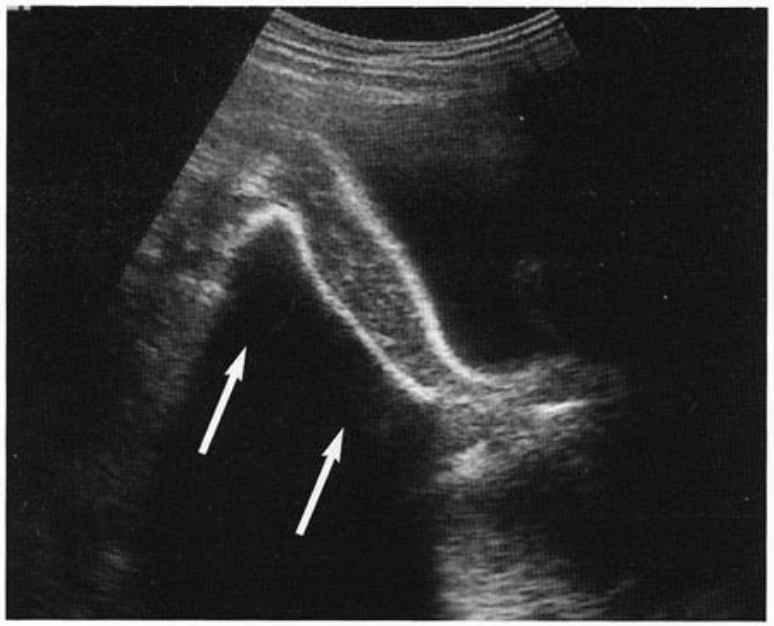
- **Microphthalmia**：Infectious disease
  （CMV・Rubella・Toxo]
- **Anophthalmia**： 13+



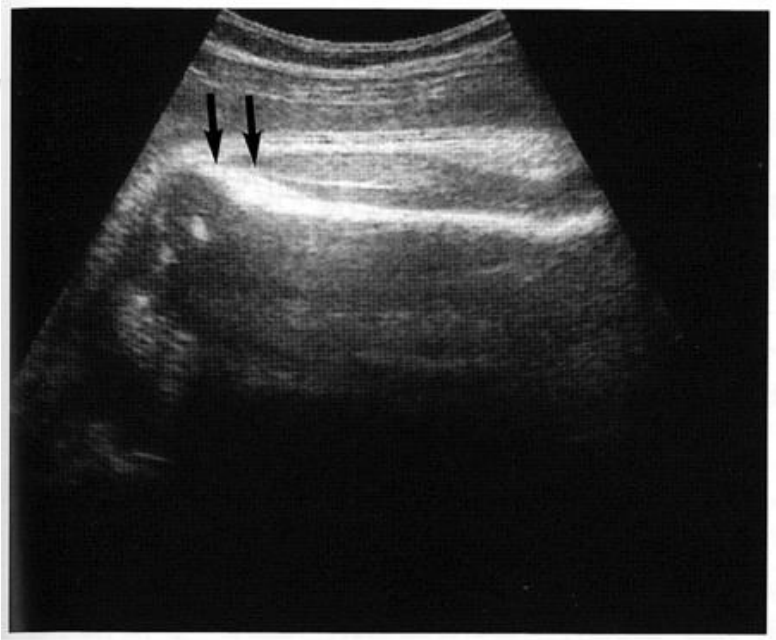
Bone

Skeletal Dysplasia

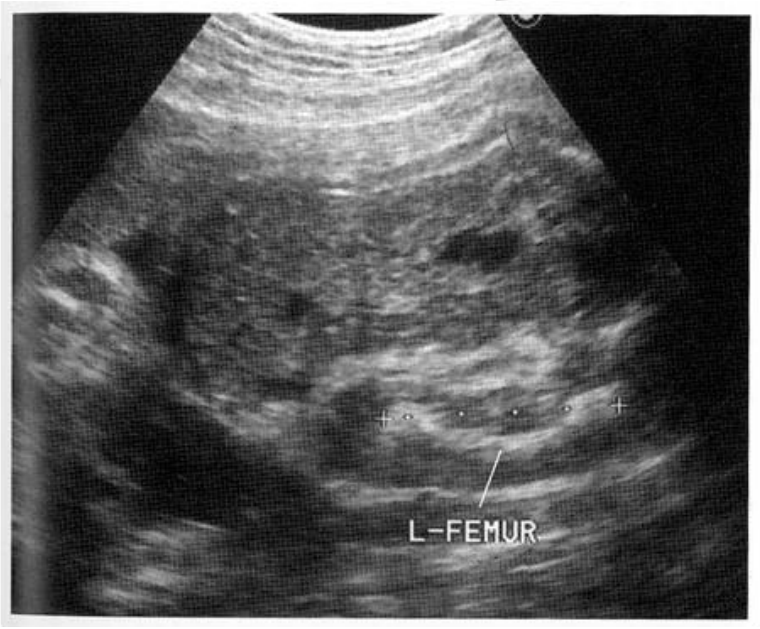
Skeletal development and abnormalities



long bone (26th)



long bone and cartilage (37th)



Thanatophoric dysplasia type 1(31th) short and curved femur, bilateral enlarged epiphysis

As ossification progresses, only the bone surface is visualized and not the entire bone. It should be taken not to include the cartilage surface echoes at the epiphysis when measuring femoral length.

If there is shortening or kyphosis of the long bones, bone and cartilage abnormalities such as osteogenesis imperfecta should be considered.

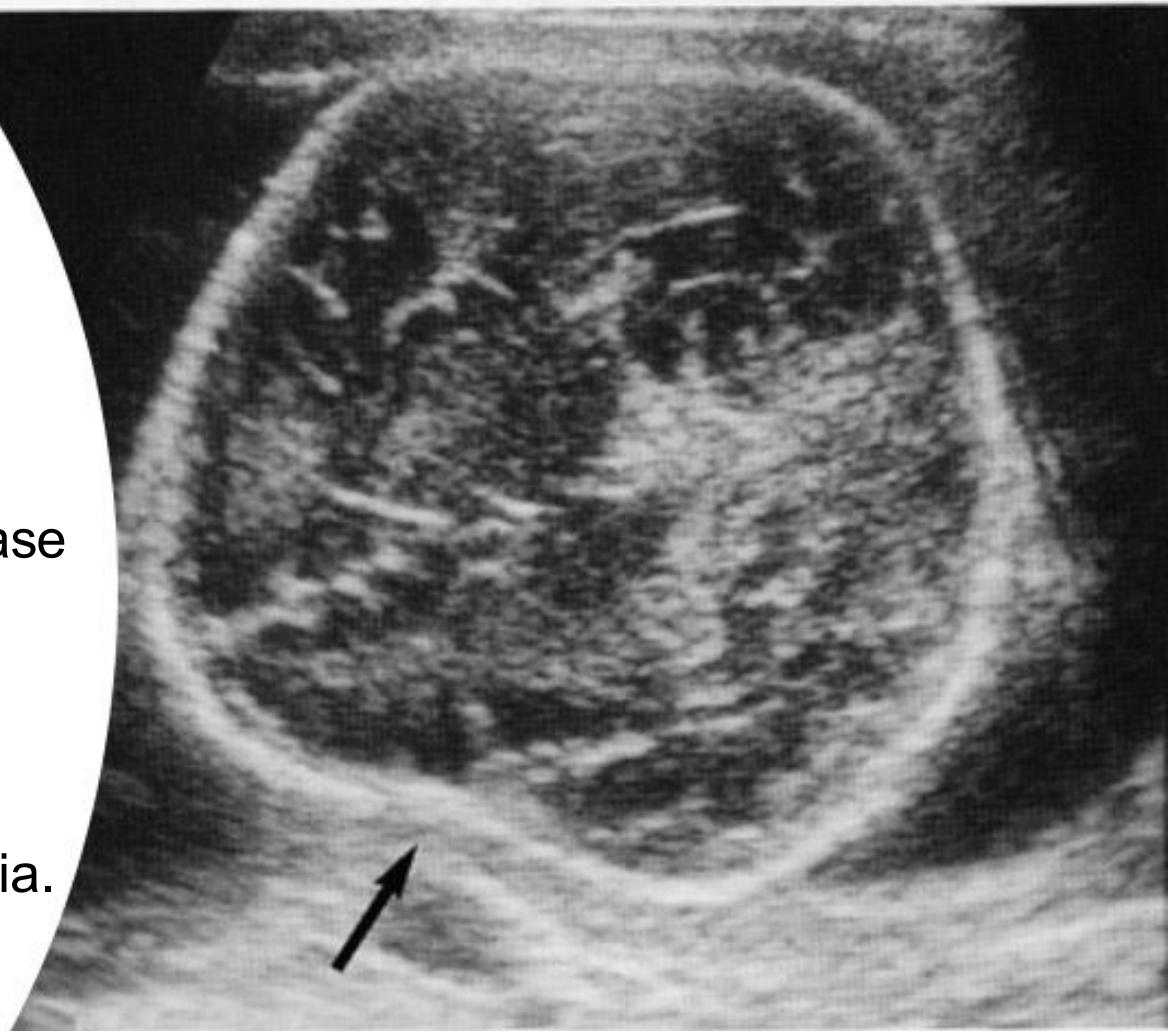
Hypophosphatasia

- Ossification failure

  → Skull is thin and easily deformed (Pressure test). Flexion/deformation of long bones.

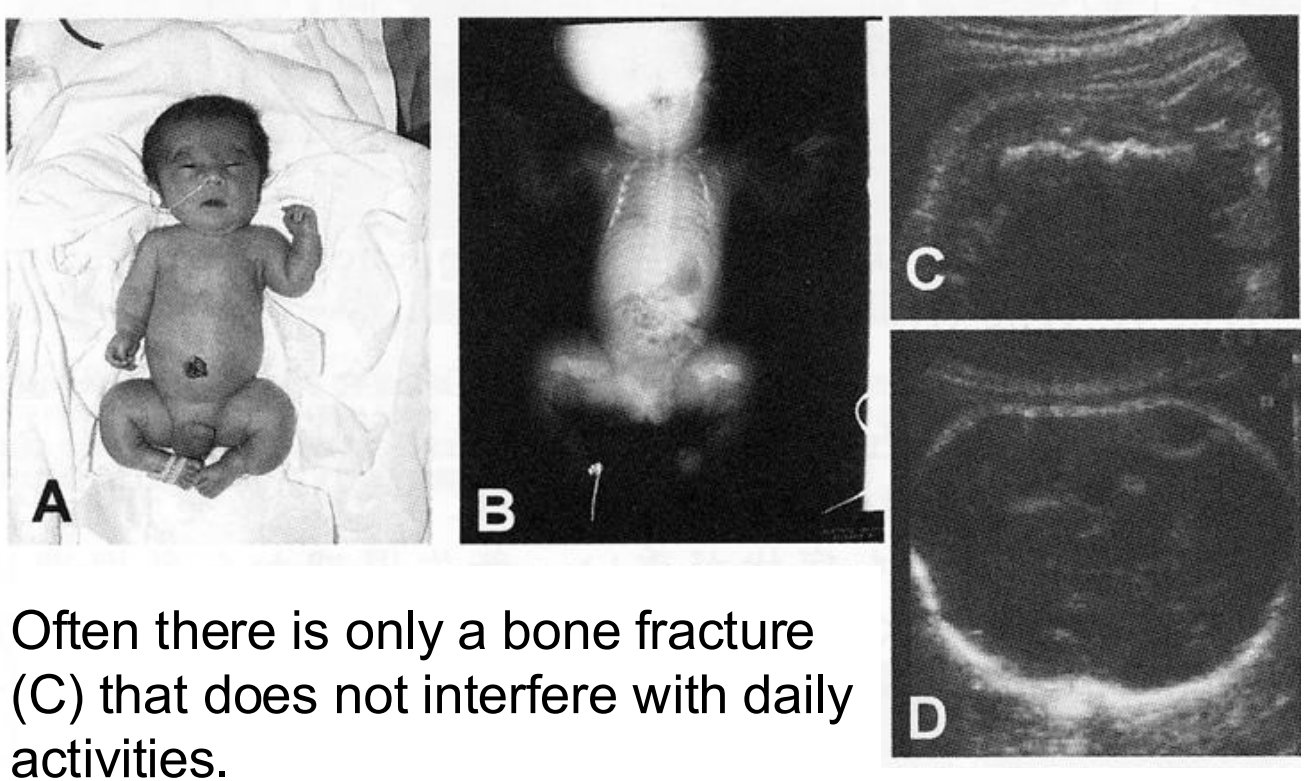
  → It is characterized by low serum alkaline phosphatase (ALP) level.

  → Most severe patients have autosomal recessive inheritance.
- Bone dysplasia is often associated with lung hypoplasia.
- Prognosis is poor if they are associated with lung hypoplasia.
- Enzyme replacement therapy, in which ALP is replenished in the body by venous injection, is effective after the birth.



Pressure test
(at 33th gestational week)

Osteogenesis imperfecta congenita type 2 · 3



Often there is only a bone fracture (C) that does not interfere with daily activities.

Bone deformities (C) can cause varying degrees of gait disturbance.

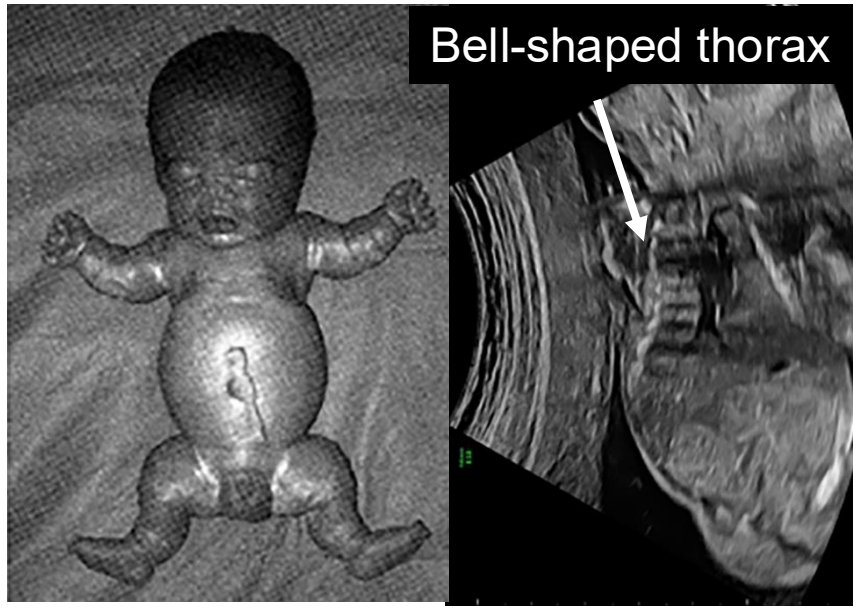
D: Pressure test positive. Scull is easily deformed.

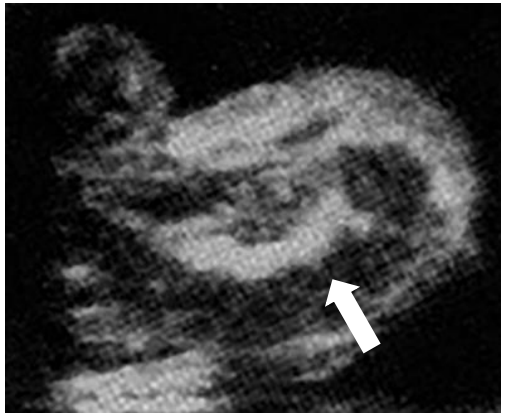
- **Cause:** Genetic mutation of type I collagen
- **Type 2**: dead around the birth because of lung hypoplasia
- **Type 3**: Severe and often requires a wheelchair
- **Type 1, 4**: milder than others (Long-term prognosis is expected.)
- **Symptoms**: easy bone fracture, blue sclera, hearing loss
- Wide, short long bones with multiple fractures, and marked deformity
- Bell-shaped thoracic hypoplasia due to multiple fractures of the ribs.
- Skull is membranous and soft due to osteogenesis imperfecta.

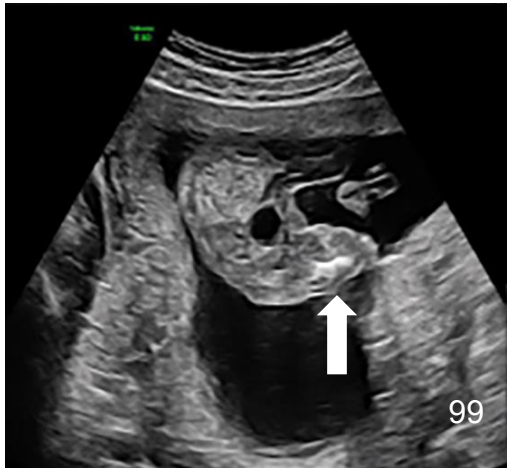
Thanatophoric dysplasia

- Caused by point mutations in the fibroblast growth factor receptor 3 (FGFR3) gene resulting in chondrocyte abnormalities.
- The femur is deformed like an old telephone receiver, the thorax is small, and the head is large in relation to the trunk. The abdomen is distended, and the limbs are always extended. Polyhydramnion is caused by thorax dysplasia.

- Neonates often die soon after birth without respiratory management, due to respiratory failure.
- Long-term survival was reported with appropriate respiratory management and is accompanied by severe mental and physical developmental deficits.



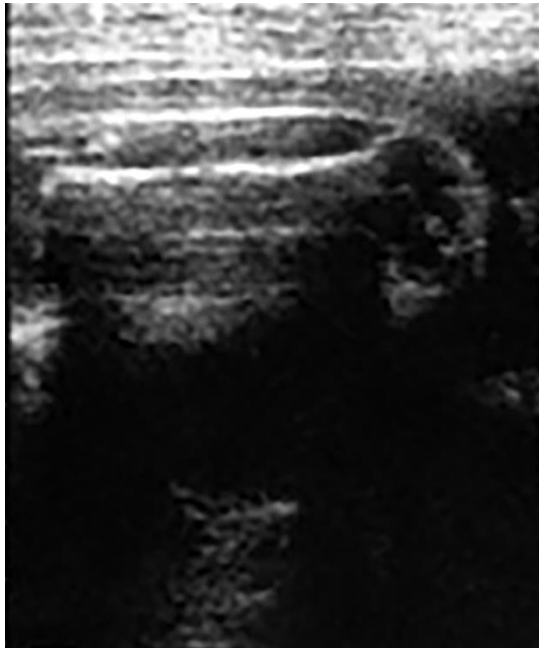




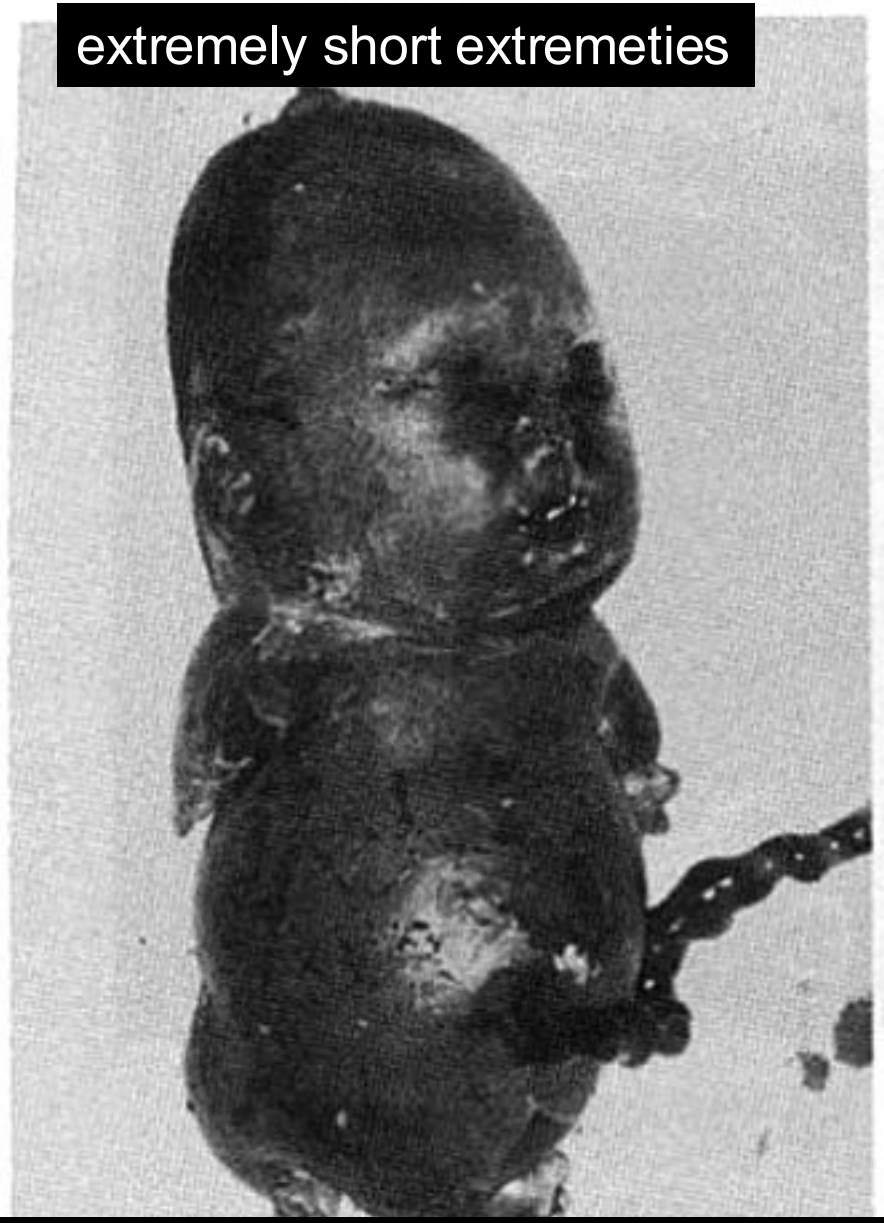
31th week gestation

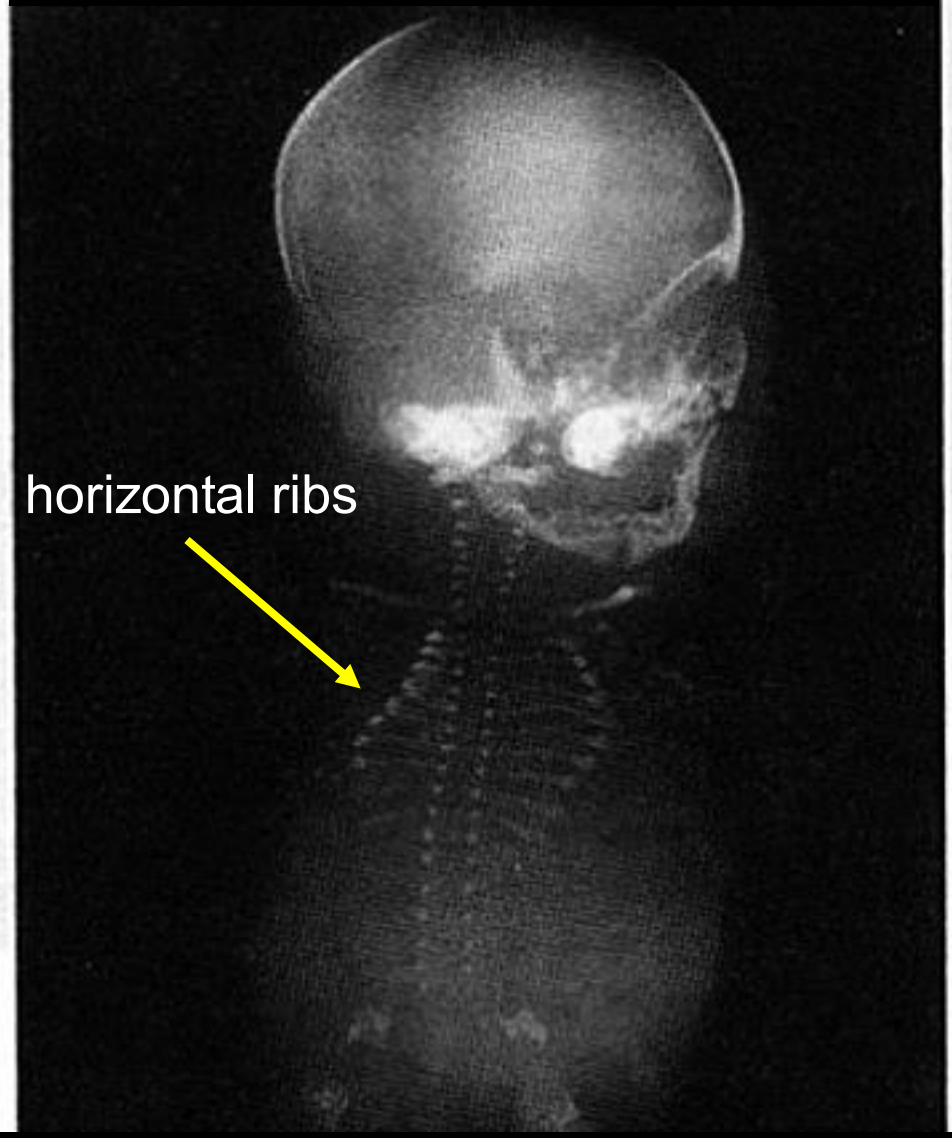
Chondrodystrophia foetalis（37th week）

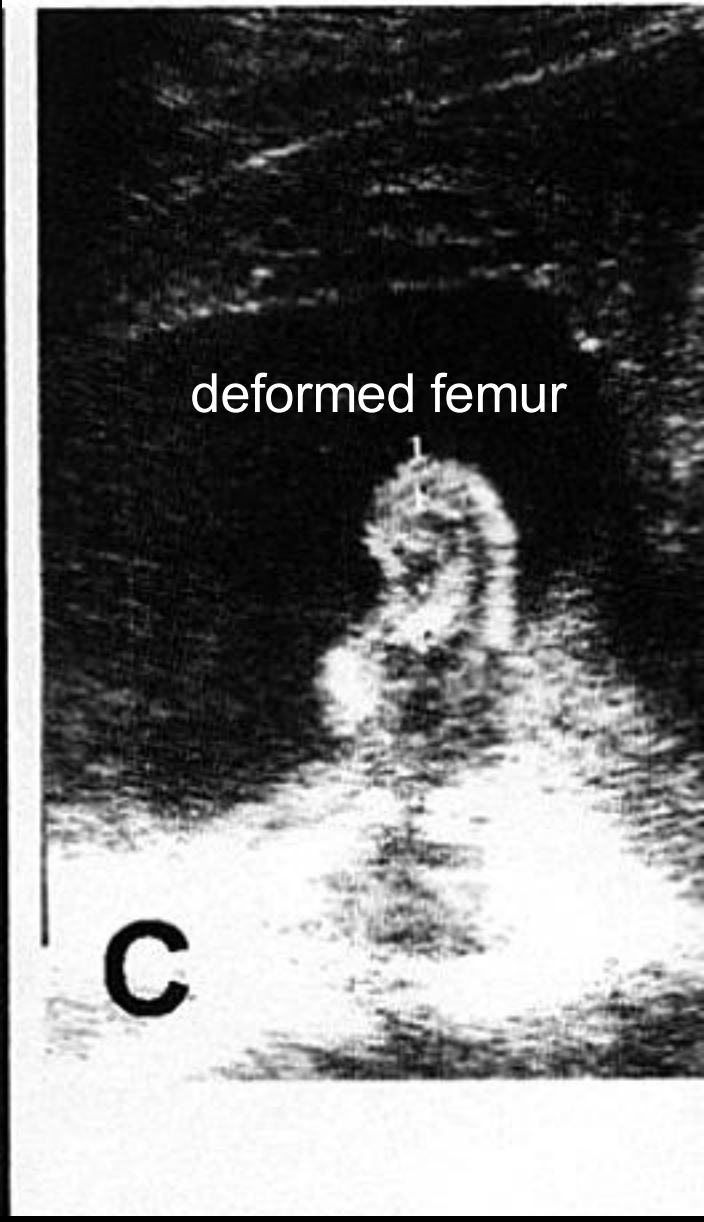
- 98% of patients have the point mutation in FGFR3 resulted in depressed cartilage growth.
- Limb shortening, characteristic facial features (relatively large cerebral cranium, protrusion of the forehead, and depressed nasal root).
- The femoral findings on ultrasonography are weak. Prognosis is good.



Achondrogenesis







Ossification failure of the spine and pelvis and hypoplasia of the thorax to hypoplasia of the lungs, resulting in the appearance of polyhydramnion. Severe limb shortening and deformity. Large head. Short trunk and abdominal distention.

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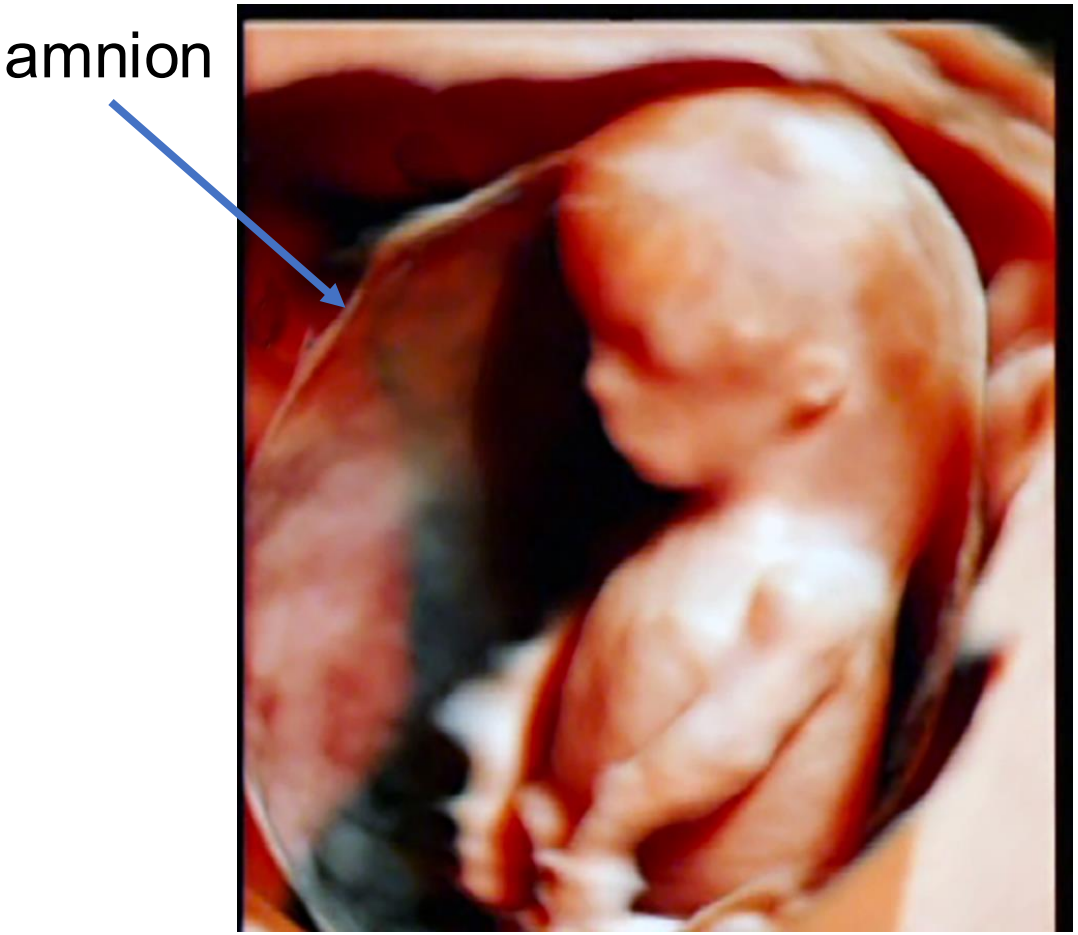
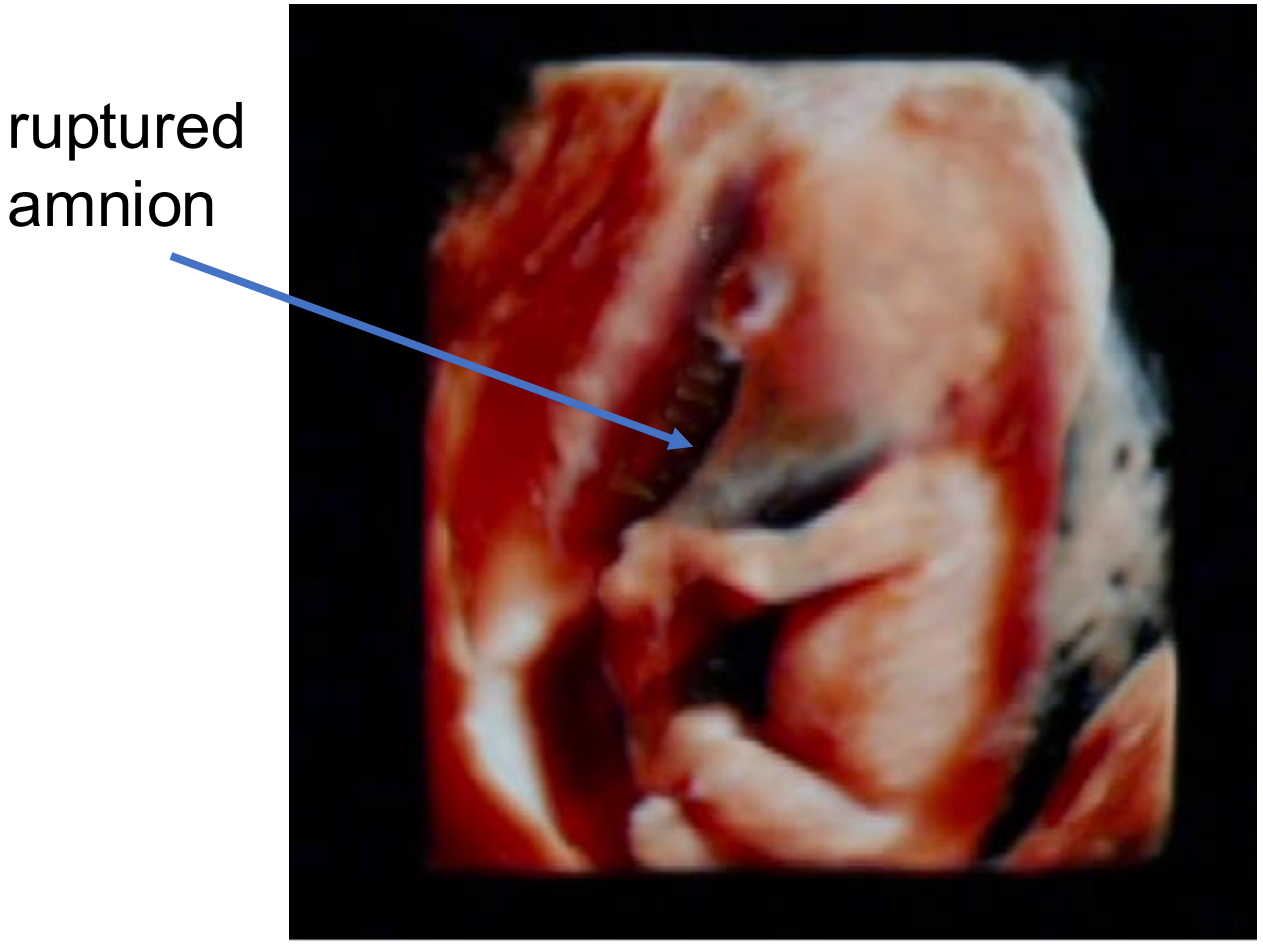
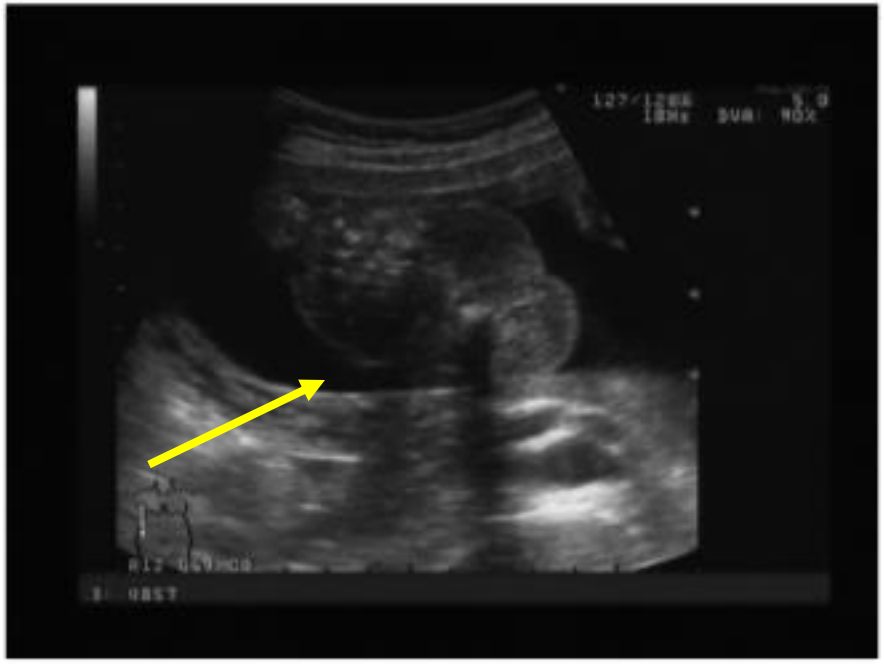


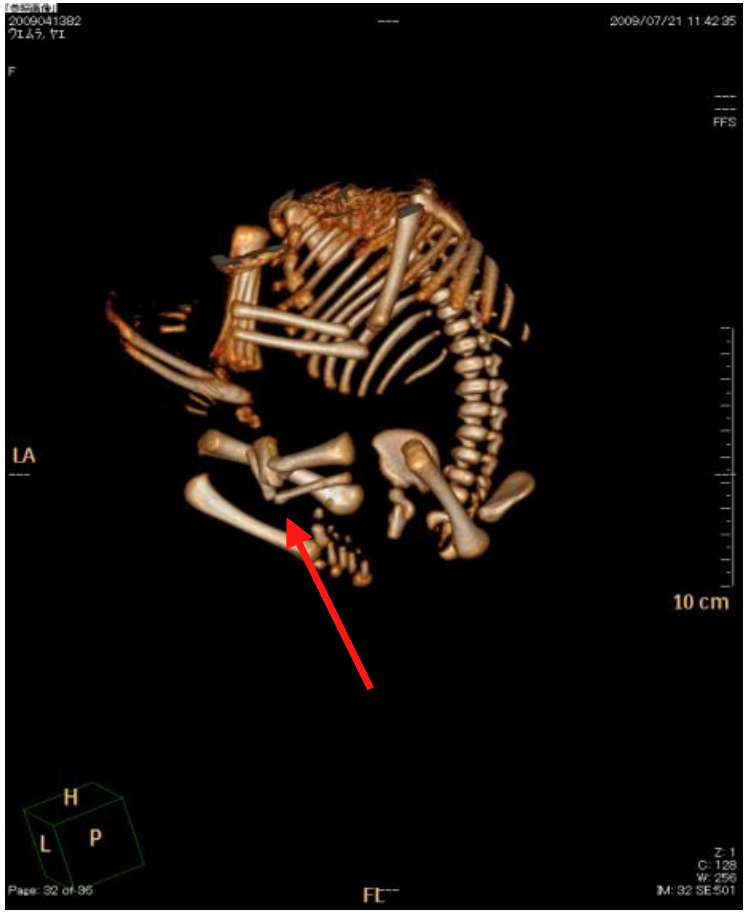


Amniotic band syndrome can cause Gastroschisis when the ruptured amnion adheres to the fetal abdominal wall or fracture when it adheres to the long bone.

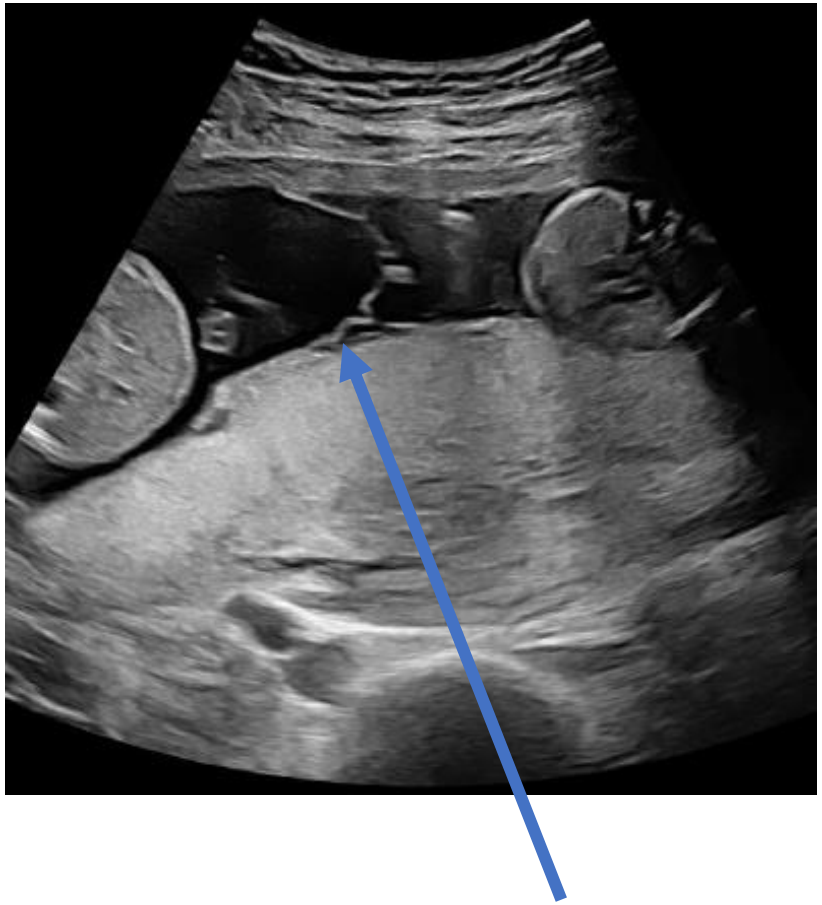
constriction band syndrome
(A part of amniotic band syndrome)



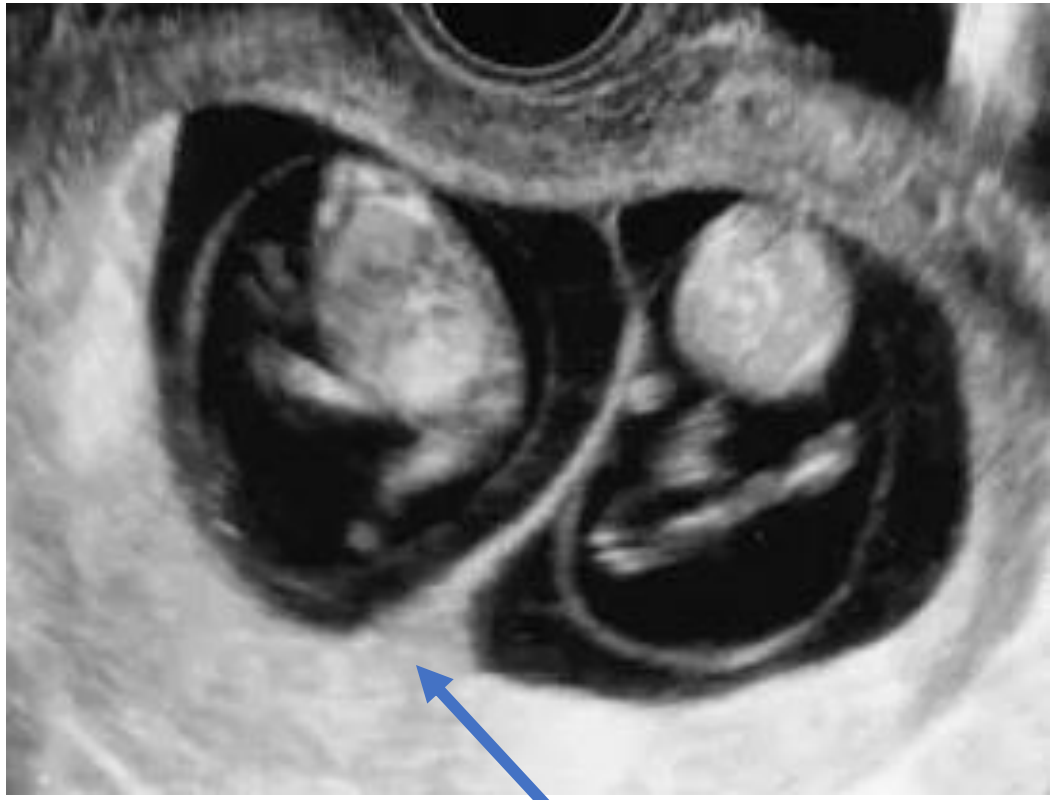
ankle fracture



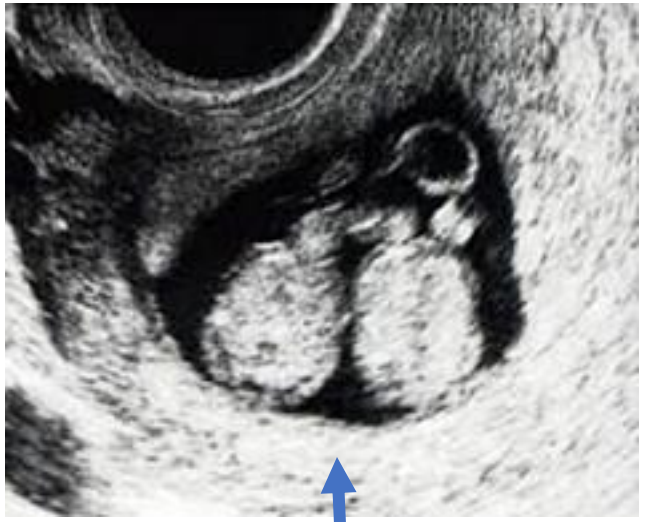
Twin



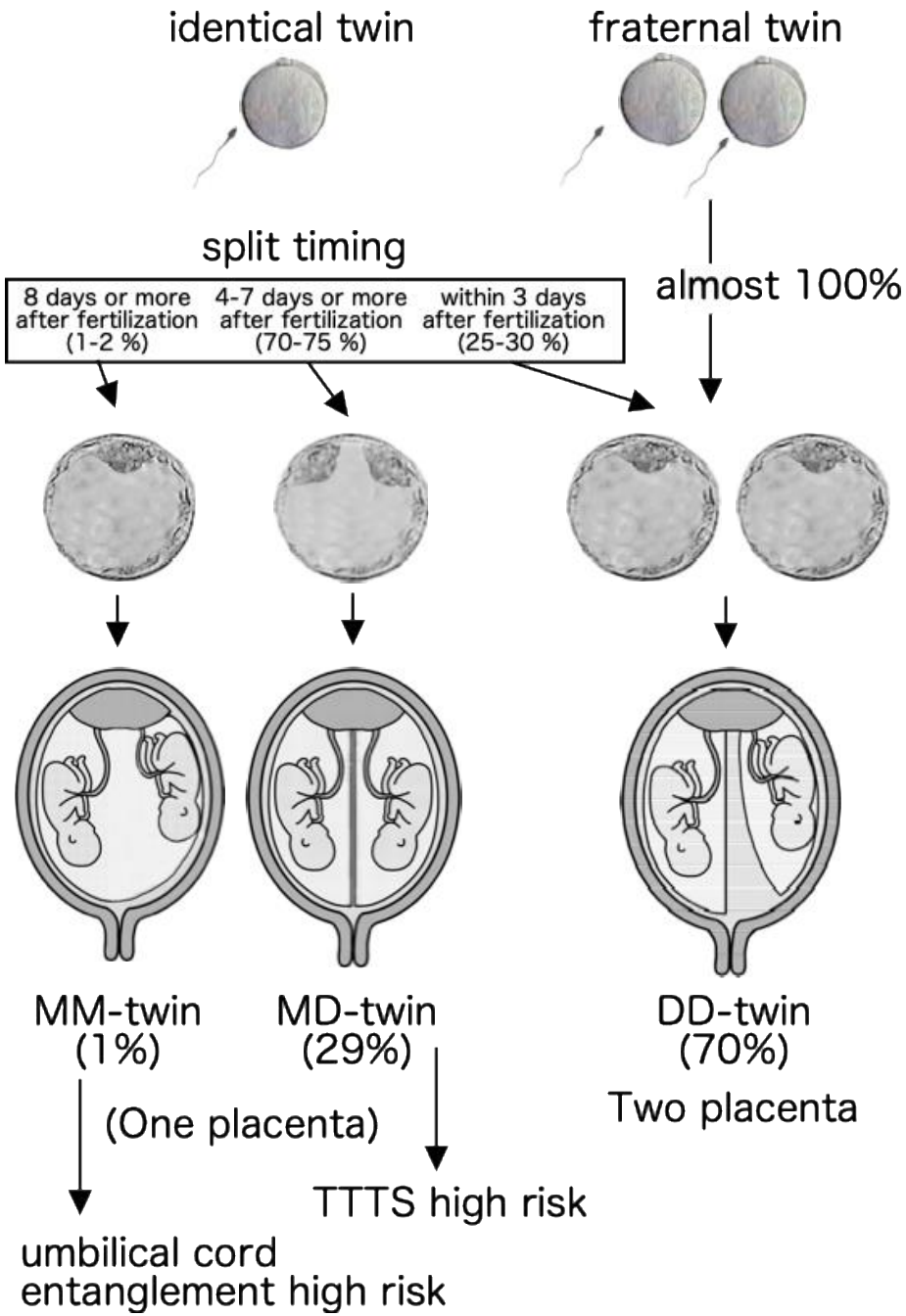
MD-twin, T sign



DD-twin, λ sign

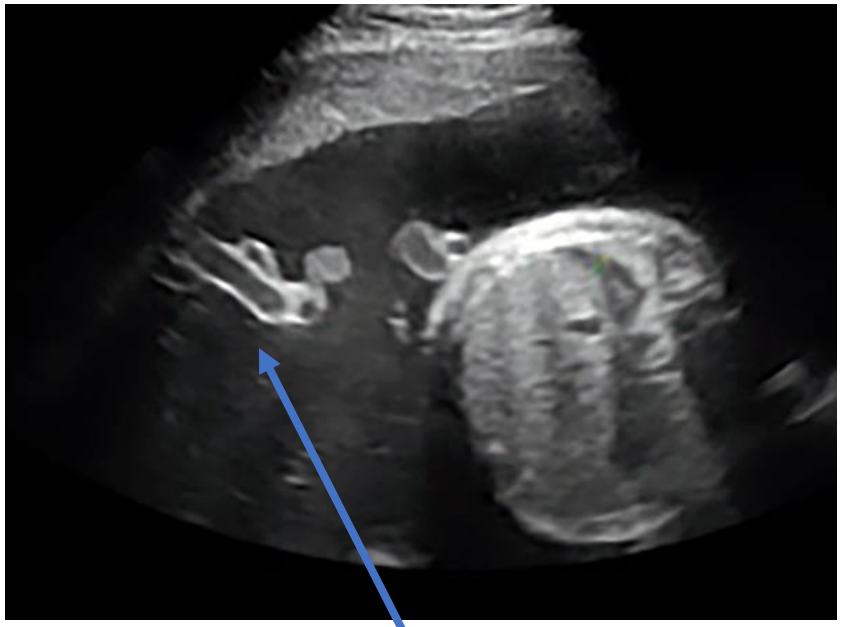


MM-twin

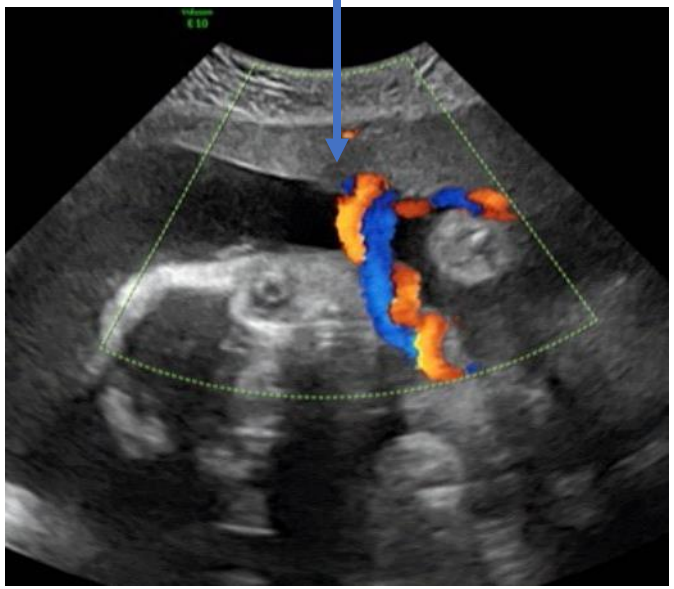


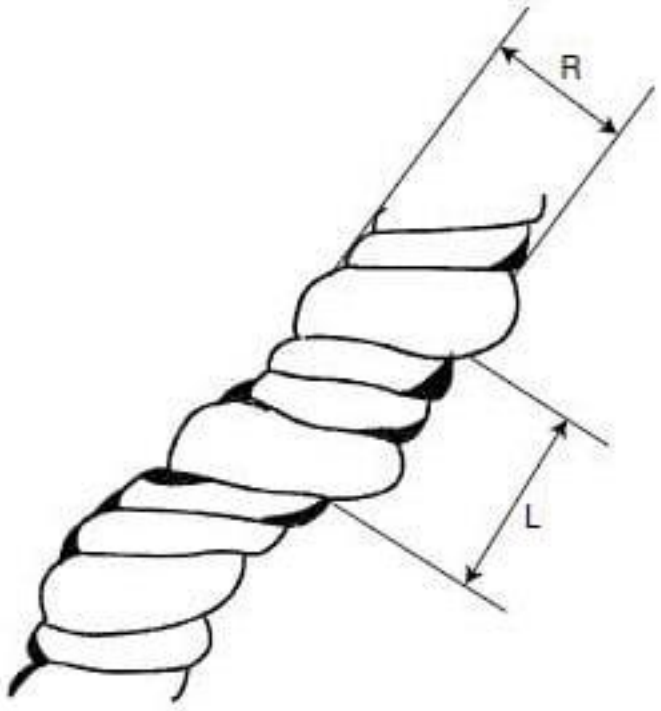
MM-twin: Monochorionic Monoamniotic twin
MD-twin: Monochorionic Diamniotic twin
DD-twin: Dichorionic Diamniotic twin
TTTS: Twin-to-Twin Transfusion Syndrome

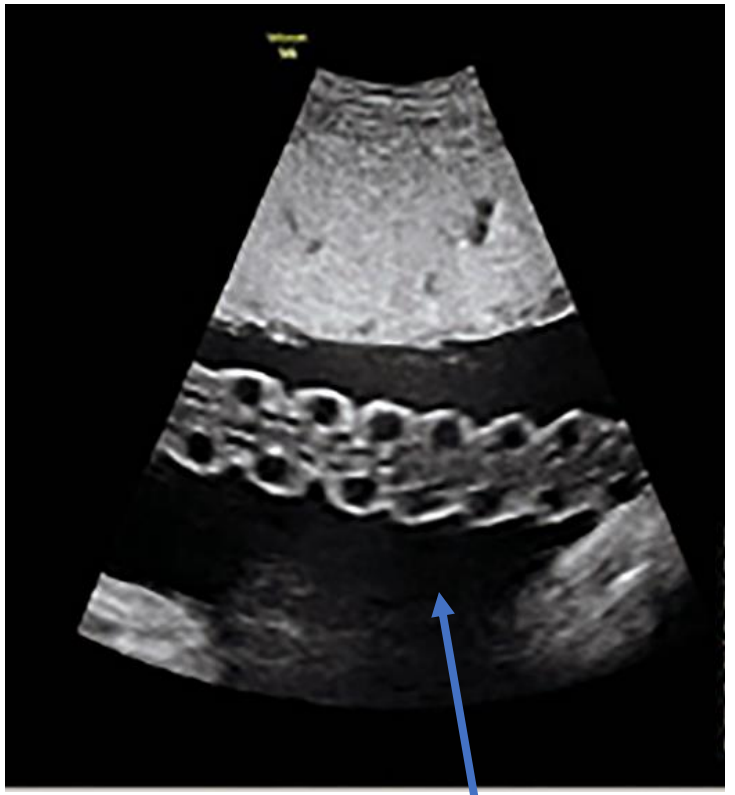
umbilical cord



single umbilical artery



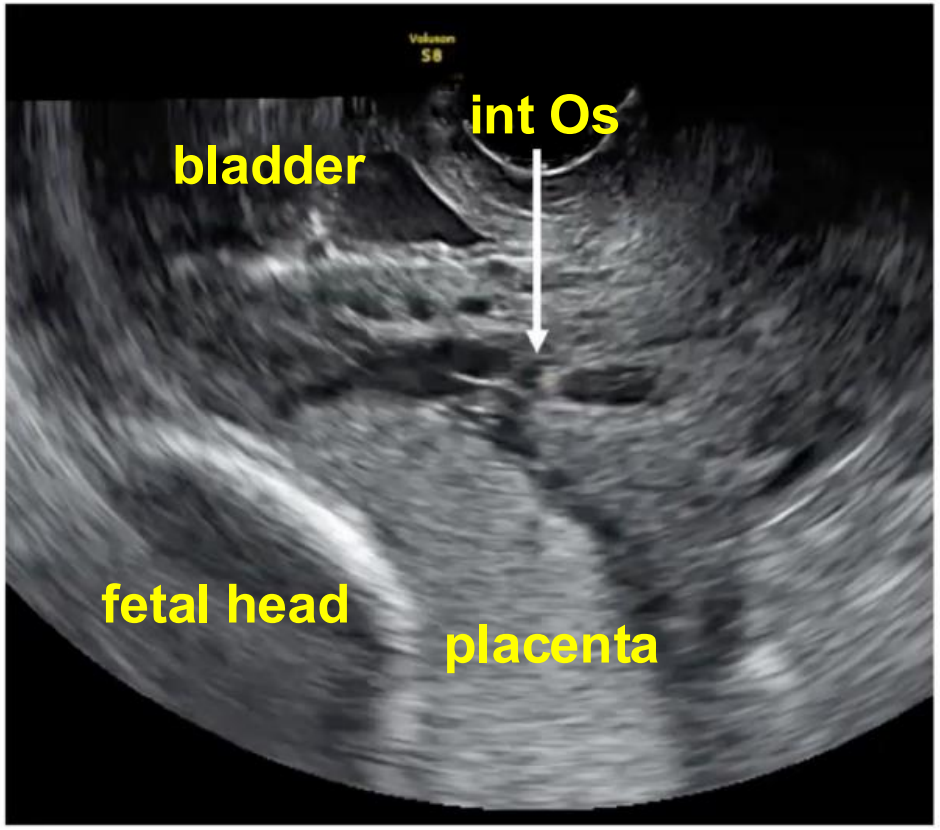




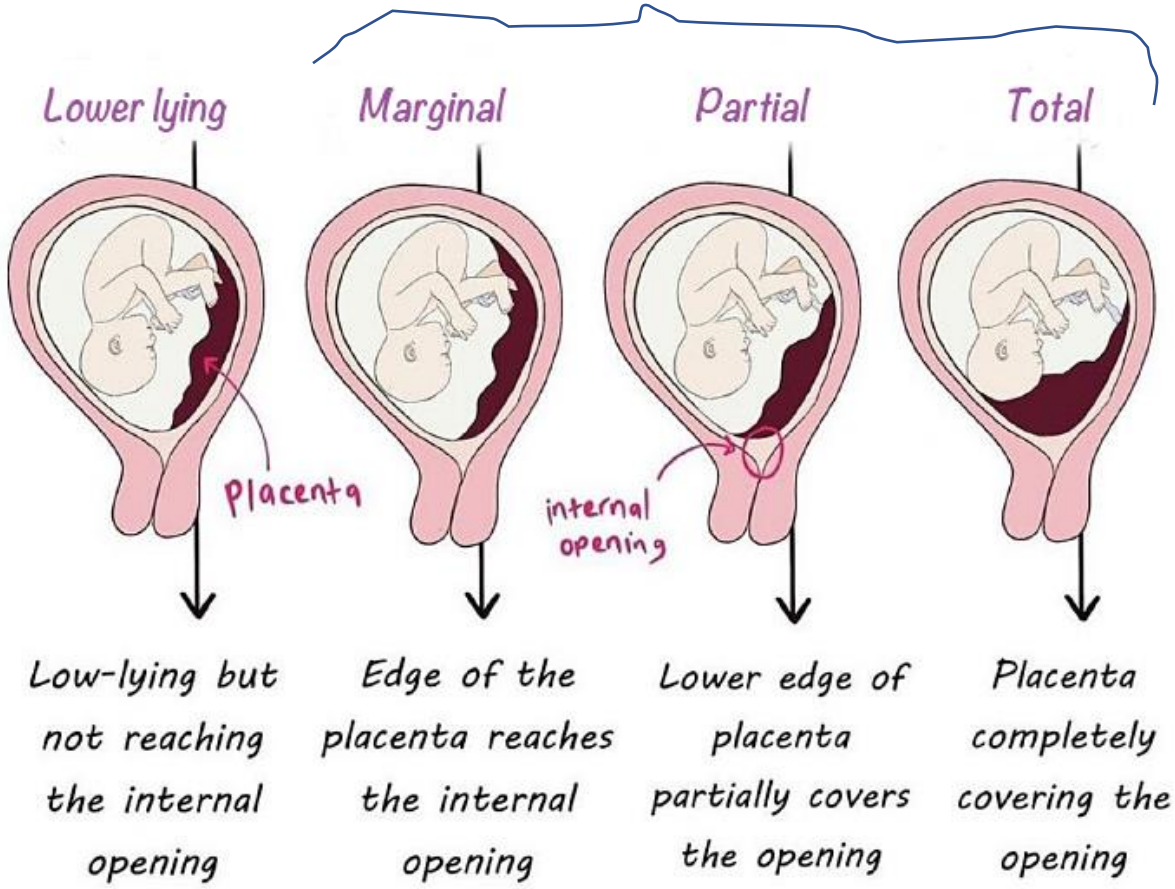
Pitch of umbilical cord coiling = L/R

If the coiling pitch is less than 2.0, it is called hyper coiling.

placenta previa



C/S



placenta～int Os
< 2cm

placenta～int Os
< 2cm

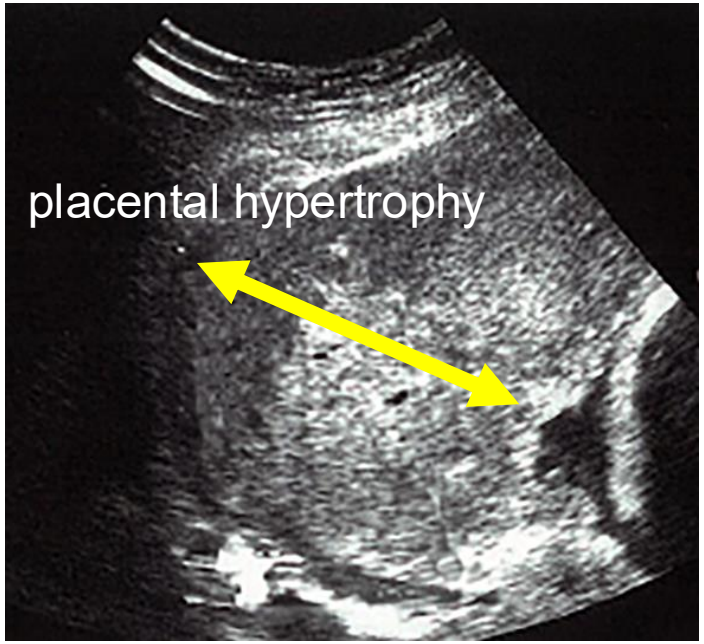
placenta～int Os
≧ 2cm

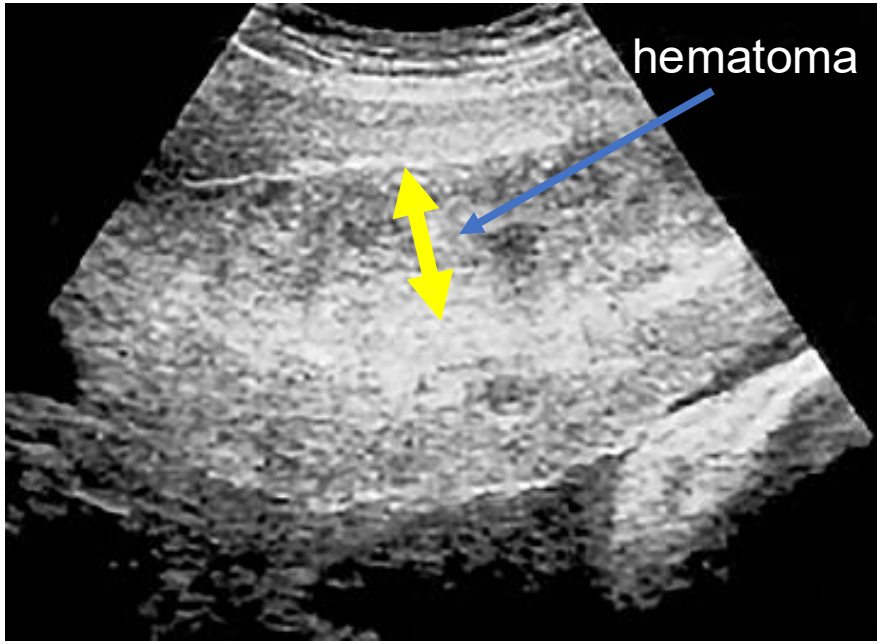
Milky Goodness™
Supporting Breastfeeding Mothers

abruptio placentae

Placenta separates from the inner wall of the uterus before birth.

placental hematoma





minimal vaginal bleeding → hemorrhagic shock, DIC

abnormal uterine contractions for hemostasis → abdominal pain (board-like hard)
back pain

bleeding into the amniotic cavity → bloody amniotic fluid vaginal bleeding

fetal blood flow impairment → non-reassuring fetal status, fetal death

Couvelaire uterus