Obstetrical Ultrasound - Basics of First Trimester Sonography

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RAD-AID

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BASICS (+ SOME NEW STUFF) OF FIRST TRIMESTER SONOGRAPHY: 2021

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3D U/S- embryo depiction

3D US image

Actual embryo/amniotic sac
3D U/S First Trimester

Normal embryo and yolk sac

Ectopic pregnancy
First Trimester

- Remarkable transformation
  - Zygote (single cell)
  - Recognizable human being (13 wks)
- Definition: 4-13 weeks
  - Embryonic period-less than 10 weeks
  - Fetal period-10 or more weeks
- GA = MA, term = 38-42 wks
- Assumes LMP is start of gestation, fertilization occurring 2 weeks after LMP
- No clinically reliable means of establishing ovulation, fertilization
Early pregnancy

- Estimate that ~50% of early pregnancies abort before being clinically evident.
- At least 25% of clinically evident pregnancies have some vaginal bleeding.
- If U/S demonstrates a viable embryo with normal HB @ 8 weeks, only 2% miscarriage rate thereafter.
- First trimester of pregnancy - very turbulent time!
First Trimester Sonography: Outline

- Normal findings/landmarks
- Abnormal intrauterine findings
  - threatened or complete abortion
  - embryonic bradycardia
  - fetal gut herniation, rhombencephalon
  - chorionic “bump”- new reports
  - molar pregnancy-early detection findings
Indications for First Trim. U/S

- DATING- Assign a gestational age
- Identify location, and # gestational sacs
- Hx of miscarriages
- Evaluate maternal symptoms
  - Bleeding
  - Pain
- First Trimester Genetic screening (NT)
- Chromosomal analysis: Guide amniocentesis, CVS
Normal U/S findings of early pregnancy

- Gestational sac ~ 4-4.5 gestational weeks
  - 2-3 mm diameter
- Hyperechoic, thick decidual reaction
  - Echogenic Rim ≥ 2 mm thick
- Eccentric implantation
  - Decidual or “double” sac sign
- Round or Ovoid shape
Early gestational sac @ 4 weeks

transverse

longitudinal
Normal Gestational Sac @ 4.3 wks

Thick decidual reaction

Double decidual sac (DDS) sign
Double or Decidual sac sign

- Theory-decidua capsularis and decidua parietalis make 2 lines on endometrial side of implantation
- Fallen from favor
- Limited sensitivity, specificity
- If seen = probably normal early gestation
Decidual or double sac sign

Parietalis  Capsularis
Gestational sac size - thresholds

- Sum of 3 dimensions/3 = mean sac diameter (MSD)
- If MSD is $\geq 8$ mm and no yolk sac, poor prognosis
- If MSD is $\geq 16$ mm and no cardiac activity, poor prognosis
- Always rare exceptions…
Gestational sac measurements

- CRL: 0.84cm, 5w3d
- Yolk Sac: 1.22cm
- GA (LMP): 5w5d
- CRL: 1.19cm, 6w0d
- Yolk Sac: 1.19cm
Anembryonic pregnancy

- MSD > 25 mm.
- no embryo
- failed intrauterine pregnancy
Risk Factors for Non-viable pregnancy--6-10 weeks

In the 668 singleton pregnancies with live fetuses and complete follow-up there were 50 (7.5%) fetal losses. The incidence of fetal loss increased significantly with maternal age and decreased with # of gestation. In the pregnancies resulting in fetal loss, compared to those with live births, the incidence of vaginal bleeding and cigarette smoking was higher, the fetal heart rate was significantly lower and the gestation sac diameter was smaller but the yolk sac diameter was not significantly different.

Ultrasound in Obstetrics & Gynecology 2003, pp 368–372,
Flat gestational sac + discordant dates.

Yolk sac seen, guarded prognosis due to abnormal gest. sac size and shape.

US dates approx. 7 days behind LMP dates --> non-viable.
Abnormal shape, weak decidual reaction @ 5 wks – guarded prog.
Now @ 7 weeks, normal embryo with normal HB – 153 bpm
Co-twin B: MSD = 24 mm, empty Gestational Sac ➔ demise
"Vanishing twin" sign - small GS
Definite Pregnancy Failure Diagnosed by Means of Transvaginal Ultrasonography.

- CRL $\geq 7$ mm
- no HB

- MSD $>25$ mm without embryo

Abnormal First Trimester development – 2 wks, no embryo
Yolk Sac (Secondary)

- Normal US visibility 5-12 weeks GA
- Max size 6-7 mm., peaks @ 8-9 weeks
- Limited life span- non-functional once placenta takes over (10-12 weeks)
- Abnormal shape (too large), echogenic, or calcified = poor prognostic markers
“Crenulated” yolk sac @ 6.5 weeks – not uncommon, OK!
Yolk sac $\geq 6$ mm

- Associated with bad outcomes
  - Non-viability
  - Aneuploidy

**J Perinatal Medicine 1999;27(4):316-20**

- 49 pts., 6-12 weeks
- Non-diabetic, all had YS $\geq 6$ mm.
- 76 % aneuploidy
- All pts with YS $\geq 8$ mm. had aneuploidy
- 6 pts had normal chromosomes
- Case reports with yolk sac = 8 mm, nl outcome
Double sac sign + large YS

Decidual sac sign
Non-viable, YS > 6 mm.
Normal Early Embryo
Normal embryos @ 7-8 w
Normal Gest. Sac, YS, embryo
Normal embryo @ 8 w 3 d
Embryonic Heart beat

- ~ 5.5-6.5 weeks
  - 90-100 bpm
- ~ 6.5-7 weeks
  - 100-110 bpm
- After 7 weeks
  - > 110-120 bpm
- < 90 bpm, grave prognosis @ any time
- < 80 bpm, impending embryo demise
- If in doubt, repeat U/S within week
Embryonic Cardiac Activity

- Threshold - embryo > 7 mm and no H.B. - NON-VIABLE
- Look for expanded amnion sign—poor prognosis
- Between 6-7 weeks, embryo next to yolk sac
- After 7 weeks they diverge
Embryonic Slow Heart = 96 bpm
Initial Early Embryonic Bradycardia

- The rates of first-trimester demise
  - 61% for pregnancies with slow heart rates
    - HR < 90 beats per minute before 6.3 weeks, or < 110 beats/min at 6.3–7.0 wks
  - 17% for those with borderline HR
    - 90-99 @ 6.3 wks, 100-110 @ 6.3-7 wks
  - 9% for those with normal heart rates (> 120 @ 6.3-7 wks)
- 59 pregnancies with a slow heart rate at 6–7 weeks and a normal heart rate at 8 weeks;
  - 15 (25.4%) resulted in first-trimester demise (vs. 7.2% loss in N @ 6 wks /N @ 8 wks heart rate).
  - 3 fold increase in miscarriage rate
- CONC: Early embryonic bradycardia @ 6-7 weeks = guarded prognosis

Amnion

- Not normally seen until 7 weeks
- If visible when embryo is < 7 mm, poor prognosis
- Helpful when small embryo (< 7 mm) and no HB
- Filly et al - The Expanded Amnion Sign. JUM 2009, 28:10, 1331-1335
  - Study-the amnion is not detectable in normal pregnancies until the embryo has achieved a CRL of ≥ 7 mm
  - Filly-if amnion is seen and no EHB, zero chance of survival
- Thickened or bright amnion-poor prognosis
- Also guarded prognosis-large amniotic cavity
Normal amnion and yolk sac
Expanded amnion sign

CRL = 3 mm., gest age = 5.9 weeks

Miscarriage
Expanded amnion sign $\rightarrow$ Non-viable
LMP-US Dating Concordance-Trends

- Concordant < 5 days discrepancy in LMP dating vs. US (CRL) dating
  - 90% viability
- Discordant : ≥ 5 days difference between LMP and US dating
  - 90% non-viable outcome
Rules of Thumb

- Gestational sac ~ 4-5 weeks
- Gest. Sac + yolk sac ~ 5-5.5 weeks
- GS + YS + embryo ~ 5.5-6 weeks
- Embryo + HB ~ 6-6.5 weeks
- HB ~ 6-7 weeks @ 90-120
- HB > 120 after 7 weeks
- Failed IUP
  - No heartbeat if embryo ≥ 7 mm.
  - No embryo if MSD > 25 mm.
FT Pregnancy and Vaginal Bleeding

3 Possibilities:

- IUP
- Non-viable IUP (Pregnancy of Unknown Viability)
- Ectopic Pregnancy (Pregnancy of Unknown Location)
Normal gestational sac vs. anembryonic pregnancy

- Normal gestational sac increases by 1.1 mm/day
- Thick, echogenic decidua
- Round or oval shape

- Abnormal gest. sac increases by < 0.7 mm/day
- Thin, irregular sac shape
- Irregular choriodecidual reaction
- Lack of double sac sign if MSD > 10 mm.*

Abnormal gestational sac--hydropic degeneration of placenta
Eccentric implantation?

Embryonic demise @ 7 weeks
Eccentric implantation??

Outcome-term infant
3D U/S in FT - miscarriage one week later
Abortion in progress (vs cervical ectopic) - poor outcome regardless

Sac + embryo in cervix

Absent embryonic heart beat
First trimester intrauterine hematoma (subchorionic bleed)

US-Hematoma had doubled over 2 days, but pt lost to f/u
---- guarded prognosis
Intrauterine Hematoma
Intrauterine Hematoma - “large”

Bleeding @ 5 weeks → normal @ 20 weeks
Clinical significance of first-trimester chorionic bumps: a matched case–control study

Ultrasound in Obstetrics & Gynecology, 2013, Volume: 42, Issue: 5, Pages: 585-589,
Recent Chorionic Bump (UW)
Chorionic Bump - cine clip
The Chorionic Bump

IVF, 6.2 wks

5 mm. embryo w/o HB

Harris et al, JUM 2006: 25:6, 756-763
The Chorionic Bump-absence of blood flow

Harris, et al. JUM, 2006: 25; 6, 757-763
6 wks by LMP, HCG > 200,000

Courtesy of T. Dubinsky, U of Washington

Harris et al, JUM, 2006: 25: 6, 757-763
Early pregnancy with IUD and chorionic "bump" 

Yolk sac @ 5.5 weeks, “chorionic bump”

IUD in cervix/LUS, had normal term delivery (fetus w/ single umbilical artery)
Chorionic bump at 11 to 13 weeks' gestation: Prevalence and clinical significance

Sepulveda, Prenatal Diagnosis. 2019: 39: 6,471-476
# Chorionic “Bump” Literature

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>N (prevalence)</th>
<th>Dates US (wks)</th>
<th>Bump Size (mean)</th>
<th>Comments</th>
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</thead>
<tbody>
<tr>
<td>Harris</td>
<td>2006</td>
<td>15 (0.7%)</td>
<td>5.8-9.3</td>
<td>0.8 ml</td>
<td>LBR 47%, 4 x miscarriage</td>
</tr>
<tr>
<td>Sana</td>
<td>2013</td>
<td>57 (0.15%)</td>
<td>Mean 6.5</td>
<td>10.5 mm</td>
<td>LBR 62%, 2 x miscarriage</td>
</tr>
<tr>
<td>Arleo</td>
<td>2015</td>
<td>119 (meta-analysis)</td>
<td>FT</td>
<td>NA</td>
<td>LBR 62%, w/ EHB 83%</td>
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<tr>
<td>Wax</td>
<td>2017</td>
<td>16 (2.3%) (High Risk)</td>
<td>5-14</td>
<td>NA</td>
<td>4-15 x aneupl. Risk</td>
</tr>
<tr>
<td>Younesi</td>
<td>2017</td>
<td>8 (0.4%)</td>
<td>5-9</td>
<td>0.7 ml</td>
<td>LBR 63%</td>
</tr>
<tr>
<td>Sepulveda</td>
<td>2019</td>
<td>23 (0.7%)</td>
<td>11-13</td>
<td>20 mm</td>
<td>All normal ex.1 case of Tri 21</td>
</tr>
</tbody>
</table>
Dichorionic twins vs. Chor. Bump

DC twinning early first trimester

Chorionic bump in early first trimester
Chorionic Bump vs. Early Mole

Chorionic bump @ 6 wks

Complete molar pregnancy @ 7 wks
Normal bowel embryology—gut herniation ~ 10-12 wks

Physiological rotation of bowel outside the abdomen

Small area, < 7 mm wide, midline
Normal Bowel Herniation @ 11 weeks
Abnormal gut in abdominal wall defect - Exomphalos
Normal bowel herniation

Abdominal wall defect
FT- Abnormal Gut herniation?

Answer: NO!!

Power Doppler: more sensitive, but no directionality
Early gastroschisis- 14 weeks
Abdominal wall @ 13 weeks-3D

Abdominal wall defect

Normal Cord insertion
Is this normal herniation?

NO

Take home point- 7 mm.

Terminated @ 17 weeks-gastroschisis
Exomphalos

- Prevalence 1:4000
- Midline anterior abdominal wall defect
- Associated with aneuploidy 30-50% (tri 18)
- Thick nuchal translucency association
- Normal bowel herniation
  - Smaller
  - Transient (10-12 weeks)
  - U.C. thru herniation
- Exomphalos when bowel herniation > 7 mm.
Embryonic Hydrocephalus?

No.... Embryonic Rhombencephalon!
Prominent Rhombencephalon

Cystic space in head?

Prominent rhombencephalon (cerebellum, pons, medulla)
Gestational Trophoblastic Disease

- Hydatidiform Mole, Complete
- Hydatidiform Mole, Partial
- Invasive Mole
- Choriocarcinoma
- Placental Site Trophoblastic Tumor
GTD Epidemiology

- Rare in Western world and Australia/NZ
  - 0.5-1 per 1000 pregnancies
- More common in SE Asia and Japan
  - 2 per 1000 pregnancies
- Increased incidence among:
  - Native Americans, Inuits, Afro-Americans, Hispanics, Asians
  - Decreased prevalence overall (better diet, SES)
Hydatidiform Mole I

- Both kinds-Abnormal pregnancy w/ varying degrees of:
  - Trophoblastic proliferation
  - Villous edema
  - Absent or abnormal embryo/fetus

- Complete mole
  - 46 XX (90%)--Sperm fertilizing egg w/ inactive or absent chromosomes (duplicate haploid chromes)
  - Absent fetus or embryo
  - 15-20% progress to post-GTD neoplasia (invasive mole or chorioCA)
Hydatidiform Mole II

- **Partial mole**
  - Fetal or embryonic tissue
  - Villous edema
  - Focal trophoblastic hyperplasia
  - 69 XXY usually
  - 2 sperm fertilizing normal ovum
  - Less than 5% develop postmolar GTN
  - 85% of cases of triploidy are partial moles
Risk Factors for Complete Mole

- Advanced maternal age
  - 2 x for > 35 years
  - 7.5 x for > 40 years
- Very young maternal age
  - 2 x for < 21 years
- Spontaneous abortion
  - 2-3 x increased risk
- Inverse relationship to B-carotene and animal fat dietary intake
Risk Factors for Choriocarcinoma

- Prior complete mole
  - 1000 fold increase c/t normal pregnancy
- *Advanced maternal age*
- Long term contraceptive use
- Blood group A
- 60% of chorioCA have no preceding molar pregnancy
- So rare hard to study this tumor
Complete Mole - Clinical

- Vaginal bleeding
- 6-16 weeks gestation
- Size greater than dates (30%)
- Hyperemesis (10%)
- PIH (1%)
- Theca lutein cysts (15%)
- hCG > 100,000
Partial Mole-Clinical

- > 90% present as incomplete or missed AB
- DX after D & C histology
- Vaginal bleeding (75%)
- hCG levels < 100,000 in 90% pts.
- S > D, hyperemesis, PIH, theca lutein cysts uncommon
Complete molar pregnancy
Complete molar pregnancy

“snowstorm”

“cluster of grapes”
Partial Mole-Triploidy

~ 15 Weeks
b-HCG 1.5 million
Partial mole--triploidy

Gestational sac present
Dead embryo/fetus or malformations
Demised fetus @ 12 weeks
Partial mole-pathology

Placental tissue with partial villous dilatation
Coexistent mole and fetus

Courtesy of Dr. Rebecca Hall; University of New Mexico
Co-existent Mole and Fetus

OB’s office, New Hampshire, 1997
Early US Dx of Complete Mole

- 39 women with path proven CHM
- 36 had at least 2 U/S before 9 wks
- First Scan (mean 7.1 wks)
  - 74% had hyperechoic mass +/- gest. Sac
  - 26% had 4 weeks sized gestational sac
- Cystic molar changes start @ 8-9 weeks
- CONC: well defined pattern: starts with “normal 4 wk” GS and then polypoid mass @ 5-7 weeks, then cysts @ 8-9 wks

Early Complete Molar pregnancy - First Trimester (5-10 weeks)

Early complete molar pregnancy

Early Complete Molar Pregnancy

DX Dilemma?

- Chorionic Bump (CB-hematoma)- mostly benign course
- Theoretical risk-polypoid early CHM can resemble CB
- No cases of Chorionic Bump attributed to Molar Pregnancy or Triploidy (to my knowledge)
Chorionic Bump - cine clip
Co-twin B: MSD = 24 mm, empty Gestational Sac → demise
“Vanishing twin” sign - small GS
Normal Gest. Sac, YS, embryo
Normal embryo @ 8 w 3 d
Embryonic Slow Heart = 96 bpm
Early gastroschisis - 14 weeks
Abdominal wall @ 13 weeks-3D

Abdominal wall defect

Normal Cord insertion
Fetal Jig
Ectopic Pregnancy-Epidemiology

- Leading cause of death in first trimester
- 2% of pregnancies
- 4-15% of all maternal deaths
- **Steadily increasing since 1970’s**
- Risk factors
  - Tubal surgery 21 x
  - Sterilization 9 x
  - Previous ectopic 8 x
  - IUD 4-45 x
  - Tubal disease 4-21x
  - DES 6 x
  - Previous PID 4 x
  - Infertility 3-21 x
  - Multiple sexual partners 2 x
HCG threshold levels w/ ectopic

- 1000-2000 level @ which most normal pregnancies have small gestational sac
- Threshold not absolute, but guide
- Approximately 25% of pts have indeterminate or normal scan, 5-20% require more than 1 U/S
- Serial HCG-normally doubles every 2 days
- Serial U/S - gest. sac grows ~1 mm/day
- However, 20% of ectopics have rise in HCG that mimics normal IUP (most < 60% rise /2 days)
Classic ectopic pregnancy

1. Empty uterus (or pseudosac)
2. Tubal ring
3. Echogenic fluid in cul-de-sac
   - Of course, positive HCG!!
Tubal “Ring of Fire”-Color Doppler (but also see in Corpus Luteum)
Corpus Luteum vs Tubal Ring

CL

Tubal ring
Tubal ring-absent color Doppler
Pseudosac of ectopic pregnancy-8 weeks GA by LMP

?ectopic, possible tubal but possible intrauterine embryo?

Apparent blood flow on Power Doppler
Intrauterine clot- no heart beat
Ectopic Pregnancy - detected 2 weeks later
Ectopic Pregnancy-Rt tube
Echogenic fluid in cul-de-sac
US "Bimanual" technique
Ectopic Pregnancy-DX by Senior resident on call
Sliding ectopic sign
Living ectopic pregnancy

Empty uterus

Embryo in rt tube - Rx'd with methotrexate
Living ectopic pregnancy
Specimens from Ectopic Pregnancy

Blood clot and ectopic in tube

Magnified view of ectopic in tube
Ectopic Pregnancy

Tubal ring sign-hyperechoic compared to CL

Pseudosac or blood in endometrial cavity
Chorionic bump in ectopic pregnancy

Chorionic “bump” dwarfs yolk sac, embryo

Ectopic embryo with heart beat
Ectopic Pregnancy -- MTX Rx

Moderate hemoperitoneum
Left ectopic tubal ring
Three days later....more pain

More hemoperitoneum  
HGB 12.4 ---> 10.4

Ectopic slightly larger but RX’d conservatively-MTX second time
Cornual pregnancy-2-4% of ectopic pregnancy

Higher M & M due to late presentation, bleeding

Rule of thumb > 5 mm of myometrium around gest. sac
Ectopic pregnancy-cine clip
Ectopic pregnancy and hCG levels

- 225 pts with hCG and proven ectopics
- 112 (50%) pts had hCG < 1000
- 9 (4%) pts had hCG < 100
- 174 (77%) pts had hCG < 3000
- 16 (7%) pts had hCG > 10,000
- 7/72 (10%) pts with hCG < 500 had a ruptured tube at surgery

CONC: little relationship between HCG and ectopics

Radiology, 2014
HCG thresholds and PUL (empty uterus)

- If hCG level > 2000 mIU, the most likely diagnosis is a nonviable intrauterine pregnancy, occurring approximately twice as often as ectopic pregnancy with empty uterus.
- Ectopic pregnancy ~ 19 times as often as viable intrauterine pregnancy when the hCG level is 2000 - 3000 mIU with empty uterus.
- Ectopic pregnancy 70 times as often as a viable intrauterine pregnancy when the hCG level is more than 3000 mIU and empty uterus.
HCG and IUP (PUL)

- Empty uterus and hCG:
  - hCG: 2000-3000 mIU/ml, likelihood of viable IUP 2%
  - hCG > 3000 mIU/ml, likelihood of viable IUP 0.5%
Basics of FT ultrasound – take home points

- Gestational sac -- 5 weeks
- Yolk sac – 5.5 weeks
- Embryo + Heartbeat – 6 weeks
- Heart rate < 80 bpm → universally bad prognosis
- hCG levels are unreliable for ruling in or ruling out IUP or ectopic pregnancy
Unknown FT cases
Infertility (ET) early twinning
Infertility discordant sacs twins
Twin sac size discrepancy - delivered @ Term
Embryo normal on outside ultrasound??
Conjoint twins-dicephalus
Another pt, similar findings

Kigali, Rwanda 2016