

Ultrasonography for Dating Pregnancies

Joseph R. Wax, M.D.
Division of Maternal-Fetal Medicine
Maine Medical Center
Portland, Maine

Disclosures

- Joseph R. Wax, MD
 - None

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Learning Objectives

- After completing this presentation, the learner will be able to:
 1. Explain importance of accurate pregnancy dating
 2. Describe first trimester measurements and accuracy
 3. Describe second trimester measurements and accuracy
 4. Describe simple algorithm for assigning due date

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Lecture Outline

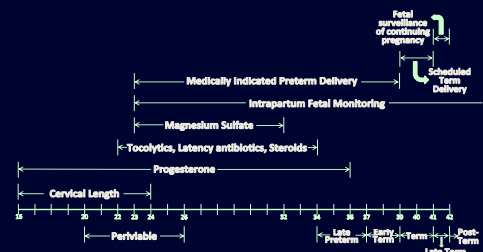
- Menstrual dating
- First trimester ultrasound dating
 - measurements
 - accuracy
 - twins
- Second trimester dating
 - measurement
 - accuracy
 - twins
- Dating algorithm
- Case studies

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- All obstetrical care stems from accurate gestational age, including timing of
 - prenatal exams
 - screening tests
 - delivery

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Obstetrical Interventions and Procedures by Gestational Age



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ACOG CO 560 ACOG PB 139
Raju T, et al. AJOG 2014

Traditional Pregnancy Dating – Last Menstrual Period (LMP)

- **Naegele's Rule**
 - 1st day of LMP + 1 year – 3 months + 7 days = EDD
- **Wheel**



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Traditional Pregnancy Dating – Last Menstrual Period (LMP)

- Assumes that all women all the time have
 - 280 day gestation
 - every 28-day cycles
 - monthly regularity
 - ovulation and fertilization on day 14
 - no recent hormonal contraception
 - accurate recall

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Wheel Accuracy

- **Findings**
 - 10/31 (35%) → 280 day EDD
 - largest single discrepancy = 4 days
 - largest interwheel difference = 7 days
 - 20/20 app → 280 day EDD
- **Conclusion**
 - *replace wheels with electronic due date calculator*



Chambis LR, et al. AJOG 2014

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Ultrasound Dating – Assumptions

- **Size of embryo/fetus is consistent with its age**
 - measurements of IVF pregnancies = spontaneous conceptions
- **Measurements conform to nomograms**
- **Measurements are reliable both**
 - within and between examiners
- **Structures measured are normal**
- **US equipment is properly calibrated**

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First Trimester Dating – Mean Sac Diameter (MSD)

- **Mean of 3 orthogonal measurements of the fluid filled space within the gestational sac**



$$\text{MSD} = \frac{1.22 + 0.83 + 0.71}{3} = 0.92 \text{ cm}$$



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MSD – General Rules

- **Gestational age (d) = MSD (mm) + 25**
 - from 5 0/7 – 8 0/7 weeks
- **Grows ~1mm/day**
 - use to time dating and viability US for MSD ≥ 25mm or 7 weeks
- **Use only until embryo present, then use CRL**
 - greater interobserver variation vs. CRL
 - *do not use to determine EDD*

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Pexsters, et al. USOG 2011
 Doubilet, et al. JUM 2013
 Grisolia, et al. USOG 1993
 Nyberg, et al. JUM 1987
 Doubilet, et al. NEJM 2013

First Trimester Dating – Crown Rump Length (CRL)

- No standard technique until recently
 - transabdominal or transvaginal scan (equivalent) ≥ 6 weeks
 - mid-sagittal view
 - entire embryo/fetus fills screen
 - embryo oriented horizontally and 90° to US beam
 - neutral position
 - linear measurement
 - “best of 3” vs. “average of 3”



Wax Papageorgiou, et al. USOG 2014 Ioannou, et al. BJOG 2013 Kaur, et al. J Pharm Bio Sci 2011
 Grisolia, et al. USOG 1993 Lohr, et al. Contraception 2010 Ferrazzi, et al. USOG 1993

Crown Rump Length – General Rules

- Use from 6 0/7 – 13 6/7 weeks (up to 84mm)
- Most accurate from 7 – 60mm
- Clinically insignificant (0.4d) difference males vs. females
- Gestational age (wks) = CRL (cm) + 6.5

| Accuracy (d) | Gestational Age (wks) |
|--------------|-----------------------|
| ± 5 | $\leq 8\ 6/7$ |
| ± 7 | 9 0/7 – 13 6/7 |

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SOGC ACOG Bukowski R, et al. Am J Epidemiol 2007

CRL Dating of Twins

- Which twin is used to date a pregnancy when LMP is
 - uncertain?
 - discordant from CRL?
- **Limited data = no consensus**



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CRL Dating of Twins

| Favor | Rationale |
|---------|--|
| Larger | <ul style="list-style-type: none"> • reduces chance of missing FGR • unlikely to have pathologically large fetus |
| Smaller | <ul style="list-style-type: none"> • more accurate if $\Delta\text{CRL} < 95\%$ ($< 9.8\text{mm}$) • no increased risk of discordance or adverse outcome |
| Average | <ul style="list-style-type: none"> • as accurate as smaller twin dating • as similar to singleton CRL as small twin |

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Salomon, et al. USOG 2005
 Chaudhuri, et al. JOGR 2013
 Dias, et al. BJOG 2010

CRL Dating of Twins

- Should twins be dated using twins-specific CRL nomograms?
 - not necessary
 - no clinically significant difference in CRL vs. singletons (1-2d)
 - no difference between mono- vs. dichorionic
 - best agreement when CRL 4-60mm

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Kalish et al. AJOG 2004 Wisser, et al. USOG 1994
 Sebire, et al. OG 1998 Dias, et al. BJOG 2010

Second Trimester Dating

- Use either unweighted composite gestational age of measurements
 or
- Regression formula incorporating measurements
 vs.
 Nomograms

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Second Trimester Dating – Biparietal Diameter (BPD), Head Circumference (HC)

- Level of thalami and cavum septi pellucidi
- No cerebellum seen
- Midline echo horizontal and perpendicular to US beam
- Symmetrical hemispheres
- BPD – calipers on outer edge near field parietal bone, inner edge far field parietal bone*
- HC – outer perimeter of bony skull

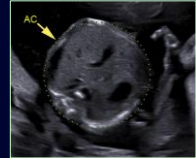


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*BMUS: outer-outer, use appropriate nomogram

Second Trimester Dating – Abdominal Circumference (AC)

- True axial section at level of umbilical vein and portal sinus
- Stomach seen
- Kidneys not visible
- Measure along skin



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Second Trimester Dating – Femur Length (FL)

- Measure only diaphyseal length of bone
- Femur horizontal and perpendicular to US beam



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Second Trimester Dating – Caveats

| Measurement | Comment | Accuracy |
|-------------|---|----------|
| BPD | Slightly less accurate than HC | ± 7-12 d |
| HC | Most accurate single measurement 14-22 wks | ± 7-12 d |
| AC | Most variable measurement <ul style="list-style-type: none"> • fetal growth factors • borders hard to discern • shape distortion | ± 7-15 d |
| FL | May vary with <ul style="list-style-type: none"> • aneuploidy • ethnicity • skeletal dysplasia | ± 7-17 d |

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Second Trimester Dating – General Rules

- Clinically as accurate (18-22 wks) as first trimester dating (11-14 wks) using IVF-dated pregnancies
- *Do not redate if earlier reliable exam available*

| Accuracy (d) | Gestational Age (wks) |
|--------------|-----------------------|
| ± 7 | 14 0/7 – 15 2/7 |
| ± 10 | 16 0/7 – 21 6/7 |

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ACOG
Kalish, et al. AJOG 2004

Second Trimester Dating – Twins

- May use singleton nomograms up to 26 weeks
- HC of larger twin – most accurate measurement

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Dias, et al. USOG 2011

Should All Women Undergo 1st Trimester Dating US?

| Organization | Recommendation (and timing, wks) |
|----------------------|--|
| U.K. NICE (2008) | offer at 10 0/7 – 13 6/7 |
| ISUOG (2013) | <ul style="list-style-type: none"> • 11 0/7 – 13 6/7 if indicated • offer at 10 0/7 – 13 6/7 |
| SOGC (2014) | offer/perform, where available |
| ACOG (2009) | if indicated |
| NIH Consensus (2014) | if indicated, 7-10 wks (dating) optimal |

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Should All Women Undergo 2nd Trimester Ultrasound?

| Organization | Recommendation (and timing, wks) |
|----------------------|---|
| U.K. NICE (2008) | 18 – 20 6/7 |
| ISUOG (2013) | -- |
| SOGC (2014) | 18 – 22 |
| ACOG (2009) | 18 – 20 (if requested by patient or agreed upon by patient and physician) |
| NIH Consensus (2014) | 18 – 20 |

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Simplified Dating Algorithm

- If pregnancy resulted from ART, use ART dating
- If pregnancy resulted from spontaneous conception, and LMP is unknown or uncertain
 - date by CRL up to 84 mm (13 6/7 wks), preferably ≥ 10 mm
 - if CRL unavailable, date by composite of BPD, HC, AC, FL up to 24 weeks, preferably 18-20 weeks or earlier

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Simplified Dating Algorithm

- If pregnancy resulted from spontaneous conception, and LMP is reliable, either
 - use US dating as above if employing universal US dating (US alone ≤ 23 weeks more accurate than certain LMP)
 - or
 - compare EDD by LMP to EDD by US and refer to table

Table 3. Statistics for Dating Based on Ultrasonography

| Standardized Age Range* | Method of Measurement | Statistical Difference Between Ultrasound Dating and LMP† |
|-------------------------|-----------------------|---|
| <13 6/7 wk | DE | More than 3.4 |
| • 13 6/7 wk | | More than 7.4 |
| + 13 6/7 wk | | |
| 13 6/7 wk | BPD, HC, AC, FL | More than 7.4 |
| 14 0/7 wk | BPD, HC, AC, FL | More than 10.0 |
| 14 3/7 wk | BPD, HC, AC, FL | More than 14.0 |
| 14 6/7 wk | BPD, HC, AC, FL | More than 21.0 |
| 15 0/7 wk | BPD, HC, AC, FL | More than 21.0 |

*Standard deviation, 0.4 standard deviations; BPD, biparietal diameter; DE, days of embryo; HC, head circumference; AC, abdominal circumference; FL, femur length; FL, head circumference; LMP, last menstrual period.

†Based on the risk of dating a gestation that was begun with an egg retrieved and fertilized in vitro. The difference between the date by ultrasound and the date by LMP is given for each combination of the gestational age and the method of measurement.

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ACOG/AIUM/SMFM Obstet Gynecol 2014

Simplified Dating Algorithm

- If dating by third trimester US
 - difficult to assign accurate EDD
 - repeat study 3-4 weeks for growth
 - rule out growth restriction

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Case Studies in Dating – ART Conception

- 36-year old with IVF conception
- 5 days between fertilization and transfer on 7/20/15
- What is her EDD?
 - egg retrieval and fertilization assigned “day 14”
 - fertilization + 5 days = 19 days since “LMP”
 - “LMP” = 7/20/15 – 19 days = 7/1/15
 - EDD = 4/6/16

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Case Studies in Dating – First Trimester

- 39-year old LMP 7/8/15 EDD 4/13/16 at 7 5/7 weeks
- CRL = 6 4/7 weeks
- What is her EDD?
 - US – LMP difference = 8 days
 - 8 days > 5 day US – LMP threshold
 - date by CRL
 - EDD = 4/21/16

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Case Studies in Dating – Second Trimester

- 28-year old LMP 7/16/15 EDC 4/21/16 at 19 5/7 weeks
- Biometry
 - BPD 17 2/7 HC 17 0/7
 - AC 17 2/7 FL 17 4/7
- What is her EDD?
 - composite EGA = 17 2/7
 - US – LMP difference = 16 days
 - 16 days > 10 day US – LMP threshold
 - date by US
 - EDD = 5/8/16

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Case Studies in Dating

- 34-year old, unknown LMP
- US on 8/31/15 shows monochorionic diamniotic twins
 - Biometry
 - CRL_A 12 0/7
 - CRL_B 11 3/7
- What is her EDD?
 - by larger twin = 3/14/16
 - by smaller twin = 3/18/16
 - by average = 3/16/16

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Conclusion

- Accurate pregnancy dating is key to optimizing prenatal care
- A validated electronic due date calculator is preferable to a “wheel”

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Conclusion

- Use ART dating, if applicable
- First and second trimester biometry are accurate EDD determinants
 - Do *not* use MSD to determine EDD
- Perform followup growth study if dated by third trimester ultrasound
- Twins may be dated by singleton nomograms

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References

1. ACOG/AIUM/SMFM Committee Opinion 611. Method of estimating due date. *Obstet Gynecol* 2014;124:863-6.
2. ACOG Committee Opinion 560. Medically indicated late-preterm and early-term deliveries. *Obstet Gynecol* 2013;121:288-90.
3. ACOG Practice Bulletin 139. Premature rupture of membranes. *Obstet Gynecol* 2013;122:918-30.
4. Bukowski R, et al. Human sexual size dimorphism in early pregnancy. *Am J Epidemiol* 2007;165:1216-8.
5. Chambliss LR, et al. Paper gestational age wheels are generally inaccurate. *Am J Obstet Gynecol* 2014;210:145.e14.
6. Chaudhuri K, et al. Determination of gestational age in twin pregnancy: which fetal crown-rump length should be used? *J Obstet Gynecol Res* 2013;39:761-5.
7. Dias T, et al. First-trimester ultrasound date of twin pregnancy: are singleton charts reliable? *BJOG* 2010;117:375-84.
8. Dias T, et al. Second-trimester assessment of gestational age in twins: validation of singleton biometry charts. *Ultrasound Obstet Gynecol* 2011;37:34-7.
9. Doubilet PM, et al. Diagnostic criteria for nonviable pregnancy early in the first trimester. *N Engl J Med* 2013;369:1443-51.
10. Doubilet PM, et al. Double sac sign and intradecidual sign in early pregnancy. *J Ultrasound Med* 2013;32:1207-14.

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References

11. Ferrazzi E et al. Miscarriage diagnosis and gestational age estimation in the early first trimester of pregnancy: transabdominal versus transvaginal sonography. *Ultrasound Obstet Gynecol* 1993;3:35-41.
12. Grisolia G, et al. Biometry of early pregnancy with transvaginal sonography. *Ultrasound Obstet Gynecol* 1983;3:403-11.
13. Ioannou C et al. Standardization of crown-rump length measurement. *BJOG* 2013;120:38-41.
14. Kalish RB, et al. First- and second-trimester ultrasound assessment of gestational age. *Am J Obstet Gynecol* 2004;191:975-8.
15. Kaur A, Kaur A. Transvaginal ultrasonography in first trimester of pregnancy and its comparison with transabdominal ultrasonography. *J Pharm Bio Sci* 2011;3:322-38.
16. Lotry PA, et al. A comparison of transabdominal and transvaginal ultrasonography for determination of gestational age and clinical outcomes in women undergoing early medical abortion. *Contraception* 2010;81:240-4.
17. Nyberg DA, et al. Distinguishing normal from abnormal gestational sac growth in early pregnancy. *J Ultrasound Med* 1987;6:237.
18. Pappageorgiou AT, et al. International standards for early fetal size and pregnancy dating based on ultrasound measurement of crown-rump length in the first trimester. *Ultrasound Obstet Gynecol* 2014;44:641-8.
19. Pexsters A, et al. Clinical implications of intra- and interobserver reproducibility of transvaginal sonographic measurement of gestational sac and crown-rump length at 6-9 weeks' gestation. *Ultrasound Obstet Gynecol* 2011;38:510-15.

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References

20. Raju T, et al. Periviable birth: executive summary of a Joint workshop by the Eunice Kennedy Shriver National Institute of Child Health and Human Development, Society for Maternal-Fetal Medicine, American Academy of Pediatrics, and American College of Obstetricians and Gynecologists. *Am J Obstet Gynecol* 2014.
21. Salomon LJ, et al. Growth discrepancy in twins in the first trimester of pregnancy. *Ultrasound Obstet Gynecol* 2005;26:512-5.
22. Sebire NJ. Intertwin disparity in fetal size in monozygotic and dizygotic pregnancies. *Obstet Gynecol* 1998;91:82-5.
23. SOGC Clinical Practice Guidelines. Determination of gestational age by ultrasound. *J Obstet Gynecol Can* 2014;36:171-81.
24. Wisser J, et al. Estimation of gestational age by transvaginal sonographic measurement of greatest embryonic length in dated human embryos. *Ultrasound Obstet Gynecol* 1994;4:457-62.

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