Current Perspectives on Gestational Age Assessment

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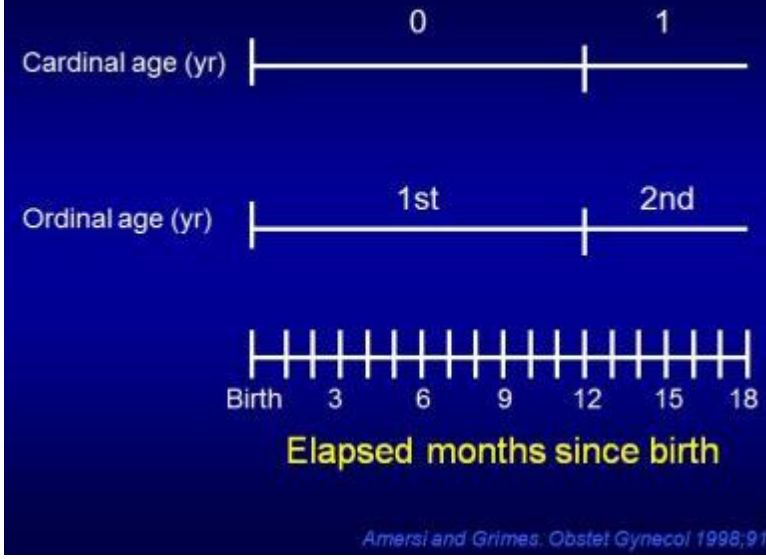
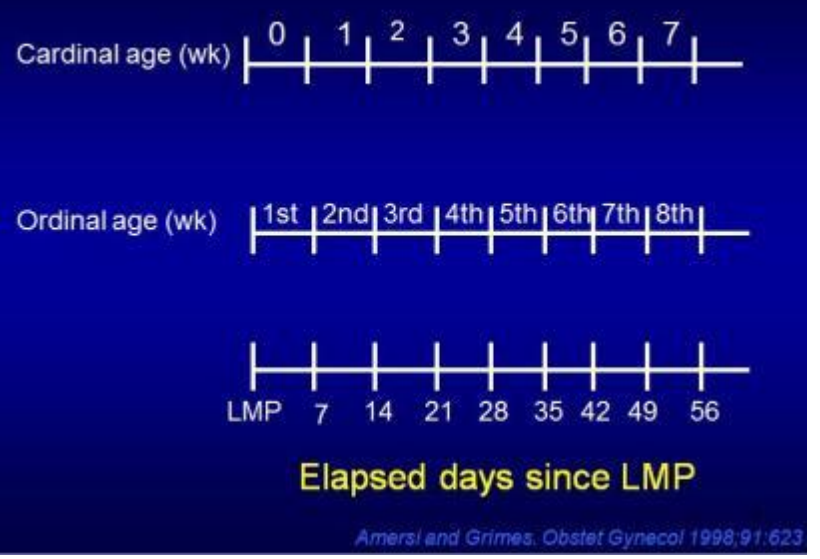
Clinical Importance of Gestational Age Assessment

- Postdates
- Preterm labor
- Elective repeat cesarean delivery
- Interpretation of biochemical screening
- CVS/amnio
- IUGR
- Abortion
- Aggressive vs non-aggressive obstetric management





Pregnancy Duration

- Traditionally, last menstrual period (LMP) used as a reference point
- Predicted delivery date 280 days later

Naegele's Rule

EDC = LMP – 3 months + 7 days

Naegele's Rule

- Assumes fertilization occurs on Day 14 of 28 day cycle

- Assumes women have a certain LMP

Duration of Menstrual Cycle

- Variable follicular phase
  - Study: Ovulation occurred at day 8-31 (Walker.BJOG)
  - Study: 30,000 cycles in 2316 women found only 77% with 25-31 day cycle (Chiazze.JAMA)

< 20 days	→	0.3%
21-25 days	→	19.1%
26-28 days	→	36.0%
29-35 days	→	39.0%
> 35 days	→	5.6%

Cycle > 28 days → underestimation of GA
Cycle < 28 days → overestimation of GA

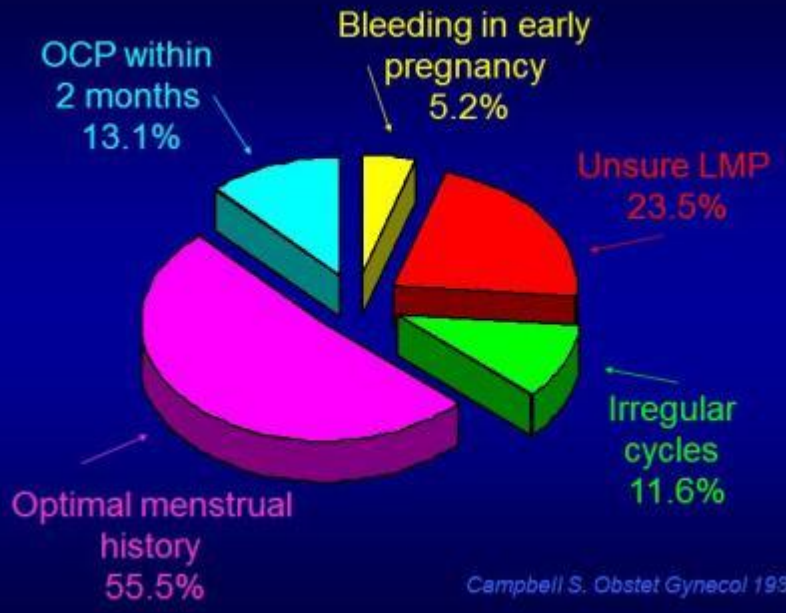
Poor recall

- Many women have uncertain LMP due to poor recall, irregular bleeding, or recent OCP use.
  - Study of 4000 pregnant women, 45% with uncertain LMP

Campbell.Obstet Gynecol

Optimal Menstrual History

- Sure dates
- 28 day cycle
- Regular menses
- No OCP, miscarriage, breastfeeding



Campbell S. Obstet Gynecol 1935

Fundal Height

- The distance between the symphysis pubis and the uterine fundus
- Fundal height (cm) correlates well with gestational age (weeks)
- 90% confidence interval: ± 3 weeks

Factors Altering the Accuracy of Fundal Height

- Patient habitus
- Multifetal gestation
- Fetal growth
- Fetal lie
- Amniotic fluid volume
- Uterine fibroids
- Fetal engagement
- Fullness of maternal bladder

Fundus at the Umbilicus

- The uterine fundus is thought to reach the umbilicis at 20 weeks
- Assuming identical habitus in all women, however, symphysis to umbilicus distance varies from 11.5 to 19 cm

Auscultation of Fetal Heart Sounds

- First unamplified fetal heart tones
  - Range: 14 - 23 weeks
  - Mean ± SD: 17 ± 1.6 weeks

Multiple Clinical Parameters

- LMP plus additional parameters
- Commonly practiced but accuracy not rigorously tested

Ultrasound Assessment of Gestational Age

First Trimester Ultrasound

- More accurate than 2nd or 3rd trimester
  - Minimal biological variation in fetal size
- Landmarks
  - Gestational sac
    - Fluid-filled sac surrounded by bright echogenic ring (developing chorionic villi) within EM cavity
    - Not very reliable for GA assessment
  - Developing structures
    - Yolk sac ~5 weeks
    - Fetal pole with cardiac activity ~6 weeks
    - Limb buds ~8 weeks

Crown-Rump Length (CRL)

- Reported by Robinson in 1973 as an accurate means of determining GA
  - Fetus imaged in a longitudinal plane
  - Greatest embryonic length measured
  - Typically, three measurements should be taken and the average used for gestational age determination

Crown-Rump Length

Second Trimester Ultrasound

- Biometric parameters used to determine GA
  - Head circumference
  - Biparietal diameter
  - Femur length
  - Abdominal circumference
  - Others – foot length, ear size, orbital diameter, cerebellar diameter, etc

Head Circumference

- Measured in a plane perpendicular to the parietal bones and traverses the third ventricle and thalami
- Image should demonstrate smooth and symmetrical calvaria and the presence of a cavum septum pellucidum
- Calipers should be placed on the outer edges of the calvaria and a computer-generated ellipse should be adjusted to fit around the head without including the scalp

HC

Biparietal Diameter

- Image taken in same plane as HC
- Calipers placed on the outer edge of the proximal calvarium wall and on the inner edge of the distal calvarium wall

BPD

Femur Length

- Long axis of the femur should be aligned with the transducer measuring only the osseous portions of the diaphysis and metaphysis of the proximal femur
- While not included in the measurement, the proximal epiphyseal cartilage (future greater trochanter) and the distal femoral epiphyseal cartilage (future distal femoral condyle) should be visualized to assure that the entire osseous femur is measured without foreshortening or elongation

FL

Abdominal Circumference

Taken in a plane slightly superior to the umbilicus at the greatest transverse abdominal diameter with the liver, stomach, spleen and junction of the right and left portal veins visualized.

AC

How Accurate is Fetal Biometry in the Assessment of Fetal Age?

Objective

To assess the accuracy of fetal biometry performed in the midtrimester of pregnancy for the estimation of gestational age

Chervenak et al. AJOG 1998

Materials and Methods

- Retrospective cohort study
- Conception through *in vitro* fertilization at New York Weill Cornell Medical Center
- Second trimester US performed between 14 and 22 weeks' (day of fertilization + 14 days)
- Normal pregnancy outcome: delivery at > 37 weeks, birth weight > 2500g, no congenital anomalies
- Statistical methods: regression analysis

Ultrasound Examinations

- Fetal biometry: BPD, HC, AC, FL measured by standard landmarks. HC and AC computed using electronic caliper ellipse
- Ultrasound scans performed by one of five sonographers using Acuson 128 machines with 3.5 MHz and 5 MHz transabdominal transducers
- Only the first sonogram performed between 14 and 22 weeks utilized

Methods

- Best prediction equation was derived by using stepwise linear regression
- Accuracy of previously published formulae as well as newly derived regression formulae were compared
- Singleton formula was applied to twins and triplets

Definitions

- True GA= day of ovum retrieval and fertilization + 14 days
- Systematic error=average difference between estimated and true GA (mean dating error)
- Random error=residual standard deviation between estimated and true GA
- Accuracy=the root-mean square deviation (RMSD) between the true and estimated gestational ages

Study Population

Pregnancy	N
Singleton	152
Twin	67
Triplet	19

Singletons: Stepwise Multiple Linear Regression

Variable (mm)	Random error (days)	P
HC	3.8	<.00001
AC	4.0	<.00001
BPD	4.3	<.00001
FL	4.4	<.00001

Singletons: Stepwise Multiple Linear Regression

Variables (mm)	Random error (days)	P
HC + AC	3.4	<.00001
HC + FL	3.6	.00002
HC + AC+ FL	3.4	.0025

Gestational Age Assessment: HC vs BPD

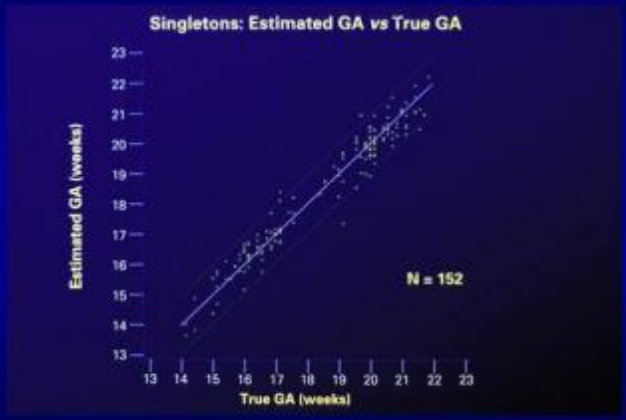
Variables (mm)	Random error (days)	P
HC BPD	3.8 4.3	<.00001
HC+AC BPD+AC	3.4 3.6	.0004
HC+FL BPD+FL	3.6 3.7	.0002
HC+AC+FL BPD+AC+FL	3.4 3.4	.02

Singleton Multiple Linear Regression

GA (days) =

51.68 + 2.324 x HC + 2.092 x AC + 5.18 x FL

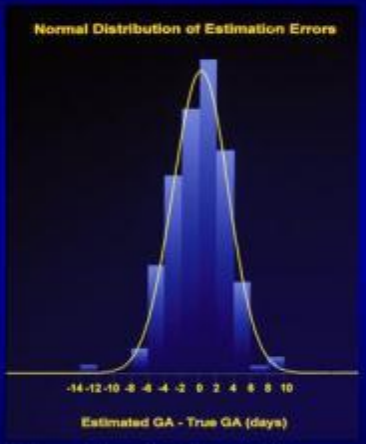
Relationship Between True and Estimated GA in Singletons



Solid line = perfect prediction
Dotted line = 95% confidence interval

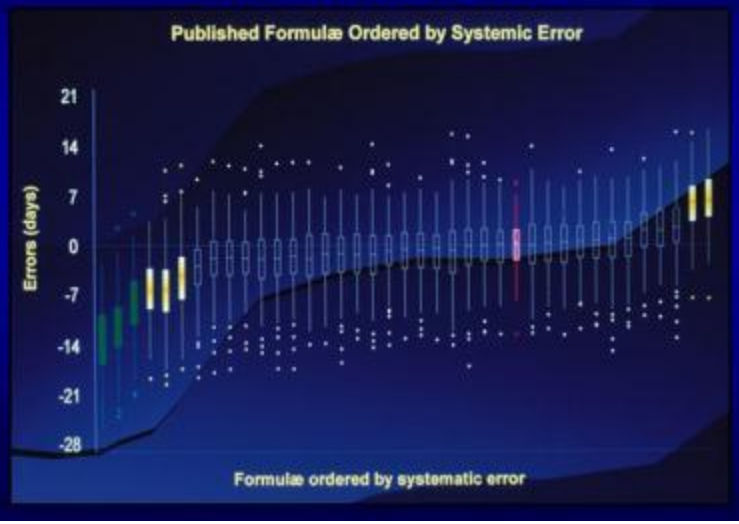
Prediction Errors

Normal distribution of discrepancy between estimated and true GA



*The absolute magnitude of the deviations between estimated and true gestational age was not correlated with true gestational age

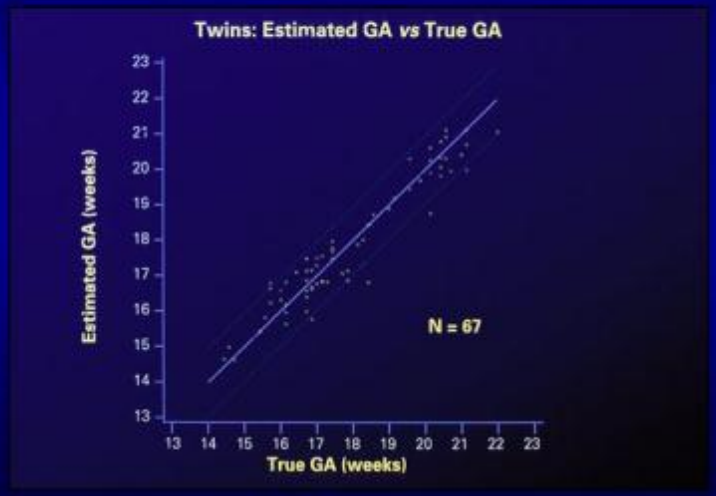
Published Formulae Ordered by Systematic Error



Singleton Multiple Linear Regression Formula Applied to Twins

Type of prediction	Mean (days)	SD
Maximum predicted GA	0.8	4.1
Minimum predicted GA	-1.3	3.9
Mean of Max and Min	-0.3	3.9
Max predicted – Min predicted	2.2	1.8

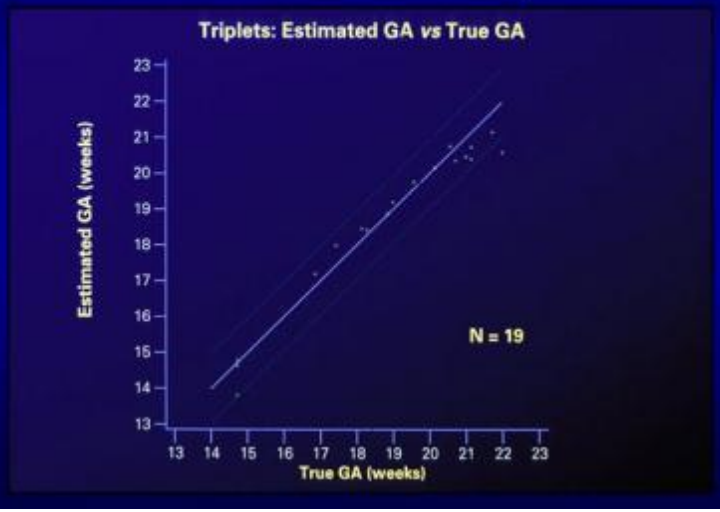
Relationship Between True and Estimated GA in Twins



Singleton Multiple Linear Regression Formula Applied to Triplets

Type of prediction	Mean (days)	SD
Maximum predicted GA	0.8	4.0
Minimum predicted GA	-3.4	3.5
Mean of Max and Min	-1.3	3.5
Max predicted – Min predicted	4.2	2.7

Relationship Between True and Estimated GA in Triplets



Accuracy of Gestational Age Prediction: Twins and Triplets (days)

	Systematic error	Random error (SD)
Singletons	-	3.4
Twins	-.03	3.9
Triplets	-1.3	3.5

Comparison of First and Second Trimester Ultrasound in the Assessment of Gestational Age

Kalish, Thaler, Chasen, Rosenwaks, Chervenak. AJOG 2004;in press.

Objective

To evaluate and compare the accuracy of first and second trimester ultrasound assessment of gestational age

Materials and Methods

- Retrospective cohort review
- Conceptions by *in vitro* fertilization at NY Weill Cornell Medical Center
- Differences between ultrasound estimated GA and true GA were calculated at 11-14 weeks and 18-22 weeks gestation
- True gestational age = day of ovum retrieval and fertilization + 14 days
- Pregnancies with fetal anomalies excluded

First Trimester Ultrasound Examinations

- All patients referred for a first trimester ultrasound for aneuploidy screening using NT
- Fetus visualized in a longitudinal plane
- Greatest embryonic length (CRL) of each fetus measured
- Transabdominal approach used in >90%
- Average of three CRL measurements used
- In multifetal pregnancies, the average of the fetuses used to estimate GA

Second Trimester Ultrasound Examinations

- Patients referred for a fetal anatomical survey between 18-22 weeks gestation
- Biometric formula included measurements of the HC, AC, BPD and FL

Ultrasound Examinations

- All ultrasound images performed by a registered sonographer and reviewed by a sonologist for accuracy
- Ultrasound images obtained with a 6MHz transabdominal transducer, with mulihertz and harmonic capability (Sequoia 512, Acuson)

Statistics

- Systematic error = "bias" the average discrepancy between the true and estimated GA
- Random error – "variability" the standard deviation of the discrepancies between estimated and true GA
- Absolute error = the average absolute value of the discrepancies between estimated and true GA
- Statistical significance of the systematic error for each trimester and of the difference in overall accuracy between trimesters was based on paired Student's t-tests

Study Population

	First trimester N	Second trimester N
Singletons	104	93
Twins	81	77
Triplets	33	32

Systematic Error

	First Trimester	Second Trimester
Singleton	+1.3 ± 0.2	-0.1 ± 0.4
Twin	+1.4 ± 0.2	-0.6 ± 0.3
Triplet	+0.8 ± 0.4	-0.6 ± 0.5

Random Error

	First Trimester	Second Trimester
Singleton	2.4	3.5
Twin	1.7	2.7
Triplet	2.1	2.8

Absolute Error

	First Trimester	Second Trimester	|Second| - |First|
Singletons	2.3 ± 0.1	2.8 ± 0.2	0.5 ± 0.3
Twins	1.8 ± 0.1	2.1 ± 0.2	0.3 ± 0.3
Triplets	1.7 ± 0.2	2.2 ± 0.3	0.5 ± 0.3

Overview

- First trimester estimates slightly overestimated GA
- Second trimester estimates slightly underestimated GA
- Absolute discrepancies between true and estimated GA improved in the first trimester
  - second trimester estimates had slightly greater variability (0.4 days on average)

Clinical Applications

- Ultrasound could determine fetal age to within less than 5 days in the first trimester and less than 7 days in the second trimester in more than 95% of cases

Third Trimester

- Accuracy/Reliability unclear
  - Doubilet and Benson found ≥ 3 weeks disparity in true and estimated GA
- Difficult to assess, as most 3rd trimester US exams are medically indicated

Frequently Asked Questions

Is ultrasound accurate in the assessment of fetal age?

First and second trimester estimates of gestational age have small systematic and random error components based on CRL measurements of biometry.

What is the most accurate 2nd trimester biometric parameter for the prediction of gestational age?

- HC is a better predictor of gestational age than AC, FL or BPD
- BPD does not further improve the prediction of GA
- BPD should not be used as the parameter of choice for pregnancy dating

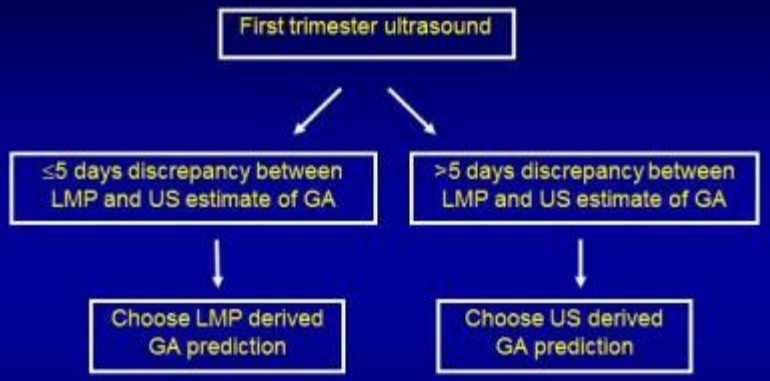
Do multiple parameters improve the accuracy of gestational age estimation?

Adding AC and FL improved the prediction by 0.4 days, yielding a random prediction error of 3.4 days.

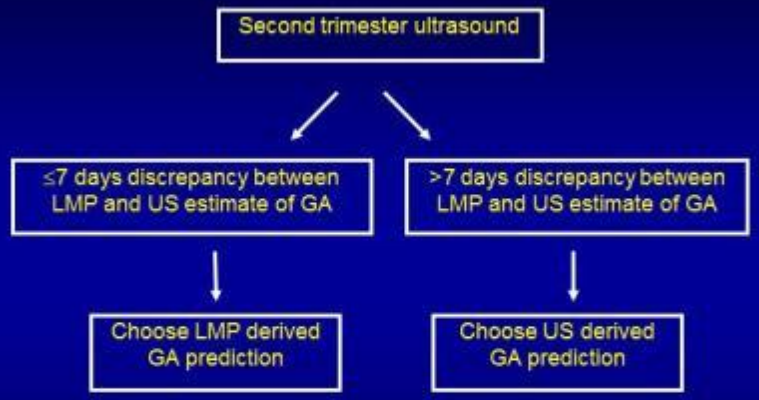
How does the accuracy of first trimester ultrasound compare with second trimester ultrasound in the assessment of gestational age?

- First trimester ultrasound has marginally better accuracy compared to second
- The overall magnitude of the difference in accuracy was less than one day on average

How should discrepancies between gestational age assessment based on the last menstrual period and fetal biometry be resolved?



Between 11-14 weeks, biometric prediction should be given preference when there is a discrepancy > 5 days (2SD) between biometric and LMP prediction



Between 14-22 weeks, biometric prediction should be given preference when there is a discrepancy >7 days (2SD) between biometric and LMP prediction

Should fetal age assessed by ultrasound be reassigned based on a subsequent ultrasound examination?

No. The inaccuracy of ultrasound dating increases with advancing gestational age

How applicable are gestational age prediction formulae between populations and institutions?

- Thirty of 38 formulae gave predictions with a systematic error < 4 days
- Only three of 38 had a systematic error > 7 days

Can a dating formula derived from singleton gestations be applied to multifetal gestations?

Yes. An equation derived from a singleton population can be applied to twins by averaging the two gestational age predictions

Conclusions

- Ultrasound is an accurate means of estimating gestational age in the first and second trimesters of pregnancy
  - First trimester
    - CRL
  - Second trimester
    - HC - better predictor than AC, FL, BPD alone
    - Multiple parameters improve the prediction error

Conclusions

An equation derived from a singleton population can be applied to multifetal and has similar accuracy to ultrasound dating of singletons in both the first and second trimester.

Conclusions

- Biometric prediction should be given preference when a discrepancy > 5 days (2SD) between biometric and LMP prediction is present in the first trimester
- Biometric prediction should be given preference when a discrepancy > 7 days (2SD) between biometric and LMP prediction is present in the second trimester

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