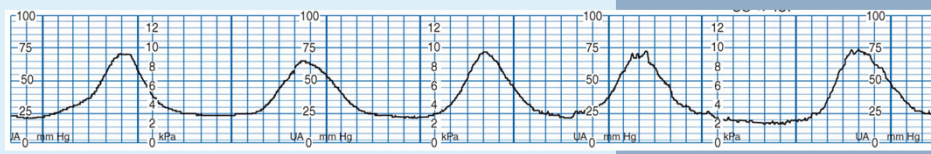




Physiologic Logic:

Fetal Acid-Base, Uterine Acid Base, and Safer Labor Practices

with Lisa A. Miller, CNM, JD



Today's Objectives

1. Discuss current trends in litigation involving labor management
2. Define the components of a complete evaluation of uterine activity during labor
3. Identify the relationships between uterine activity and fetal acid-base and uterine muscle acid-base
4. Discuss the association of elevated amniotic fluid lactate (AFL) and labor outcomes

Litigation in obstetrics

40% of OB claims involve allegations related to management of labor.

80% of OB claims are high-severity* and 24% resulted in death of the baby, mother, or both.

52% of OB claims involve vaginal deliveries (7% higher than claims involving cesarean sections).

*High-severity injury includes National Association of Insurance Commissioners (NAIC) injury codes = 6,7,8,9

A DOSE OF INSIGHT®: MATERNAL/FETAL RISKS: USING CLAIMS ANALYSIS TO IMPROVE OUTCOMES

2018

Litigation in Obstetrics

Management of Labor

40% of claims
49% of indemnity paid

Risks include failure to:

- Recognize and act on nonreassuring fetal heart tracings.
- Abandon attempts at vaginal birth or a trial of labor after cesarean section (TOLAC) in favor of cesarean section.
- Manage induction and augmentation of labor in response to clinical findings.
- Monitor mother/fetus during administration of high-risk medications (e.g., oxytocin and magnesium sulfate).
- Recognize and act on obstetric emergencies.
- Provide deep vein thrombosis (DVT) and pulmonary embolism (PE) prophylaxis.
- Communicate and document clinical information, risk factors, and informed consent/refusal.

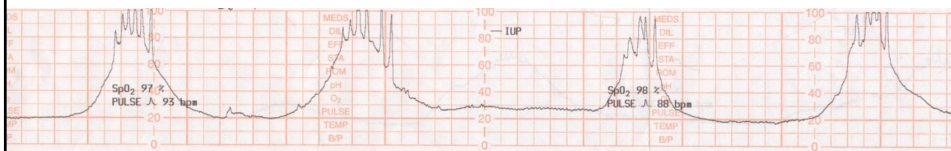
A DOSE OF INSIGHT®: MATERNAL/FETAL RISKS: USING CLAIMS ANALYSIS TO IMPROVE OUTCOMES

2018

Uterine Activity - Deconstructed

Three steps to ensuring a shared mental model:

1. Definitions; components for evaluation
2. Understanding core physiologic principles
3. Evidence-based labor support/management



crico

892 cases | \$486M total incurred

Clinical judgment issues are the most prevalent contributing factor in obstetrics-related cases.

FACTOR	% CASES*
Clinical Judgment	71%
Communication	32%
Technical Skill	30%
Documentation	20%
Clinical Environment	17%
Administrative	16%
Behavior-related	16%

TOP CLINICAL JUDGMENT FACTORS	% CASES*
Selection/management therapy—labor and delivery	44%
Patient assessment—misinterpretation of dx studies (X-rays, slides, films)	12%
Selection/management therapy—pregnancy	11%
Patient monitoring—physiological status (other than medical response)	10%

TOP COMMUNICATION FACTORS	% CASES*
Communication—regarding patient's condition	15%
Communication—patient/family & provider—other	5%
Communication—patient/family & provider—language barrier	4%

TOP TECHNICAL SKILL FACTORS	% CASES*
Technical performance—known possible complication	15%
Technical performance—poor technique, other	6%
Retained foreign body	3%

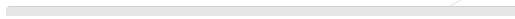
*A case will often have multiple factors identified.

N=892 MPL cases asserted 1/1/10–12/31/14 with Obstetrics, OB hospitalist, or Midwifery as the primary responsible service and with an Obstetrics-related major allegation.

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Tachysystole...

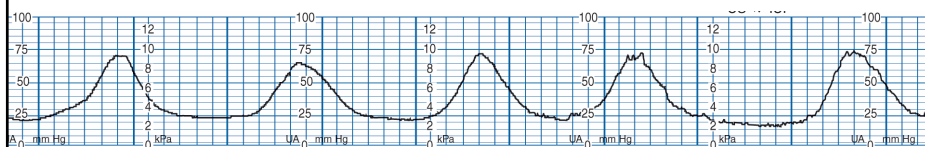
1. Is defined as >6 contractions in 10 minutes, averaged over a 30 min. window
2. Requires abnormal FHR changes before clinical response
3. Requires an IUPC to correctly diagnose
4. Applies to spontaneous as well as stimulated labor
5. Is significant only with Category II or III tracings.



Definitions - Frequency

Number of contractions in a 10 minute period.

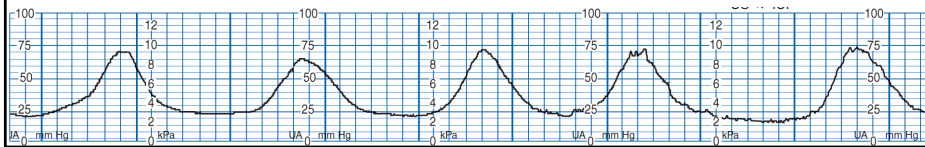
Contraction frequency overall generally ranges from 2 to 5 per 10 minutes during labor, with lower frequencies seen in the first stage of labor and higher frequencies seen during the second stage of labor.



Definitions - Duration

Time from the onset of a contraction to the offset, measured from the baseline resting tone.

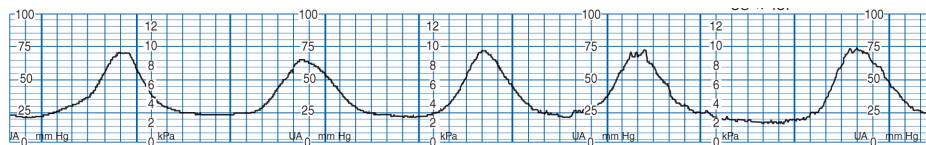
Contraction duration remains fairly stable throughout the first and second stages, ranging from 45 to 80 seconds, not generally exceeding 90 seconds.



Definitions - Intensity

The peak of the contraction less the resting tone. Intensity of uterine contractions generally range from 25-50 mm Hg in the first stage of labor and may rise to over 80 mm Hg in second stage.

It is commonly accepted in clinical practice that contractions palpated as “mild” would likely peak at less than 50 mm Hg if measured internally, whereas contractions palpated as “moderate” or greater would likely peak at 50 mm Hg or greater if measured internally.

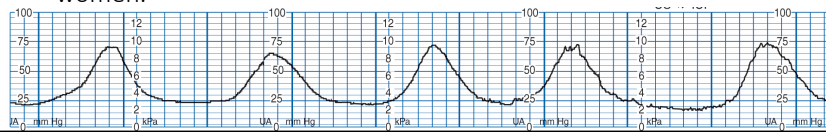


Definitions – Montevideo units (MVUs)

The average intensity of contractions in mmHg multiplied by the number of contractions in a ten-minute window. MVUs range from 100 to 250 in the first stage, may rise to 300 to 400 in the second stage.

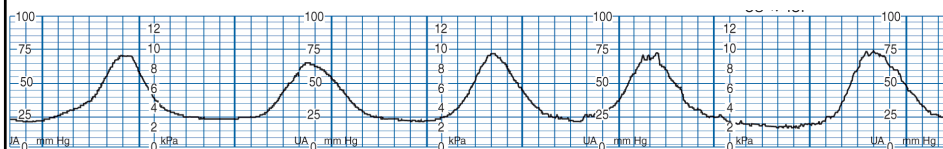
Contraction intensities of 40 mmHg or more and MVUs of 80 to 120 are generally sufficient to initiate spontaneous labor. “Adequate” uterine activity during active labor has been defined as greater than 200 Montevideo units (MVUs)

According to Caldyro-Barcia’s work, normal labor that is spontaneous is generally less than 280 MVUs, although there is wide variation among women.



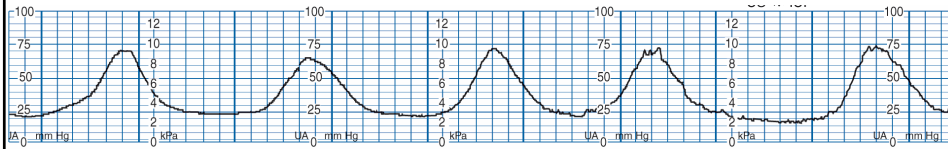
Definitions – Relaxation time

Time from the end of one contraction to the beginning of the next. *Not to be confused with resting tone.* In first stage, an average relaxation time of 60 seconds is considered normal, whereas an average of 45 seconds relaxation time is normal in second stage as contraction frequency increases.



Definitions – Resting Tone

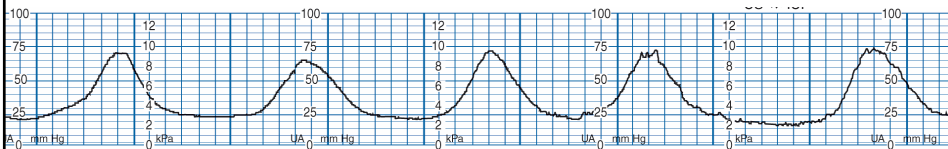
The intrauterine pressure when the uterus is not contractile. Average resting tone during labor is 10 mm Hg; if using palpation, should palpate as “soft”, i.e., easily indented, no palpable resistance. Increased uterine resting tone is called hypertonus and is usually defined as a resting tone exceeding 20-25 mm Hg, or a uterus that does not palpate as soft if using palpation.



NICHD Summary Terms

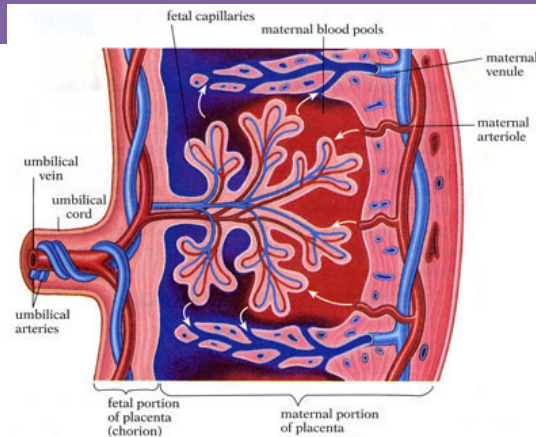
The NICHD published two summary terms related to uterine contraction frequency. Contraction frequency is considered **normal** when there are ≤ 5 contractions in 10 minutes, averaged over a 30 minute window. If there are > 5 contractions in 10 minutes, averaged over a 30 minute window, it is called **tachysystole**.

Tachysystole includes spontaneous and stimulated uterine contractions, and should be qualified as to the presence or absence of fetal heart rate decelerations.



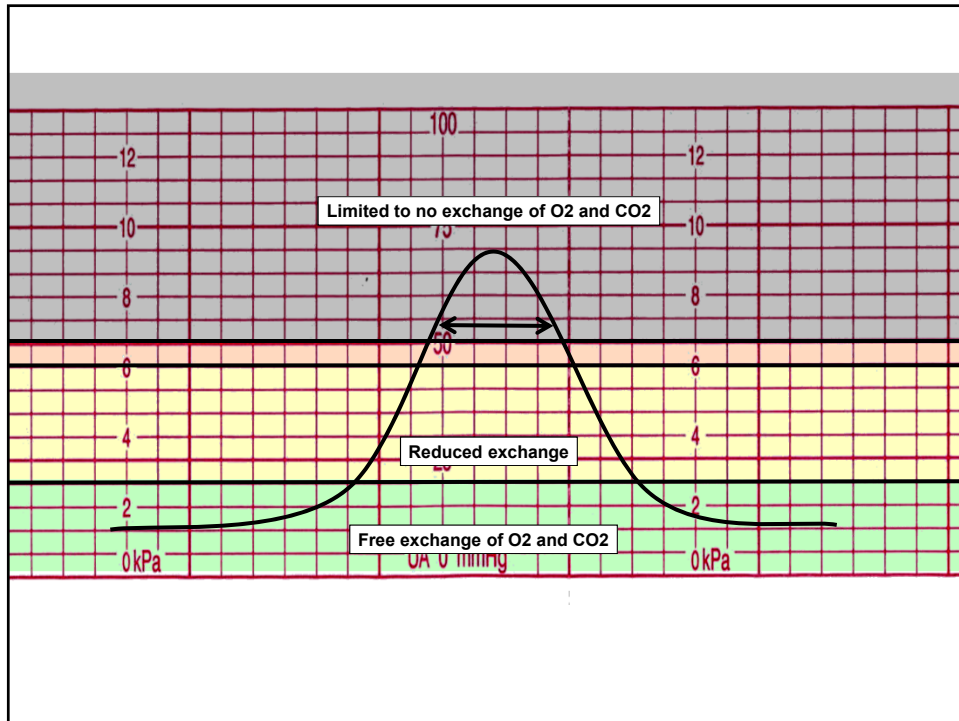
Uteroplacental

- 700-800 ml of blood (10-15% of maternal cardiac output) perfuses the uterus each minute, 70-90% of this passes through the intervillous space
- Dependent upon maternal blood pressure



Factors that affect uterine blood flow

- Uterine contractions
- Hypertonus (abruption, tetany, pitocin)
- Hypotension (epidural block, supine position, hypovolemic shock)
- Hypertension (chronic, PIH)
- Vasoconstriction, endogenous (sympathetic discharge)
- Vasoconstrictors, exogenous



Effect of uterine activity on base deficit during labor

- From labor onset to about 4cm, contractions have minimal effect on base deficit
- From 4cm to complete dilation, the mean base deficit will increase by approximately 1mmol/L every 3 hours, due to an increase in the frequency and intensity of UCs
- In second stage, with the increase in both strength and frequency and the additional pushing efforts, base deficit will increase by 1mmol/L every hour

Ross MG, Gala R. Use of umbilical artery base excess: algorithm for the timing of hypoxic injury. *American Journal of Obstetrics & Gynecology*. 2002 Jul 1;187(1):1-9.



So, what can we do to protect our patients and ourselves?

- Shift focus to attaining adequate uterine activity vs. avoiding tachysystole
- Agree on physiologically sound guidelines for appropriate uterine activity (recall differences in labor)
- Be vigilant about FHR changes and look for early signs of interrupted oxygenation
- Understand the application of partograms and various labor curves, one size does not fit all!
- Keep up with the literature and share info with colleagues

“6 is the New 4” – Evaluation of Labor

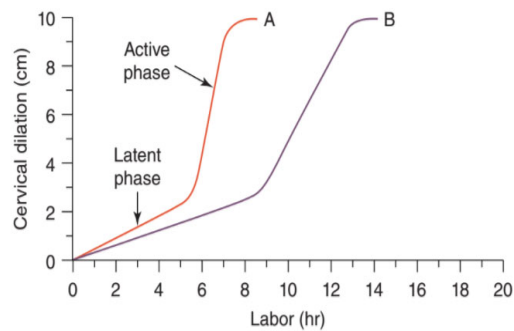
- There is no doubt we should be doing everything we can to reduce the C-section rate, and there is also no doubt that re-evaluation of labor curves and labor progress is a key component in meeting this goal
- Unfortunately, the mantra “6 is the new 4” is something of an oversimplification, and the lack of knowledge regarding labor progress and evaluation of labor is endemic among even the most experienced clinicians.

PROLONGED LATENT PHASE IS...

1. Greater than 12 hours regardless of parity
2. 20 hours or more in a multiparous woman
3. 25 hours or more in a nulliparous woman
4. 14 hours or more in a multiparous woman

Active Phase of First Stage

The traditional Friedman curve showed a point of inflection for nulliparous women occurring at approximately 3-4 centimeters dilation



The first stage of labor: Friedman curve. A, Multipara. B, Nullipara.

Obstetrics & Gynecology, 2010

Labor Curves

- Revealed longer latent phases, with a less clear point of inflection that is closer to 6cm
- No real deceleration phase was seen
- Proper use requires understanding of the median versus 95th percentile
- Only applies to patients in spontaneous labor, should not be used with inductions

Contemporary Patterns of Spontaneous Labor With Normal Neonatal Outcomes

Jun Zhang, MD, MS, Helain J. Leidy, MD, D. Ware Branch, MD, Ronald Berkman, MD, Shoshana Hakeman, MD, PhD, Kimberly D. Gregory, MD, MPH, Christine G. Hogg, MD, Mildred M. Ramirez, MD, Jennifer L. Bailit, MD, MPH, Victor H. Gonzalez-Quintero, MD, MPH, Judith U. Hibbard, MD, Matthew K. Hoffman, MD, MPH, Michelle Komisaruk, MD, Lee A. Leeman, MD, PhD, Paul Van Veldhuisen, MD, James Tronkle, MD, and Uma M. Reddy, MD, MPH, for the Consortium on Safe Labor

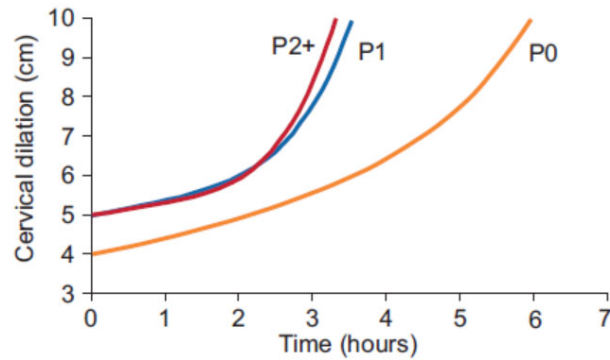


Fig. 2. Average labor curves by parity in singleton term pregnancies with spontaneous onset of labor, vaginal delivery, and normal neonatal outcomes. P0, nulliparous women; P1, women of parity 1; P2+, women of parity 2 or higher.

Zhang. Contemporary Labor Patterns. Obstet Gynecol 2010.

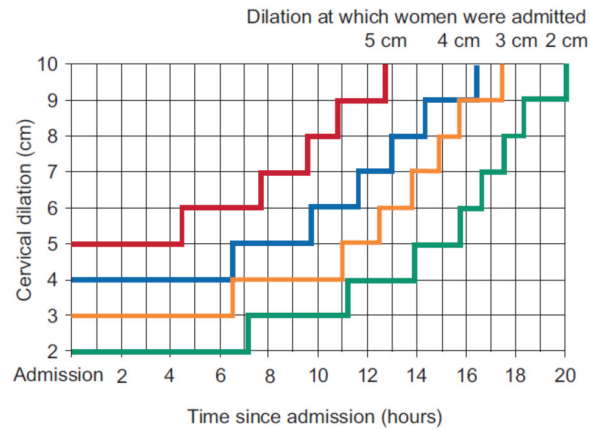
Crucial to reducing primary cesarean in the nulliparous patient – *clinician and patient* understanding of normal versus prolonged parameters in labor

Table 3. Duration of Labor in Hours in Nulliparous Women With Spontaneous Onset of Labor

Cervical Dilation (cm)	Admitted at 2 or 2.5 cm (n=4,247)	Admitted at 3 or 3.5 cm (n=6,096)	Admitted at 4 or 4.5 cm (n=5,550)	Admitted at 5 or 5.5 cm (n=2,764)
Admitted to 3	0.9 (7.1)	NA	NA	NA
Admitted to 4	3.2 (11.2)	1.0 (6.5)	NA	NA
Admitted to 5	5.0 (13.9)	2.9 (11.0)	0.9 (6.5)	NA
Admitted to 6	6.0 (15.7)	4.2 (12.5)	2.2 (9.7)	0.6 (4.5)
Admitted to 7	6.6 (16.6)	5.0 (13.8)	3.2 (11.6)	1.5 (7.7)
Admitted to 8	7.1 (17.5)	5.6 (14.9)	3.9 (13.0)	2.4 (9.6)
Admitted to 9	7.6 (18.3)	6.1 (15.7)	4.5 (14.3)	3.0 (10.8)
Admitted to 10	8.4 (20.0)	6.9 (17.4)	5.3 (16.4)	3.8 (12.7)

NA, not applicable.
Data are median (95th percentile).

Using newer labor data, we can create individualized labor assessments



But Zhang and colleagues looked at term nulliparous women in spontaneous labor, can we apply the same labor progress curves to nulliparas being induced?

Obstetrics & Gynecology 2012

Labor Curves

- Significant differences between spontaneous versus induced labor for both nullips and multips
- Also showed a point of inflection closer to 6cm, but longer latent phases
- Effects of parity lessened in induced labors

Normal Progress of Induced Labor

Lorie M. Harper, MD, MSCI, Aaron B. Caughey, MD, PhD, Anthony O. Odibo, MD, MSCE, Kimberly A. Roehl, MPH, Qizhong Zhao, MS, and Alison G. Cahill, MD, MSCI

Note the significant differences between spontaneous (yellow and green lines) versus induced labor (red and blue lines).

Effect of parity appears more pronounced in spontaneous labor versus induced labor

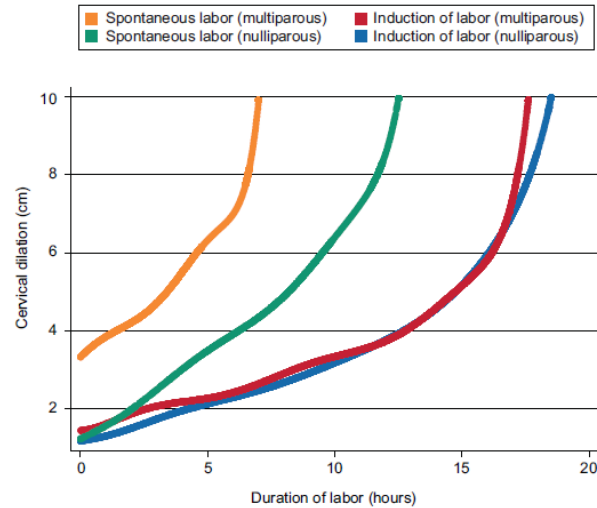


Fig. 1. Average labor curves stratified by parity and type of labor onset.

Harper. Normal Labor in Induction. Obstet Gynecol 2012.

Obstetrics & Gynecology 2012

Labor Curves

- Curves showed both a longer durations and slower progression during first stage of labor for women with BMIs of 30 or higher
- Effect was even more pronounced when BMI was over 40
- Elevated BMI must be considered when assessing labor progress

The Effects of Obesity on the First Stage of Labor

Shayna M. Norman, MD, Methodius G. Twuli, MD, MPH, Anthony O. Odibo, MD, MSc, Aaron B. Caughey, MD, PhD, Kimberly A. Roehl, MPH, and Alison G. Cahill, MD, MSc

BMIs of 30-40 and greater than 40 were associated with a significantly longer first stage of labor, though velocity of labor after 6cm was unaffected by BMI

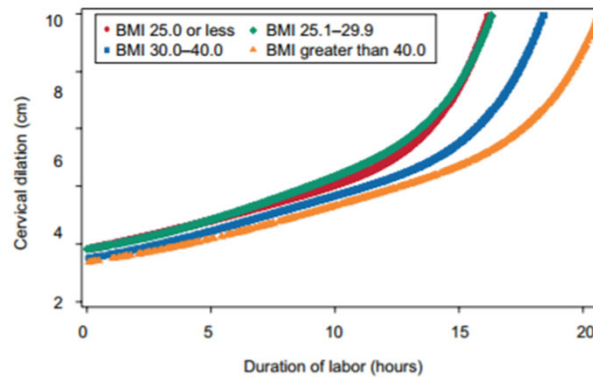


Fig. 3. Labor curve for nulliparous women stratified by body mass index (BMI).

Norman. *Effect of Obesity on the Labor Curve.* *Obstet Gynecol* 2012.

NICHD publication on Failed IOL

Defining failed induction of labor



William A. Grobman, MD, MBA; Jennifer Bailit, MD, MPH; Yinglei Lai, PhD; Uma M. Reddy, MD, MPH; Ronald J. Wapner, MD; Michael W. Varner, MD; John M. Thorp Jr, MD; Kenneth J. Leveno, MD; Steve N. Caritis, MD; Mona Prasad, DO; Alan T. N. Tita, MD, PhD; George Saade, MD; Yoram Sorokin, MD; Dwight J. Rouse, MD; Sean C. Blackwell, MD; Jorge E. Tolosa, MD, MSCE; for the Eunice Kennedy Shriver National Institute of Child Health and Human Development Maternal-Fetal Medicine Units Network

BACKGROUND: While there are well-accepted standards for the diagnosis of arrested active-phase labor, the definition of a "failed" induction of labor remains less certain. One approach to diagnosing a failed induction is based on the duration of the latent phase. However, a standard for the minimum duration that the latent phase of a labor induction should continue, absent acute maternal or fetal indications for cesarean delivery, remains lacking.

OBJECTIVE: The objective of this study was to determine the frequency of adverse maternal and perinatal outcomes as a function of the duration of the latent phase among nulliparous women undergoing labor induction.

STUDY DESIGN: This study is based on data from an obstetric cohort of women delivering at 25 US hospitals from 2008 through 2011. Nulliparous women who had a term singleton gestation in the cephalic presentation were eligible for this analysis if they underwent a labor induction. Consistent with prior studies, the latent phase was determined to begin once cervical ripening had ended, oxytocin was initiated, and rupture of membranes had occurred, and was determined to end once 5-cm dilation was achieved. The frequencies of cesarean delivery, as well as of adverse maternal (eg, postpartum hemorrhage, chorioamnionitis) and perinatal (eg, a composite frequency of seizures, sepsis, bone or nerve injury, encephalopathy, or death) outcomes, were compared as a function of the duration of the latent phase (analyzed with time both as a continuous measure and categorized in 3-hour increments).

RESULTS: A total of 10,677 women were available for analysis. In the vast majority (96.4%) of women, the active phase had been reached by 15 hours. The longer the duration of a woman's latent phase, the greater her chance of ultimately undergoing a cesarean delivery ($P < .001$, for time both as a continuous and categorical independent variable), although >40% of women whose latent phase lasted ≥ 18 hours still had a vaginal delivery. Several maternal morbidities, such as postpartum hemorrhage ($P < .001$) and chorioamnionitis ($P < .001$), increased in frequency as the length of latent phase increased. Conversely, the frequencies of most adverse perinatal outcomes were statistically stable over time.

CONCLUSION: The large majority of women undergoing labor induction will have entered the active phase by 15 hours after oxytocin has started and rupture of membranes has occurred. Maternal adverse outcomes become statistically more frequent with greater time in the latent phase, although the absolute increase in frequency is relatively small. These data suggest that cesarean delivery should not be undertaken during the latent phase prior to at least 15 hours after oxytocin and rupture of membranes have occurred. The decision to continue labor beyond this point should be individualized, and may take into account factors such as other evidence of labor progress.

Key words: labor induction, latent phase, outcomes

Grobman WA, Bailit J, Lai Y, et al. Defining failed induction of labor. *Am J Obstet Gynecol* 2018;218:122.e1-8.

- The study looked at 10,677 nulliparas with singletons at 37 or greater weeks gestation, with vertex presentation undergoing induction of labor
- The latent phase of labor in the setting of induction was defined to begin once any cervical ripening had been completed (ie, when it was no longer used), oxytocin had begun, and ROM (either spontaneously or artificially) had occurred.
- Latent phase labor was defined to end once at least 5-cm dilation had been reached (or if cesarean occurred before that dilation).

TABLE 2
Proportion of women no longer in latent phase after initiation of labor induction

Latent phase, h	N	%	Cumulative %
0–2.9	3523	33.0	33.0
3–5.9	3470	32.5	65.5
6–8.9	1997	18.7	84.2
9–11.9	921	8.6	92.8
12–14.9	380	3.6	96.4
15–17.9	192	1.8	98.2
≥18	194	1.8	100.0

Women at least 5 cm (or who had cesarean within given time interval) after cervical ripening had been completed, oxytocin had begun, and rupture of membranes (either spontaneously or artificially) had occurred.
Grobman et al. Defining failed induction of labor. Am J Obstet Gynecol 2018.

Grobman WA, Bailit J, Lai Y, et al. Defining failed induction of labor. Am J Obstet Gynecol 2018;218:122.e1-8.

Conclusion

“The large majority of women undergoing labor induction will have entered the active phase by 15 hours after oxytocin has started and rupture of membranes has occurred. Maternal adverse outcomes become statistically more frequent with greater time in the latent phase, although the absolute increase in frequency is relatively small.

These data suggest that cesarean delivery should not be undertaken during the latent phase prior to at least 15 hours after oxytocin and rupture of membranes have occurred. The decision to continue labor beyond this point should be individualized, and may take into account factors such as other evidence of labor progress.”

Grobman WA, Bailit J, Lai Y, et al. Defining failed induction of labor. Am J Obstet Gynecol 2018;218:122.e1-8.

RECOMMENDATIONS

Individualize

Individualize evaluation of labor for each woman, considering parity, BMI, and whether labor is induced, augmented, or spontaneous

Ensure

Ensure that clinicians understand the difference between a mean or median and the 95th percentile when utilizing labor curves

Recognize

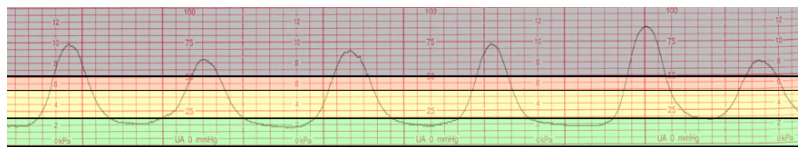
Recognize the value of informed consent and the rights of the pregnant person to be a fully informed decision-maker regarding induction, augmentation and labor progress assessment/intervention



WHAT'S
NEW
WHAT'S
NEXT

Amniotic fluid lactate (AFL)

- As the uterus contracts during labor, blood flow to the uterine muscle is temporarily decreased/blocked due to compression of the spiral arteries. This results in brief periods of anaerobic activity in uterine muscle and is part of the normal labor process.
- During relaxation time, oxygenated blood flow returns and metabolites such as lactate are cleared.
- Several studies have demonstrated a close correlation between high levels of amniotic fluid lactate (AFL) and arrested labor progress with an increased frequency of operative intervention such as vacuum, forceps, and cesarean delivery.
- These same studies have revealed that when AFL levels are normal and labor progress is arrested or slowed, uterine muscle is receptive to oxytocin stimulation as an intervention.
- High AFL levels have also been shown to be closely associated with complications postpartum complications including postpartum hemorrhage and postpartum infections.



Amniotic fluid lactate (AFL)

Acta Obstetrica et Gynecologica. 2008; 87: 924-928

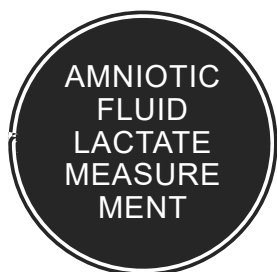
informa
healthcare

Table II. Association between one or two consecutive high lactate concentrations measured in AF and operative delivery due to dystocia. Values are expressed as Odds Ratios (OR) with corresponding 95% confidence intervals (CI), using logistic regression.

Explanatory	n (%)	Univariable OR (95%CI)	Multivariable** OR (95%CI)
One lactate sample >10.1mmol/l			
No	3/18 (17)	Reference	Reference
Yes	28/36 (78)	17.5 (4.0-75.9)	14.5 (3.2-69.3)
At least two consecutive samples >10.1mmol/l			
No	6/25 (24)	Reference	Reference
Yes	25/29 (86)	19.1 (4.7-77.8)	21.4 (4.4-104.0)

**Adjusted for parity.

Showed an association between elevated AFL and "dysfunctional labor" which was defined as operative vaginal delivery or cesarean due to dystocia.



RESEARCH ARTICLE

Lactate in Amniotic Fluid: Predictor of Labor Outcome in Oxytocin-Augmented Primiparas' Deliveries

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OPEN ACCESS

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Abstract

Background

One of the major complications related to delivery is labor dystocia, or an arrested labor progress. Many dystocic deliveries end vaginally after administration of oxytocin, but a

Table 4. Associations between possible risk factors and the risk of an operative intervention. Values are expressed as Odds Ratio (OR) with corresponding 95% confidence intervals (CI). (n = 638).

<i>Risk factors for operative intervention during delivery</i>	OR unadjusted(95% CI)	OR adjusted (95% CI)
Maternal age: < 30 years vs. >30 years**	1.9 (1.3 to 2.7) *	1.7 (1.1 to 2.7) *
Maternal education: Low ^ vs. High^^**	2.4 (1.5 to 3.7)	0.8 (0.4 to 1.5)
Gestational age: <41+0 weeks vs. >41+0 weeks**	1.9 (1.3 to 2.9) *	1.8 (1.1 to 3.0)
Fetal presentation: Anterior vs. Posterior	11.6 (5.5 to 24.6) *	9.6 (4.2 to 21.9) *
Latent phase: <15h vs. >15h	1.8 (1.2 to 2.7)	1.5 (0.9 to 2.5)
Arrested labor progress according to the partogram: No vs. Yes	1.9 (1.3 to 3.0) *	1.7 (1.0 to 3.1)
Epidural anesthesia: No vs Yes	3.4 (2.3 to 5.1) *	1.8 (1.1 to 3.1) *
AFL > 10.1 mmol/l when oxytocin was initiated: No vs. Yes	5.2 (3.2 to 8.4) *	4.5 (2.6 to 8.1) *
Countries: Sweden vs. Switzerland vs. Tanzania vs France	2.3 (1.4 to 4.0) * vs. 0.2 (0.1 to 0.5) * vs. 1.5 (0.6 to 4.0)	4.2 (2.2 to 8.2) * vs. 0.3 (0.1 to 5.1) vs. 1.7 (0.6 to 5.1)

Adjusted odds ratio for operative intervention was highest for OP presentation and high AFL values

Implications for practice

- Clearly, a physiologic approach to labor and labor management is key to reducing the cesarean rate as well as reducing postpartum complications.
- AFL evaluation is one method to objectively evaluate uterine muscle function during labor and can aid clinicians in appropriate use of oxytocin during prolonged or arrested labors.
- Measuring AFL can also assist clinicians in anticipating risk for certain postpartum complications associated with significant maternal morbidity/mortality.

Closing thoughts...

Liability in the intrapartum setting continues to be a significant issue, and reflects medical and nursing error leading to poor outcomes in over 50% of cases

Knowledge gaps related to core physiology of FHR, labor, and labor progress is significant and must be addressed

Multidisciplinary training with a focus on shared mental models is key to reducing error and improving outcomes

