Chapter 1

Normal Labor

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Introduction

Term labor begins as result of complex signaling cascade between the mother, placenta, and fetus. Labor is the process by which uterine contractions result in progressive cervical dilation and delivery of the fetus. The inciting event for human labor remains unclear. Human labor is influenced by maternal, fetal, and placental hormones, which alter myometrial responsiveness and facilitate organized uterine contractions in response to oxytocin, prostaglandins, and inflammatory mediators.[1–3] The first stage of labor is characterized by two phases: the latent phase and the active phase. The latent phase of labor has a slower rate of dilation. An evaluation of contemporary labor management challenges our historical understanding of labor progress and indicates that the transition from the latent phase to active phase occurs at a more advanced cervical dilation than previously thought. The duration of labor can be influenced by maternal factors, fetal factors, and labor practices. This chapter will review labor physiology, present a description of labor mechanics, and review contemporary evidence to support normal labor progress.

Scope of the Problem

Why is it important to understand normal labor? Successful inpatient management of women in labor depends upon the obstetric provider's ability to recognize normal labor from abnormal labor and above all "to do no harm" should there be a need for medical intervention. In 2014, the combined primary and repeat cesarean section rate for the United States averaged 32.2%.[4] The primary cesarean section rate for term nulliparous low-risk women with a singleton vertex fetus averaged 26%.[4] Evidence describes significant variability for the primary cesarean section rate at the state and hospital level. In 2009, the primary cesarean section rate for nulliparous term low-risk women ranged from 2.4% to 36.5% depending upon hospital type and location.[5] Regional practice patterns, patient demographics, hospital characteristics, and local resources can influence clinical decision making with regard to the route of delivery.[6] A basic understanding of normal labor is important in order to deliver safe healthcare to our patients and minimize the risk of adverse outcomes for mother and baby.

Labor Hormonal Physiology

Activation of the fetal hypothalamic pituitary axis, progesterone withdrawal, and estradiol synthesis have each been identified as the triggering mechanism for labor in several species. [7] In humans, however, the identification of one inciting event for term labor remains controversial. Corticotropin-releasing hormone (CRH), estradiol precursors, progesterone, and prostaglandins are all believed to play an important role in facilitating myometrial contractility.[1–3,8]

In humans, the fetal hypothalamic pituitary axis is activated by placental production of CRH. CRH stimulates the production of dehydroepiandrostenedione (DHEAS) by the fetal adrenal gland, which is subsequently converted by the placenta to estradiol and estriol. The estrogen precursors, in turn, promote transcription of gap junction proteins and receptors for oxytocin, PGF2α, and PGE_2.[7–9] Unlike other species, human concentrations of progesterone remain stable toward the end of pregnancy and there is no evidence of a decline near term.[7,8,10,11] There is, however, evidence in humans that labor is associated with increased expression of myometrial and amniotic fluid membrane progesterone receptor isoforms, which increase intracellular calcium and transcription of contraction associated proteins.

In humans, myometrial prostaglandin receptors are upregulated toward the latter half of pregnancy.[8]

Prostaglandins directly enhance uterine contractility by increasing the intracellular calcium concentration. Prostaglandins stimulate the release of calcium from the sarcoplasmic reticulum and promote the influx of extracellular calcium into cells via activation of transmembrane calcium channels.[1,2,7,8]

A review of the hormonal mediators of labor would be incomplete without a brief review of oxytocin and its mechanism of action. Oxytocin is a polypeptide of hypothalamic origin, which is stored and released intermittently from the posterior pituitary. Oxytocin is secreted in a pulsatile fashion and undergoes hepatic and renal degradation. During pregnancy, it is inactivated by placental oxytocinase. There is evidence that the maternal oxytocin concentration remains relatively unchanged during the antepartum period; however, maternal oxytocin concentrations increase during the second stage of labor.[12–14] Near term, there is an increase in myometrial responsiveness to oxytocin, which is largely mediated by an increase in the number of oxytocin receptors, their distribution within the myometrium, and relative affinity to oxytocin. The number of oxytocin receptors has been demonstrated to increase 100- to 200-fold during pregnancy with a peak concentration in early labor.[12,15,16] Evidence shows a greater number and distribution of oxytocin receptors within the uterine fundus compared to the lower uterine segment.[12] Receptor sensitivity to oxytocin also increases near term. High-affinity oxytocin receptors have been identified in the decidua and amnion. It is postulated that receptor activation in these tissues may play a role in the production of prostaglandins, which also promote uterine contractility.[12,15] Oxytocin is a potent uterotonic agent capable of stimulating uterine contractions with concentrations as low as 1–2 mIU/min.[15] Higher doses may be required, however, in order to generate contractions of sufficient frequency and intensity to facilitate cervical dilation. Intravenous oxytocin is rapidly degraded and has a biologic half-life of 3–4 min.

Labor Mechanics

Successful labor depends upon many factors. The three most important of which are the uterus, the fetus, and the pelvis. A popular mnemonic to describe these three is the "power," "passenger," and "pelvis."[17] Alterations in any of these variables can affect the duration of labor and its success.

Power

Uterus

Uterine contractions may be characterized by their frequency, intensity, and duration. Objective methods of assessing uterine activity include direct palpation, measurement via external tocodynamometer, and measurement through an intrauterine pressure catheter (IUPC). Direct palpation can be used to estimate frequency and duration of contractions although it is less exact with regard to duration and intensity compared to the external tocodynamometer. The external tocodynamometer measures changes in abdominal wall tension, which can occur as a result of uterine contractions, maternal repositioning, fetal movement, or increased intra-abdominal pressure due to maternal factors such as coughing or laughter. Uterine contractions produce a slow increase in abdominal wall tension, which will peak and then return to baseline. Neither external tocodynamometer nor palpation will permit an assessment of baseline uterine tone or contraction intensity. An IUPC provides the most accurate evaluation of uterine tone, contraction intensity, and contraction frequency. Because the IUPC must traverse the vagina and cervix prior to intrauterine placement, its use is associated with a theoretical risk of ascending infection. In randomized controlled trials (RCTs) of internal and external monitor use, internal monitors were not associated with a significant reduction in cesarean section or an increase in intrauterine infection.[18] A recent retrospective cohort study, however, reports a twofold higher risk of fever for women with an IUPC compared to women without (11.7 versus 4.5%, adjusted odds ratio (AOR) 2.0, 95% confidence interval (CI) 1.6–2.5), there was no significant difference in composite neonatal morbidity.[19] Use of the IUPC can be especially beneficial for women with a high body mass index (BMI) with a body habitus that does not permit adequate external evaluation of uterine tone. Additional studies are needed in order to determine the risks and benefits of this device with regard to maternal infection.

The minimum frequency of uterine contractions necessary to result in cervical change is variable and poorly defined. The American Congress of Obstetrics and Gynecology (ACOG) and the National Institute of Child Health and Human Development (NICHD) have defined the upper limit of normal uterine contraction frequency as less than or equal to five contractions in 10 min, averaged over a 30 min window.[20,21] Tachysystole is a term used to define abnormal uterine contraction frequency of more than five contractions in 10 min averaged over 30 min. Any documentation of tachysystole should also include the presence or absence of fetal heart rate decelerations.

After placing the IUPC, the Montevideo unit (MVU) can be used as an objective estimate of uterine activity. The MVU is a measure of the average strength of uterine contractions (peak amplitude minus basal amplitude in mmHg) multiplied by the number of contractions over 10 min. ACOG recommends a threshold of ≥200 MVU to define adequate labor in the active phase.[22,23] The MVU threshold associated with adequate labor in the latent phase has not been determined.

Definitions for several fetal characteristics that may affect the duration of labor are detailed below.

Passenger

Fetal Size

Relative disproportion between fetal weight and maternal pelvic dimensions can increase the risk for prolonged labor, cesarean section, and shoulder dystocia.[24] In the third trimester, ultrasound-derived estimates of fetal weight have an average range of error of 15%. The superiority of ultrasound-derived estimates of fetal weight over clinical estimates has not been established.[25] Among parous post-term women with fetal estimated fetal weight (EFW) > 4,000 g, the mean standard error of the patient's estimate of fetal weight was not significantly different from the standard error of the estimation of fetal weight by her obstetric provider.[26]

Fetal Lie

The term fetal lie refers to the long axis of the fetus in relation to the long axis of the mother. Fetal lie can be longitudinal, transverse, or oblique. In a singleton gestation, delivery of a fetus in a transverse or oblique lie is not recommended due to higher risk of risk of cord prolapse and greater risk of neonatal morbidity. Delivery of a fetus with a longitudinal lie can be attempted.

Fetal Presentation

The expression fetal presentation refers to the fetal part above or within the pelvic inlet. In a fetus with a longitudinal lie, the presentation can be either vertex, breech, brow, or chin (mentum). The term compound presentation refers a fetus that has two body parts within the pelvic inlet. A funic presentation occurs when a fetus has its umbilical cord within the pelvic inlet below the level of a fetal part. With a funic presentation, the umbilical cord will deliver or "present" before a fetal part.

Fetal Attitude

The term fetal attitude refers to the degree of flexion or extension of the fetal head in relation to the spine. The fetal attitude can be either flexed (fetal chin in close proximity to the chest), extended (fetal chin extended superiorly such that the occiput is in closer approximation to the base of the posterior neck), or military (fetal head is neither flexed nor extended, the coronal and sagittal planes of the head are contiguous with the coronal and sagittal planes of the body). The degree of extension will determine the presenting bony part and the largest presenting diameter of the fetal head. With a brow presentation, the head is extended and will present the larger diameter through the pelvic inlet (vertex to mentum 13.5 cm). With a face presentation, the head is hyperextended with an average presenting diameter of 9.5 cm (submentum to bregma). Labor arrest is more common when larger diameters present through the pelvic inlet. The architecture of the pelvic floor may help to either maintain flexion or exert corrective forces on an extended head in the early stages of labor.

Fetal Position

The expression fetal position refers to the relationship of the fetal presenting part to the maternal pelvis and is detailed in Table 1.1. Persistent occiput transverse and occiput posterior position can affect the duration of labor and the likelihood of vaginal delivery success.

Fetal Station

The term fetal station refers to the location of bony presenting part above or below the level of the ischial spines. Station is measured in centimeters above (+1 to +5) or below (−1 to −5) the ischial spine, which is designated by 0 station. During a pelvic examination, a right-handed person will most easily palpate the ischial spine on the maternal right at approximately 8 o'clock position. A left-handed examiner will most easily palpate the ischial spine on the maternal left at 4 o'clock position.

Table 1.1 Fetal Presentations and Positions in Labor

Lie	Presentation	Leading Fetal Part	Attitude	Diameters (average cm)	Position
Longitudinal	Breech	Sacrum			Sacrum anterior Sacrum posterior Sacrum transverse
	Cephalic	Occiput	Military	Occipital-frontal (11 cm)	Occiput anterior Occiput posterior Occiput transverse
			Flexed	Suboccipital bregmatic (9.5 cm)	Occiput anterior Occiput posterior Occiput transverse
	Brow	Frontal bone	Extended	Verticomental (13.5 cm)	Frontoanterior Frontoposterior Frontotransverse
	Face	Mentum(chin)	Hyperextended	Submental bregmatic (9.5 cm)	Mentum anterior Mentum posterior Mentum transverse
	Compound	Variable			
	Funic	None-Umbilical cord presents			

Pelvis

Primer on Pelvic Assessment

Normal labor at term requires (1) an appropriate match between the fetal head size and the size of the pelvis, (2) effective uterine propulsive forces, and (3) normal positioning of the presenting fetal part as it traverses the pelvis and pelvic floor. The pelvis is an important component of this triad, which is often overlooked.

Definitions for pelvic diameters, pelvic planes, and pelvic types are detailed below. A comparative evaluation of pelvic types is detailed in Table 1.2. Historically, Coldwell and Malloy are credited with identifying and characterizing four basic female pelvic types, which are named according to the shape of the pelvic inlet.[27] Gynecoid (female) and anthropoid (elongated oval) shaped pelvises have more favorable pelvic diameters for vaginal delivery while android (male) and platypelloid (transverse oval) have shorter anteroposterior and transverse pelvic diameters respectively. These types are seen in Figure 22.1 in Chapter 22. In actual practice, a female pelvis may combine characteristics from several pelvic types.[28] Descriptions of specific components of the boney pelvis are seen in Box 1.1.

An argument can be made that detailed evaluation of the pelvic inlet, mid-pelvis, and pelvic outlet is slowly becoming a lost art. This is in part due to the fact that radiographic attempts to determine threshold pelvic diameters indicative of cephalopelvic disproportion (CPD) have low sensitivity and specificity for the prediction of cesarean section. Neither X-ray pelvimetry, computed tomography, nor magnetic resonance imaging have been proven to have sufficient sensitivity and specificity to predict cesarean section due to CPD prior to the onset of labor.[29,30] It has been said that there is no pelvic shape in which labor is absolutely contraindicated. Fetal weight and head size are important variables as is the ability of the head to "mold" within the pelvis overtime. Clinical evaluation of the pelvis can, however, be a useful adjunct to the maternal assessment and should be used to identify those women who are at risk for a prolonged or protracted labor course due to pelvic dimensions relative to fetal size.

Cardinal Movements of Labor

The fetal head performs a series of movements in order to present its smallest diameter as it traverses inferiorly through the pelvis and vagina. Fetal movement during labor is a continuous process that is

Table 1.2 Comparative Evaluation of Pelvic Characteristics According to Pelvic Type

	Gynecoid (Female)	Android (Male)	Anthropoid	Platypelloid
Pelvic shape of inlet	Oval – round	Heart shaped	Elongated oval	Transverse oval
Pelvic inlet diameters – Diagonal conjugate (Average)	(12.5 cm)	Average to short	Very long	Very short
– Transverse diameter (Average)	(13.5 cm)	Average	Average to Narrow	Wide
Posterior capacity	Deep, broad	Shallow	Long, narrow	Shallow
Anterior capacity (forepelvis)	Rounded, broad	Narrow, angled	Long, rounded	Shallow
Midpelvis characteristics				
– Sidewalls	Straight	Convergent (funnel)	Straight	Straight-divergent
– Ischial spines	Not prominent	Prominent	Variable	Variable
– Interspinous diameter (Average)	10.5 cm	Narrow (9.5 cm)	Average-narrow	Wide
Pelvic outlet				
Subpubic arch	Wide, >90	Angular		
Theoretical risk of malpresentation	none	Possible occiput posterior	Possible occiput posterior	Possible deep transverse arrest

Modified from Caldwell W, Moloy H. Anatomical variations in the female pelvis and their effect in labor, with a suggested classification. *Am J Obstet Gynecol*. 1933;26:479; Whitley 1985.

Box 1.1 Components of the female boney pelvis

Pelvic inlet Boundaries for the bony pelvic inlet are the sacral promontory, bilateral iliopectineal line, and the symphysis pubis.

Diagonal conjugate Distance from sacral promontory to the inferior border of the symphysis pubis. Can be assessed clinically in order to estimate the true anteroposterior diameter of the pelvic inlet.

Obstetric conjugate Distance from the superior border of the symphysis pubis to the sacral promonitory. Can only be measured radiographically. A clinical estimation of this diameter can be determined by subtracting 1.5 cm from the diagonal conjugate.

Midpelvis The midpelvis is bounded anteriorly by the inferior border of the symphysis pubis, laterally by the ischial spines, posteriorly by the sacrum. It is considered the pelvic plane with the smallest pelvic dimension.

Pelvic Outlet Most inferior boundary of the bony pelvis. It is defined by the pubic arch, pubic rami, ischial tuberosities, and tip of the coccyx. The pelvic outlet is of less clinical significance. It can be described by the angle of the subpubic arch and the distance between the ischial tuberosities. The average pubic angle is > 90° and can accommodate two fingers.

characterized by seven discrete events. The fetus may perform these sequentially or the fetus may perform several simultaneously during its descent through the birth canal.[17] The events are described in Box 1.2.

Labor Progress

Labor is defined as the process by which regular uterine contractions result in cervical dilation and effacement. Labor is divided into three discreet stages. The first stage of labor begins with the onset of labor and ends with complete cervical dilation. The second stage of labor begins with complete cervical dilation and ends with delivery of the fetus. The third stage of labor begins with delivery of the fetus and ends with delivery of the placenta. The first stage of labor is divided into two phases: (i) the latent phase, which is characterized by a slow rate of cervical dilation, and (ii) the active phase, which has a more rapid rate of dilation. Skilled evaluation of the cervix with regard to dilation and effacement are necessary in order to track labor progress. Effacement refers to the ability of the cervix to decrease in thickness and length over time as labor progresses. Effacement can be reported as an absolute length or as a percentage. A cervix that is 0% effaced is thick, is typically at least 2 cm long, and has not begun

Box 1.2 Cardinal movements of labor

1. **Engagement** occurs when the widest diameter of the presenting part passes through the pelvic inlet. With a cephalic presentation, the largest anteroposterior and transverse diameters of the fetal head entering the pelvic inlet will depend upon the attitude of flexion. In a fully flexed head, the biparietal diameter (BPD) (average length at term 9.5 cm) is the widest diameter to traverse the pelvic inlet and the suboccipitobregmatic diameter is the longest anterior posterior diameter (average length at term 9.5 cm). Engagement typically occurs when the leading fetal part reaches the level of the ischial spines (O station) and is an appropriate test of the size of the pelvic inlet relative to fetal dimensions.
2. **Descent** refers to downward movement of the fetus through the pelvic inlet, midpelvis, and pelvic outlet onto the pelvic floor. This is a continuous process. The rate of descent is affected by maternal parity, uterine contractile forces, pelvic dimensions, fetal size, and maternal pushing effort prior to delivery.
3. **Flexion** of the fetal head is believed to begin before the onset of labor. The degree of flexion increases passively during the course of labor as the fetus traverses the pelvis and encounters the pelvic floor.
4. **Internal Rotation.** Many fetuses will enter the pelvis in the occiput transverse position. Movement of the fetal head from occiput transverse to the occiput anterior (common) or occiput posterior (less common) occurs passively as the fetus encounters the symphysis pubis and inferior hollow of the sacrum.
5. **Extension** refers to upward movement of the chin away from the fetal chest as the occiput passes below the symphysis. The birth canal curves upward as the fetal presenting part begins to pass the inferior border of the sacrum and reaches the coccygeus and ileococcygeus muscles of the pelvic floor. Progressive extension of the fetal head occurs due to the downward force exerted by uterine contractions and the upward forces generated by resistance from the musculature of the pelvic floor.
6. **External Rotation** refers to passive lateral movement of the fetal head to its anatomically correct position. After the fetal head passes the vaginal introitus, resistance from the pelvic floor is no longer a determining factor in the direction of movement of the fetal head. Intrinsic tone within the musculature of the head and neck will facilitate passive lateral rotation of the head so that the face and anterior thorax are properly aligned within the same plane.
7. **Expulsion** refers to the delivery of the body below the level of the fetal head. The downward forces generated by uterine contractions and maternal pushing efforts and the upward resistance generated by the pelvic floor facilitate rotation of the anterior shoulder below the symphysis and out the vaginal introitus. The body follows the anterior shoulder in similar fashion.

to decrease in size due to labor forces. A cervix that is 100% effaced has no palpable length or thickness. An effacement of 80% or more is typically observed for women in the active phase of labor. There is a significant association between maternal parity and the rate of cervical dilation and effacement. Progressive descent of the fetal presenting part is expected as labor progresses. Like cervical dilation, fetal station can be affected by parity, uterine contractile forces, fetal size, and pelvic dimensions.

The onset of labor is hard to define as it is often made retrospectively in a patient with uterine contractions after documented evidence of cervical change is present. Exactly when a patient develops uterine contractions of sufficient intensity and frequency to begin the process of cervical change is difficult to determine with certainty. The latent phase of labor is characterized by a period of slow cervical change while the active phase of labor is characterized by a rapid rate of cervical dilation. Identification of the period in which the patient transitions from the latent phase to the active phase is often made retrospectively as it is dependent upon the timing and frequency of cervical examinations in labor.

Landmark data presented by Friedman has been used historically to define normal and abnormal rates of cervical dilation in labor. In the original study, the rate of cervical dilation during term labor at term for 500 primaparous and 500 multiparous women was used to generate a sigmoid shaped curve of average labor progress.[31,32] The plotting of the cervical dilation in cm (y-axis) against time in hours (x-axis) transforms the cervical examination from a static assessment performed at discrete intervals into a continuous process by which the average rate of change

Box 1.3 **Average spontaneous labor characteristics in a study of 500 primaparous and 500 multiparous women at term in the 1950s**

	Primipara[a]	95th percentile	Multipara[b]	95th percentile
Latent phase duration(mean, h)	8.6	20.6	5.3	13.6
Active phase duration (mean, h)	4.9	11.7	2.2	5.2
Maximum slope (cm/h)	3.0	1.2 (5th percentile)	5.7	1.5 (5th percentile)
Second stage duration (mean, h)	57 min	2.5	18 min	50 min

Data from: [a]Friedman E. Primigravid labor. *Obstet Gynecol*. 1955;6:567 and [b]Friedman E., Labor in multiparas: A graphicostatistical analysis. *Obstet Gynecol*. 1956;8:691.

can be determined. The latent phase of labor is characterized by a more flattened slope. The latent phase is followed by a brief acceleration phase in which the slope begins to increase. The active phase corresponds to a steep slope, which is characterized by the most rapid rate of cervical change (see Figure 1.1). The reported mean and 5th percentile of normal duration of the latent phase, active phase, first stage, and second stage of labor are listed in Box 1.3. It is important to note that the most rapid rate of cervical dilation begins after 4 cm cervical dilation is achieved and as a result 4 cm is used to signal the beginning of the active phase. The average rate of cervical dilation in the active phase for nulliparous women was 3.2 cm/h with 1.2 cm/h as the 5th percentile of normal.[31] From 1955 to 2000 as a result of the Freidman studies, a cervical dilation of 4 cm was used to denote the active phase of labor and a minimum rate of cervical dilation of 1 cm/h in the active phase was expected. In the studies published by Friedman, only 13.8% of the primparous women and 11.2% of the multiparous women were augmented with pitocin. Approximately 51.4% of the nulliparas and 20.2% for multiparas were delivered by low forceps. As expected in the 1950s, the cesarean section rate in the study population was very low (1.8% for nulliparas and 0.8% multiparas).[31,32]

Labor management options have changed significantly over the last five decades. Labor induction, epidural analgesia, oxytocin, and continuous fetal monitoring are readily available options for patients

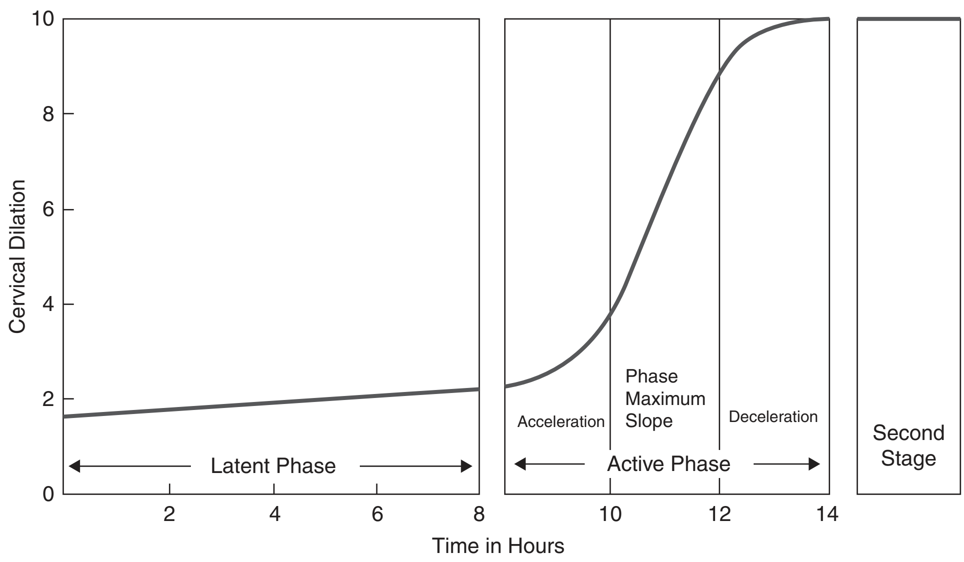

Figure 1.1 Friedman's curve.

and their obstetric providers. The obesity epidemic has resulted in an average BMI that is higher now than it was in the 1950s and as a result fetal macrosomia is more common now than it was five decades ago. More recent studies evaluating labor progress with a contemporary patient population have challenged traditionally held beliefs regarding the latent phase duration, active phase duration, and cervical dilation, which heralds the beginning of the active phase. The transition from latent to active labor was evaluated by Peisner and Rosen in 1986.[33] Approximately 1,600 nulliparous and multiparous women in spontaneous labor were evaluated. In this study, active labor was defined as a cervical dilation rate of 1.5 cm/h for multiparas and 1.2 cm/h for nulliparas; both of which are the 5th percentile of normal according to the original Friedman cohort.[33] With contemporary labor management, only 50% of women at 4 cm cervical dilation met active phase criteria. At 5 cm, 74% of women were in the active phase. At 6 cm, 89% of women met active phase criteria. This study suggests that a significant percentage of women who go on to have a vaginal delivery will still be in the latent phase of labor at 4 cm of cervical dilation. Review of data generated by the National Collaborative Perinatal Project from 1959 to 1966 similarly determined a slow rate of cervical change prior to 6 cm, regardless of parity.[34] Retrospective evaluation of contemporary spontaneous term labor data from the Consortium on Safe Labor further challenged historical assumptions regarding the duration and rate of dilation in the active phase.[35] In this study, detailed labor and delivery data from >62,000 women in 19 medical centers from 2002 to 2008 was evaluated. It was found that 71–84% of women received an epidural and 45–47% received oxytocin augmentation. Nulliparous and multiparous women were determined to have a similar slow rate of cervical change prior to 6 cm dilation. For nulliparas, a change in cervical dilation from 4 to 5 cm could take up to 6.4 h (95th percentile) and a change in cervical dilation from 5 to 6 cm could take up to 3.2 h (95th percentile). After achievement of dilation to 6 cm, the rate of cervical change increased regardless of parity although multiparas were noted to have a faster rate of change. Median and 95th percentile duration of incremental cervical change according to parity is detailed in Box 1.4. ACOG and the Society for Maternal Fetal Medicine (SMFM) issued a consensus statement in support of the recommendations generated by Zhang et al. and the Consortium on Safe Labor data.[36] With contemporary labor management, most women in term labor continue to have a slow rate of cervical change from 4 to 6 cm and as a result 6 cm and not 4 cm should be considered the threshold cervical dilation for the initiation of the active phase.[36]

Second Stage of Labor

With regard to the duration of the second stage of labor, the Consortium on Safe Labor data regarding the median and 95th percentile duration of the second stage of labor are detailed in Box 1.4. It should be

Box 1.4 Median duration (h) for each centimeter of change in cervical dilation for nulliparas and multiparas (parity =1) in spontaneous labor

Cervical dilation (cm)	Nullipara		Multipara	
	Median (h)	95th percentile (h)	Median (h)	95th percentile (h)
3–4	1.8	8.1	____	_____
4–5	1.3	6.4	1.4	7.3
5–6	0.8	3.2	0.8	3.4
6–7	0.6	2.2	0.5	1.9
7–8	0.5	1.6	0.4	1.3
8–9	0.5	1.4	0.3	1.0
9–10	0.5	1.8	0.3	0.9

* An interval-censored regression model to estimate the distribution of time for progression from one centimeter to the next with the assumption of log normal distribution of the labor data.

Modified from Zhang J, Landy H, Branch D, et al. Consortium on safe labor: Contemporary patterns of spontaneous labor with normal neonatal outcomes. *Obstet Gynecol* 2010;116:1281.

noted that an epidural extended the median duration of the second stage by 1 h for nulliparous women.[35] In addition to epidural analgesia, there are a number factors that have been reported to influence the length of the second stage including fetal position, parity, fetal weight, maternal BMI, epidural analgesia, and maternal pushing efforts. With contemporary management and continuous fetal monitoring, an absolute maximum threshold duration for the second stage of labor, which is associated with an increased risk of neonatal morbidity has yet to be clearly defined.[36] While most women will have a second stage duration of less than 2 h, the ACOG/SMFM consensus document now considers at least 2 h of pushing for multiparas and 3 h of pushing for nulliparas without an epidural appropriate. For women with an epidural, at least 3 h of pushing for multiparas and 4 h of pushing for nulliparas are appropriate depending upon maternal and fetal status. There is no evidence that these time limits are associated with increased maternal or neonatal morbidity.[36]

Delivery of the Fetus

The obstetric provider is physically present during the second stage of labor in order to facilitate maternal pushing efforts, assess fetal position and station as the fetus navigates the pelvis, and to assure maternal and fetal stability prior to delivery. During the delivery process, the obstetric provider is responsible for leading a team that includes the patient, her support person(s), nursing staff, and pediatric staff if they are called to attend. It is not only the obstetric provider's hands but his or her voice that can play an important role in the facilitation of a safe delivery for mother and baby. Communication with the patient during the intrapartum period manages patient expectations enables the patient to be a proactive participant and facilitates nursing support during the birth process.

When delivery is imminent, the fetal head will extend through the vaginal introitus. The obstetric provider should place gentle pressure on the fetal head in order to minimize rapid extension of the head and reduce the risk of perineal and/or periurethral injury. The head will deliver over the perineum and then rotate laterally so that the face and body are in the anatomically correct orientation. Nuchal umbilical cord loops may be reduced if they are loose or the cord may be transected and cut if reduction over the head is not possible. The patient should then be asked to push while the obstetric provider applies gentle downward and outward traction in the axis of the pelvic curve on the fetal head in order to facilitate delivery of the anterior shoulder. The posterior shoulder is then delivered with upward traction. It is important to avoid injury to the maternal perineum and fetal brachial plexus during this process. Avoiding excessive use of force and excessive lateral traction are ways to reduce fetal and maternal risk.

Meconium staining of amniotic fluid is no longer an indication for intubation and suctioning below the level of the vocal cords if the fetus is vigorous at delivery. If the fetus is depressed, however, prompt evaluation is recommended per American Academy of Pediatrics (AAP) guidelines.[37] If the amniotic fluid is meconium stained and the fetus is vigorous, routine suctioning below the vocal cords is not indicated.

After delivery, holding the baby at or below the level of the placenta/maternal perineum will facilitate passive transfusion of blood from the cord to the baby. Passive transfusion will cease when the cord is clamped or when the umbilical veins begin the spasm and contract. There is evidence that a > 2 min delay in umbilical cord clamping for term infants after delivery results in a significant increase in hematocrit, ferritin, and stored iron at 2 to 6 months with no significant increase in the risk of maternal hemorrhage. Delayed cord clamp was associated, however, with an increased neonatal risk of jaundice and polycythemia.[38,39] In preterm infants <37 weeks gestation, a > 30 s delay was associated with a decreased risk of anemia requiring transfusion, 50% reduction in intraventricular hemorrhage, and decreased risk of necrotizing enterocolitis compared to infants with immediate cord clamping. A higher bilirubin was also identified in this population.[40] For preterm infants, ACOG supports the practice of delayed cord clamping (>30 s) compared to immediate cord clamping when clinically possible in a vigorous infant. For term infants, however, the data is insufficient to either confirm or refute the benefits of delayed cord clamping (>2 min).[41] Additional data is required in order to determine the neonatal benefits in term infants associated with a shorter duration of delay (>30 s) and or with "milking" of the umbilical cord prior to clamping.

After delivery, the infant should be placed on the mother's abdomen and dried. A blanket and hat may be placed on the neonate in order to assist with temperature regulation. The neonate should lay with its bare chest and abdomen exposed on the maternal skin near the patient's breast in order to facilitate bonding and attachment. Meta-analysis of data from 13 RCTs suggests that immediate or early "skin to skin contact" increases the likelihood of breastfeeding initiation at 1 to 4 months by 27% (RR 1.27; 95% CI, 1.06 to 1.53) and results in higher blood glucose at 75 to 90 min of life compared with standard care.[42]

Third Stage of Labor

The third stage of labor begins after delivery of the baby and ends with delivery of the placenta. The three signs of placental separation are: (1) change in shape of the uterine fundus as it begins to contract, (2) lengthening of the umbilical cord as the placenta descends through the cervix, and (3) a gush of blood from the vagina secondary to separation of the placenta from the uterine myometrium. Separation of the placenta can occur passively without manual manipulation of the placenta or uterus. Active management of the third stage of labor refers to: (1) administration of uterotonic medication after delivery of the baby in order to improve uterine tone, (2) controlled traction on the umbilical cord and counter traction against the fundus/lower uterine segment in order hasten placental separation and prevent uterine inversion, and (3) uterine massage after delivery of the placenta.[43,44] Active management of the third stage of labor has been proven in randomized controlled trials to significantly decrease the risk of postpartum hemorrhage and is recommended by ACOG as a universal measure to reduce the risk of postpartum hemorrhage due to uterine atony for all women regardless of the their pre-delivery hemorrhage risk.[45]

Concluding Remarks

Normal labor is a complex process that requires adequate uterine contractions, a fetus of sufficient size to navigate the maternal pelvis, and favorable pelvic dimensions relative to fetal size. Fetal presentation, position, and the attitude of flexion of the fetal vertex can affect the duration of labor, its likelihood of success, and the safety of a vaginal delivery attempt. Labor is not a passive process for the obstetric provider as it requires careful evaluation of the cervix over time, along with an assessment of uterine contractions and an assessment of fetal descent within the pelvis. These evaluations distinguish those women who would benefit from obstetric interventions from those who are progressing as expected. Abnormal labor can increase maternal and fetal risk of an adverse outcome. Chapter 2 will present the evidence supporting our current understanding of abnormal labor and review management strategies proven to reduce maternal and fetal morbidity once abnormal labor is identified.

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