Implementation of New Definitions of Labor Arrest Disorders and Failed Induction Can Decrease the Cesarean Rate

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ABSTRACT

NEW DEFINITIONS OF LABOR ARREST DISORDERS AND FAILED INDUCTION CAN DECREASE THE CESAREAN RATE

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Cesarean delivery for labor arrest currently makes up the largest proportion of primary cesarean delivery in the United States. Because cesarean delivery is associated with significant morbidity, it is important to limit its use to ensure the benefits outweigh the risks. New diagnostic criteria to limit the diagnosis of labor arrest have the potential to decrease the cesarean delivery rate. To investigate how cesarean delivery for arrest of dilation or descent and failed induction contributed to the primary cesarean delivery rate, we analyzed rates of primary cesarean for these indications among 17,864 live births at our institution from 2010 through 2013. We used multiple logistic regression modeling to identify predictors of meeting diagnostic criteria for these indications based on guidelines published in 2012 by Spong et al. From 2010 through 2013 the total primary cesarean delivery rate decreased from 23.5% to 21.1%. Over the same period, primary cesarean delivery due specifically to arrest of dilation or descent and failed induction decreased from 8.5% to 6.7%. Primary cesarean delivery due to arrest of dilation alone decreased from 5.1% to 3.4%. The rate of meeting minimum criteria for arrest of dilation increased from 18.8% to 34.9%. Primary cesarean delivery due to arrest of descent alone remained relatively stable, however, the percent of cases meeting minimum criteria increased from 57.8% to 71.0%. The rate of primary cesarean delivery due to failed induction alone also remained relatively stable, as did the percent of cases meeting minimum criteria with 50.00% meeting criteria in 2013. Attending type was a significant predictor of meeting criteria for all three indications. Hospitalist cases were two to seven times as likely to meet criteria compared with private cases. Dilation on admission increased, as well as the likelihood of meeting criteria for arrest of dilation and arrest of descent. Epidural use decreased the likelihood of meeting criteria for arrest of descent. In summary, the decrease in primary cesarean delivery from 2010 through 2013 is significantly attributable to a decrease in the diagnosis of labor arrest disorders and failed induction, and specifically to a decrease in diagnosis of arrest of dilation. An increased likelihood of meeting minimum criteria for arrest of dilation in 2012 and 2013 compared to 2010 suggests that applying new definitions of labor arrest published in 2012 can decrease the overall primary cesarean rate. As of 2013, only 34.9% of primary cesareans performed for arrest of dilation, 71.0% for arrest of descent, and 50.0% for failed induction, met new respective minimum diagnostic criteria. This suggests that an even bigger decrease in the primary cesarean rate can be achieved if a greater effort is made to meet minimum criteria before moving to cesarean.

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WHAT'S SO BAD ABOUT A CESAREAN?

Cesarean delivery has become so commonplace in today's world that patients often forget that it is major abdominal surgery with different risks from vaginal delivery, including injuries to surrounding structures such as bowel and bladder, anesthetic complications, wound hematoma, infection, and dehiscence.[1,2] While cesarean delivery is often objectively necessary for the health of the mother and/or fetus, there are many occasions when its necessity is uncertain and it has the potential to cause more complications than it prevents.

A study by the National Institute of Health published in 2009 examined the prevalence of delivery hospitalizations complicated by at least one severe obstetric complication from 1998 to 2005. They found that when controlling for factors like maternal age, multiple births, and select comorbidities, the increase in cesarean rate over that period was associated with an increase in obstetrical complications. These complications were renal failure, respiratory distress syndrome, ventilation, shock, pulmonary embolism, and blood transfusions.[3]

Deep vein thrombosis and pulmonary embolism (together referred to as a venous thrombotic event or VTE) are leading causes of maternal mortality in the United States (U.S.), United Kingdom, and Canada.[4] Cesarean delivery puts already vulnerable postpartum patients at an increased risk for VTE by adding risk factors: surgery, longer hospitalization and bedrest.[5] Luckily, compared to general surgery patients, the rate is relatively low. One prospective cohort study in the U.S. found the rate of DVT following cesarean to be 0.5%. The authors suggest this is because of younger age, mostly using regional versus general anesthesia, and early movement after surgery to tend to the needs of the newborn.[4] Still, as a recent metanalysis shows, cesarean delivery puts women at fourfold increased risk of VTE compared to vaginal delivery.[6]

Endometritis is a common maternal complication of childbirth and has been shown to occur more frequently after cesarean than vaginal delivery, occurring after cesarean delivery 10 to 20 times as often compared to vaginal delivery.[7]

A large Canadian retrospective cohort study found that women with a low risk planned cesarean delivery experienced severe morbidity (defined as hemorrhage requiring hysterectomy or transfusion, uterine rupture, anesthetic complications, shock, cardiac arrest, acute renal failure, venous thromboembolic event, major infection, or in-hospital wound disruption/hematoma) about 3 times as often as women with planned vaginal delivery. However, it is important to note that while the planned cesarean delivery group had an increased risk of most of the complications, this study did not find that this group had an increased risk for hemorrhage requiring transfusion or uterine rupture compared to the planned vaginal delivery group. In fact, the odds of necessitating a blood transfusion or uterine rupture were lower in the planned cesarean group. [8] A large Australian population-based study assessing risks for postpartum hemorrhage, also found that the risk of postpartum hemorrhage was less with cesarean compared to vaginal delivery. However, they note that estimation of blood loss in cesarean delivery may be inaccurate and suggest that cesarean patients are more closely monitored postpartum and therefore bleeding may be found and treated earlier.[9]

That said, it is important to emphasize the severe morbidities that are significantly associated with cesarean delivery, namely hemorrhage requiring hysterectomy, anesthetic complications, shock, cardiac arrest, acute renal failure, VTE, major infection such as endometritis, and wound disruption/hematoma.[6-8]

Beyond these potential sequelae seen in the postpartum period, much of the harm from cesarean may not be seen until a subsequent pregnancy. In a committee opinion on maternal request for cesarean delivery, The American College of Obstetricians and Gynecologists (ACOG) advocates for vaginal delivery when safe and has concluded cesarean delivery increases complications in subsequent pregnancies such as uterine rupture, placenta previa, placenta accreta, and hysterectomy.[10] Importantly, the risk of abnormal placental implantation and need for gravid hysterectomy increase after each subsequent cesarean.[11,12] A recent meta-analysis confirms that prior cesarean delivery increases the odds of hysterectomy and antepartum hemorrhage in the subsequent pregnancy. However, interestingly, cesarean delivery decreases the odds of postpartum hemorrhage.[13]

Some studies have shown that cesarean delivery may lower fertility.[14-18] They found that women who had a cesarean delivery were less likely to have another child compared with women who delivered vaginally. This could be due to biological factors related to the cesarean like scarring, adhesions, and abnormal placentation,[18] as well as psycho-social factors related to negative ideas of labor and delivery.[16,19,20] One study suggested a complex relationship where subfertility may both cause and be a consequence of cesarean delivery.[18]

In addition, ectopic pregnancy and spontaneous abortion may be more common after cesarean delivery.[21] One recent meta-analysis from 2013 by O'Neill et al. found no association with ectopic pregnancy, but advises that the studies included in the analysis were of poor quality.[22] Additionally concerning are studies demonstrating an increased risk of stillbirth in women with previous cesarean, which may be attributed to abnormalities in uterine blood flow, placentation, and placental abruption.[22-24] It may be that uterine scarring prevents normal implantation and migration of the placenta.[11]

Another 2013 meta-analysis by O'Neill et al. suggested that women with previous cesarean delivery have a 23% increased odds of subsequent stillbirth compared with women who have had a previous vaginal delivery.[25] One large retrospective cohort of over 120,000 deliveries the risk of unexplained stillbirth was double for a woman who had previously had a cesarean delivery compared to a woman with no history of cesarean delivery. However, the absolute risk differences are low, with the excess risk of still birth to be less than 1 in 1000.[23]

Wood et al. argue in their 2015 analysis of 98,000 deliveries that shows no association of previous cesarean delivery with stillbirth,[26] that the meta-analysis mentioned above failed to include the largest study published on the subject with over 11 million deliveries, and which did not find a positive association.[27] In addition, they believe the studies included in the meta-analysis have important confounding factors that were not controlled for consistently.[26]

However, the most recent metanalysis of long-term risks associated with cesarean delivery published in January 2018 found that cesarean delivery is associated with an increased risk of miscarriage, ectopic pregnancy, and stillbirth in subsequent pregnancies.[13] Therefore, it is clear from the three meta-analyses that there is at least some increased risk of miscarriage and stillbirth, and possibly an increased risk of ectopic pregnancy with previous cesarean delivery.[13,22,25]

In addition to maternal and pregnancy-related complications, some studies suggest negative consequences for the neonate such as neonatal respiratory morbidity.[2,10] Delay in initiating and maintaining respiration, low 5-minute Apgar scores (≤ 3), hypoxic ischemic encephalopathy (HIE, Sarnat score > stage 1, meaning deficits were apparent for greater than 24 hours), respiratory distress syndrome, aspiration pneumonitis, and neonatal intensive care unit (NNICU) stays longer than 24hrs have been shown to be associated with cesarean delivery. However, as Liston et al. explain, these associations may represent outcomes associated with the indication for cesarean. Infants delivered at term by cesarean in labor compared to those delivered by spontaneous vaginal delivery were three to four and a half times more likely to have depression at birth: delay in initiating and maintaining respiration, low 5-minute Apgar score, or HIE. They were twice as likely to have transient tachypnea and aspiration pneumonitis, and over one and a half times as likely to have a NNICU stay > 24 hours. Infants delivered at term by cesarean without labor compared to spontaneous vaginal delivery were over three times as likely to have a low 5-minute Apgar score, but were not more likely to have a delay in initiating and maintaining respiration or HIE. They were also over five times as likely to have respiratory distress syndrome and almost two and a half times as likely to have transient tachypnea, but did not have an increased risk of aspiration pneumonitis. They also had an increased risk of a NNICU stay > 24 hours. The increased risks of depression at birth, including HIE, in the cesarean with labor group compared to the cesarean without labor group may be due to the reason cesarean was necessary. For example, the fetus of a woman in labor is found to have a severely abnormal heart rate and therefore cesarean is necessary.[28]

It is important to note that while cesarean delivery may increase odds of depression at birth, respiratory morbidity, and NNICU stay, the rate of poor outcomes was rare (<1%). It is also important to mention that cesarean delivery significantly decreased the odds of major neonatal trauma (one or a combination of any fracture, facial palsy, phrenic nerve palsy, Erb's palsy, Klumpke's palsy, spinal cord trauma, traumatic intracranial hemorrhage or intraventricular hemorrhage of grade III or IV). [28]

Previous research has suggested that respiratory morbidity is greater in deliveries without labor, which could be in part due to delivery before full lung maturity and/or lack of vaginal compression of the thorax to assist in the removal of interstitial and alveolar fluid. [29-31] A recent study in mice provides evidence that fetal lungs help initiate labor by secreting signals when its lungs have developed the capacity to produce enough surfactant to support respiration.[32] This suggests that if labor has not begun, it is possible the lungs are not optimally mature. The stress of being born vaginally has been shown to result in increased catecholamine levels in the infant not seen with cesarean delivery without labor, which may lead to greater arousal and help with the clearance of fluid from the lungs.[33-36]

Existing data on long-term consequences of cesarean delivery for the child is limited and controversial, but some studies suggest increased rates of bronchial asthma,[37,38] type 1 diabetes mellitus,[39] allergic rhinitis,[37] and sensitization to food allergens.[40] A very recent meta-analysis found that cesarean delivery conferred an increased risk of childhood asthma and a child being overweight/obese. The analysis found no association of mode of delivery with hypersensitivity/allergy/dermatitis/atopy, and interestingly found a decreased risk of inflammatory bowel disease with cesarean delivery versus vaginal delivery.[13]

Table 1 compares accepted adverse maternal and neonatal outcomes based on mode of delivery.

Table 1. Risk of adverse maternal and neonatal outcomes by mode of delivery. Adapted from ACOG/SMFM Consensus on the *Safe Prevention of the Primary Cesarean Delivery*.[41]

Outcome		Vaginal Delivery	Cesarean Delivery
Maternal			
	Overall morbidity	8.6%	9.2%
	and mortality[A]	0.9%	2.7%
	Maternal mortality[B]	3.6:100,000	13.3:100,000
	Amniotic fluid embolism	3.3-7.7:100,000	15.8:100,000
	Placental abnormalities	Increased with prior cesarean vs vaginal delivery, and risk continues to increase with each subsequent cesarean delivery	
	Urinary incontinence	No difference between cesarean and vaginal delivery at 2 years	
	Postpartum depression	No difference between cesarean and vaginal delivery	
Neonatal			
	Laceration	NA	1.0-2.0%
	Respiratory morbidity	<1.0%	1.0-4.0% (without labor)

NA, not available.

A. Defined as ≥1 of following: death, postpartum bleeding, genital tract injury; wound disruption, wound infection, or both; systemic infection

B. Defined as any 1 of following: death, hemorrhage requiring hysterectomy or transfusion; uterine rupture; anesthetic complications; shock; cardiac arrest; acute renal failure; assisted ventilation venous thromboembolic event; major infection; in-hospital wound disruption, wound hematoma, or both.

THE OPTIMAL CESAREAN RATE

Since 1985, the World Health Organization (WHO) has recommended that an adequate cesarean rate is 10-15%, stating “There is no justification for any region to have a rate higher than 10-15%.”[42] It is unclear whether these recommendations were based on mortality statistics alone or additionally took into account morbidity. Due to changes in maternal age, birthweight, and other factors, the WHO acknowledges that this estimation may be less valid today.[43] In addition, optimal rates may differ depending on resources and technical abilities of the place where a woman is going to give birth. Still, studies have shown no evidence of benefit for the health of the mother or child to have a cesarean rate above 15%.[44-46] Two of these studies only considered maternal and neonatal mortality,[45,47] while the third also included morbidity such as maternal blood transfusion, hysterectomy, and ICU admission and neonatal ICU stay > 7 days.[46] This last study was a WHO global survey of 97,000 deliveries from 8 countries in Latin America, and found that an increase in rates of cesarean delivery was associated with greater severe maternal and fetal/neonatal morbidity and mortality after adjustment for confounders. The maternal morbidity and mortality was linearly associated with an increase in cesarean delivery, and risk of preterm delivery and neonatal death increased with a cesarean rate between 10-20%.[46] This suggests that rates above this may result in more harm than good.[43,46]

A cross sectional study of 119 countries found that in low income countries as the cesarean rate (found to be <10% in 76% of low income countries) increased, neonatal and maternal mortality decreased. This effect was not seen in middle and high-income countries, of which 84% and 97% had a rate above 10%. The authors suggest that in low-income countries fewer cesarean deliveries are performed than needed for the population at risk, whereas high income countries perform a sufficient number of cesarean deliveries to protect the at-risk population, but then also perform additional cesareans to prevent severe morbidity and possibly additional unjustified cesareans. From this, the authors conclude that a cesarean rate of 10% decreases risk of maternal and neonatal mortality.[45] A review of studies from sub-Saharan Africa from 1970-2000 analyzed the need for cesarean delivery for maternal complications like eclampsia and placental abruption and found that while the observed rate of cesarean delivery is 1.3%, a rate of 3.6-6.5% (median 5.4%) is more appropriate to address high rates of maternal mortality in this region.[48] These two studies suggest that a cesarean rate of 5%-10% may be appropriate to prevent maternal mortality [45,48] and a rate of 10% to prevent neonatal mortality .[45]

If a rate of 10% is necessary to prevent maternal and neonatal mortality and a rate above 15% does not decrease morbidity and mortality, it may be appropriate to suggest the cesarean rate should be at least 10% and at most 15%.

The U.S. government's Healthy People 2020 has set a target rate of 23.9% for low-risk primary cesarean deliveries[49] and 81.7% for low-risk repeat cesarean deliveries.[50] Both represent a 10% decrease from the national rates in 2007, which appears to be the generic goals generated when there is not enough data available to otherwise calculate a target rate.[51] Therefore, for the purpose of this paper, the optimal range for cesarean delivery will be considered 10-15%, which happens to align with the WHO's original 1985 recommendation of an adequate cesarean rate.[42]

Cesarean rates in the United States have exceeded this suggested range for decades. The overall cesarean delivery rate in the U.S. increased 55% from 1996 to 2015, from 20.7% to 32.0%. The increased cesarean rate was seen across all maternal ages and races, geographic areas, and gestational ages..[52] Most recently, Connecticut was found to have a cesarean rate of 34.0% in 2015,[53] a 72% increase from 1996 when the cesarean rate was 19.8%.

The dramatic rise in cesarean sections is likely due to many factors. A decrease in vaginal births after cesarean (VBAC) and concurrent increase in repeat cesareans likely contributed to the increasing rate.[54] In addition, the medicolegal environment, provider practice patterns, increase in maternal request, and increase in high risk pregnancies have been suggested.[52]

However, several studies that examined high risk pregnancies and cesarean rates did not conclude that changes in maternal risk profile could explain the increased cesarean delivery rate.[55-57] Bailit et al. found that despite better treatment options decreasing maternal risk profiles, cesarean rates continued to rise.[58]

TARGETING THE PRIMARY CESAREAN RATE

A major focus in the pursuit to lower the overall cesarean rate has been to target the primary cesarean rate, the first cesarean section that a woman has. This is because only about 10% of subsequent deliveries are vaginal deliveries after the first cesarean.[59] Many efforts to better understand the primary cesarean rate have been undertaken.

Concurrent with national trends, the cesarean rate at Yale New Haven Hospital rose steadily from 2000 to 2002, which encouraged a departmental investigation into the contributing factors. Data has been prospectively collected on physician-recorded indications for every cesarean since 2003. In 2011 Barber et al. described indications for the continued rise of the cesarean delivery rate at Yale New Haven Hospital among 32,443 births between 2003 and 2009, which had increased from 26% to 36.5% during that time. They found that 50% of this increase was attributable to an increase in primary cesarean deliveries. Non-reassuring fetal status, labor arrest disorders, multiple gestation, suspected macrosomia, preeclampsia, maternal request, maternal-fetal conditions, and other obstetric conditions contributed to the total increase in the primary cesarean rate. Non-reassuring fetal status (32%) and labor arrest disorders (18%) were responsible for much of the increase. When labor arrest disorders was divided into arrest of dilation and arrest of descent, arrest of dilation was found to have significantly increased over time, while arrest of descent remained relatively stable. Other indications that significantly increased over time included multiple gestation, suspected macrosomia, preeclampsia, and maternal request. Malpresentation, maternal-fetal indications, and other obstetric indications (e.g. cord prolapse, placenta previa), remained relatively stable over time.[60]

A CHANGING UNDERSTANDING OF LABOR

Until recently, the Friedman curve was used to determine how women were progressing in labor. Dr. Friedman created the first labor curve in 1955 by mapping time points taken from 500 primigravid women laboring at term (See Figure 1). He divided the first stage of labor into latent and active phases. He defined the start of the latent phase of labor to begin at the onset of regular uterine contractions and end at the beginning the active phase. He defined the active phase as starting when the rate of dilation steepens and ending with full dilation, the start of the second stage of labor.[61] This labor curve and his other publications on labor[62-64] became the foundation of labor management worldwide.

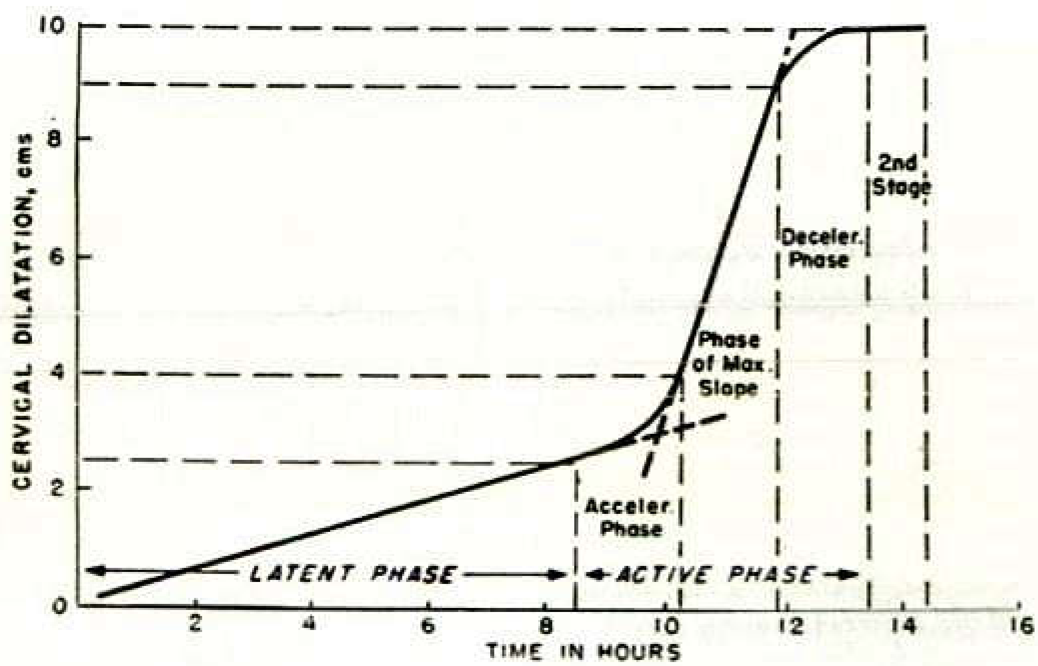


Figure 1 Mean labor curve developed by Dr. Friedman in 1955, based on the study of 500 primigravid women at term.[61]

In the decades since, maternal demographics and obstetrical histories have greatly changed. For instance, more women are having children later in life and maternal and fetal body sizes are larger. In addition, some interventions are more commonly used, such as induction of labor and epidural anesthesia. Other practices are much rarer, such as mid forceps operative delivery and breech vaginal delivery.[65]

To reexamine modern labor patterns and better define acceptable durations of labor, Zhang et al. studied 1329 nulliparous parturients with a term, singleton, vertex fetus with normal birth weight after spontaneous labor from 1992 to 1996.[65] Zhang et al. later studied 62,415 parturients with a term, singleton, vertex fetus with vaginal delivery after spontaneous labor and normal perinatal outcome from 2002 to 2008.[66]

First stage of labor

Latent Phase

Friedman chose to define the onset of latent labor as regular uterine contractions and the end with the beginning of active labor, where the rate of change of cervical dilation markedly increases.[61] Friedman defined prolonged latent phase of labor as > 20 hours in a nulliparous woman and > 14 hours in a multiparous woman.[62] New research has not focused on the latent phase of labor and because of this the Friedman definition is still used. However, because most women will either stop contracting (labor subsides) or enter the active phase if expectantly managed or with amniotomy and/or oxytocin, the number of hours in the latent phase should not be an indication for cesarean delivery.[41]

Active Phase

The Friedman curve showed active labor, the second phase of the first stage of labor, beginning before 4 cm.[61] Friedman described cervical change in normal active labor to be at a minimum 1.2 cm per hour in the nulliparous woman and 1.5 cm per hour in the multiparous woman based on 95^{th} percentiles. This lead to the recommendation that no cervical change for more than two hours in the setting of adequate contractions and cervical dilation of 4cm or more should be considered labor arrest.[41]

Zhang et al. found labor progression in the active phase to be much slower than Friedman. After 6 cm, they found the normal rate of cervical change to be at least 0.5-0.7 cm per hour for nulliparous women and 0.5-1.3 cm per hour for multiparous women based on 95^{th} percentiles.[41,66] In addition, they found that labor could take more than 8 hours to progress from 3 to 4 cm (a rate of 0.1 cm per hour), 6 hours to progress from 4 to 5 cm (a rate of 0.2 cm per hour), and more than 3 hours to progress from 5 to 6 cm (a rate of 0.2 cm per hour). They also found that nulliparous and multiparous women progressed at a similar pace before 6 cm, at which time multiparous labor progressed more rapidly. The median duration of 6 cm to full dilation was 2.1 hours in nulliparous women and 1.5 hours in multiparous women, with 8.6 hours and 7.5 hours the 95^{th} percentile, respectively. (See Table 2)

Table 2. Spontaneous labor pattern in the first stage by parity adapted from Zhang et al.[66]

Cervical dilation	Parity 0	Parity 1	Parity ≥ 2
3-4 cm	1h 48m (8h 6m)	--	--
4-5 cm	1h 18m (6h 24m)	1h 24m (7h 18m)	1h 24m (7h)
5-6 cm	48m (3h 12m)	48m (3h 24m)	48m (3h 24m)
6-7 cm	36m (2h 12m)	30m (1h 54m)	30m (1h 48m)
7-8 cm	30m (1h 36m)	24m (1h 18m)	24m (1h 12m)
8-9 cm	30m (1h 24m)	18m (1h)	18m (54m)
9-10 cm	30m (1h 48m)	18m (54m)	18m (48m)

Data are median time in hours and minutes (95^{th} Percentile)

Zhang et al. discovered that many of the active labor patterns, particularly those of nulliparous women, were not consistent with the expected pattern, but that many were still able to achieve vaginal delivery. Thus, they suggested that average labor times should not be used to define arrest of labor, but instead a woman should be allowed to continue to labor as long as maternal and fetal conditions are reassuring. In addition, they believe that 6 cm may be a more appropriate landmark for the active phase vs. 4 cm.[66]

Figure 2 shows the labor curve based on parity developed by Friedman and Figure 3 shows the labor curve based on parity developed by Zhang et al.

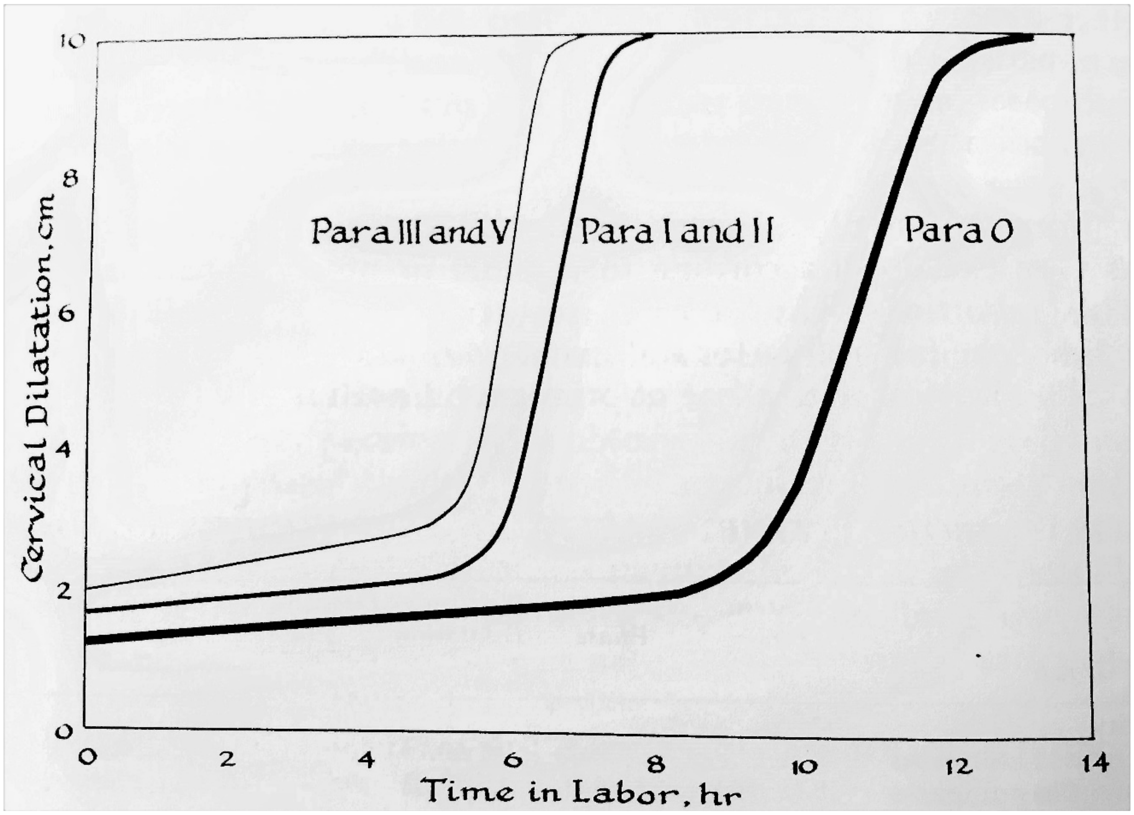


Figure 2 Labor curves developed by Dr. Friedman in 1978 to compare parity and rate of cervical dilation.[67]

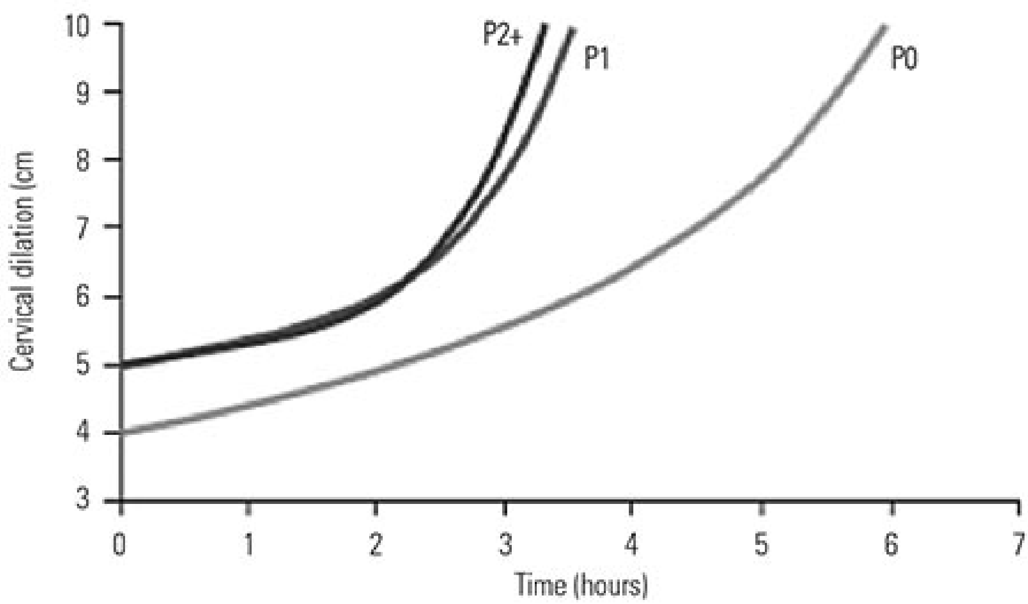


Figure 3 Average labor cures by parity in singleton term pregnancies with spontaneous labor, vaginal delivery and normal neonatal outcomes by Zhang et al. P0=nulliparous, P1=primiparous, P2+= multiparous.[66]

Second stage of labor

The second stage of labor begins when the cervix is fully dilated and ends when the neonate is delivered. Friedman calculated the length of the second stage from his cohort of 500 primigravid parturients, finding the median to be 0.8 hours with the 95 percentile 2.5 hours.[61]

Zhang calculated the median (95th percentile) second stage to be 1.1 hours (3.6 hours) in a nulliparous woman with epidural anesthesia, 0.4 hours (2.0 hours) for a primiparous woman with an epidural, and 0.3 hours (1.6 hours) for a multiparous woman with an epidural. In addition, they found the second stage to be 0.6 hours (2.8 hours) for a nulliparous woman without an epidural, 0.2 hours (1.3 hours) for a primiparous woman without an epidural, and 0.1 hours (1.1 hours) for a multiparous woman without an epidural.[66] (See Table 3)

It is important to note that while Friedman did not separate women with and without epidural anesthesia for his calculations, many fewer women (only 8.4%) used epidural anesthesia during that time. Instead, all but 19 received some amount of sedation, which did not change the length of the second stage.[61]

Table 3. Spontaneous labor pattern in the second stage by parity adapted from Zhang et al.[66]

	Parity 0	Parity 1	Parity >= 2
With epidural	1h 6m (3h 36m)	24m (2h)	18m (1h 36m)
Without epidural	36m (2h 48m)	12m (1h 18m)	6m (1h 6m)

Data are median time in hours and minutes (95th Percentile)

Several studies have shown that the length of the second stage does not affect neonatal outcomes and therefore an intervention in the second stage is not warranted solely because of an arbitrary amount of time has passed.[68,69]

Rouse et al. studied 4,126 nulliparous women in the second stage and found even in women who labored more than 5 hours, no increase in neonatal morbidity was found. They defined neonatal morbidity as 5-minute Apgar < 4, umbilical artery pH < 7.0, intubation in the delivery room, need for admission to neonatal ICU, or neonatal sepsis.[69] Another study of 1,862 nulliparous women in the second stage found that early vs. delayed pushing did not affect neonatal outcomes, including in women who pushed for more than 3 hours.[70] A third study of 15,759 nulliparous women also found no association of the length of second stage with neonatal outcomes, even in women pushing for greater than 4 hours.[71]

However, two studies of multiparous women in the second stage did find some association of the length of second stage and increased neonatal morbidity. A study of 5,158 multiparous women found that if the second stage of labor was greater than 3 hours, the risk of a 5-minute Apgar score < 7 and admission to neonatal ICU increased.[72] Another study of 58,113 multiparous women found an increase in neonatal morbidity if the second stage was more than 2 hours. However, it is important to note that while the neonatal morbidity did increase with time, the absolute risk was low.[41,73]

In addition, while studies of nulliparous women found no association of length of second stage and neonatal morbidity, they did find an association with maternal morbidity, including puerperal infection, third and fourth-degree lacerations, and post-partum hemorrhage.[69] It is important to note that some of the morbidity may not be due to the length of the second stage itself, but rather to interventions used by physicians such as operative delivery that can cause perineal trauma.[74] It is also possible that the outcomes themselves caused an extended labor, for example evolving chorioamnionitis may predispose to longer labors.[41]

In addition, all studies found that as time went on, the chance of spontaneous vaginal delivery significantly decreased. Menticoglou et al. found that after 5 hours in the second stage, the chance of spontaneous delivery in the following hour are only about 10-15%.[68] Rouse et al. found that while 85% of those whose second stage was under one hour delivered spontaneously, when the second stage was over 5 hours, the rate of spontaneous vaginal delivery dropped to 9%.[69] A study of multiparous women found after 3 hours in the second stage only 1 in 3 women delivered spontaneously and more than a third required vaginal operative delivery.[72]

Induction of labor

Twenty-three percent of gravid U.S. women undergo induction of labor.[53] Induction of labor is used to stimulate regular uterine contractions before the onset of spontaneous labor in the hopes of achieving vaginal delivery. It is used when the risks of continuing the pregnancy outweigh the risks of induction. Example conditions that may warrant induction are: gestational hypertension, preeclampsia, diabetes mellitus, premature rupture of membranes and severe fetal growth restriction.[75]

Methods of induction include oxytocin infusion, prostaglandin administration, amniotic membrane stripping, and amniotomy. Women who undergo induction are about twice as likely to have a cesarean than those who enter labor spontaneously, and this risk may be due to unfavorable cervices. An unfavorable cervix is defined as a Bishop score less than 6; calculated from dilation, effacement, station, consistency, and position of cervix; see Table 4.[76-78] A 2004 retrospective cohort study found that nulliparous women at term were 1.8 times as likely to have a cesarean delivery if they had an elective induction compared to those who entered labor spontaneously.[77] A 2005 prospective cohort study of nulliparous women at term medically and electively induced found that compared to women who entered labor spontaneously, those induced for medical reasons had a 2.2 fold increased risk of cesarean delivery and those induced electively had a 2.3 fold increased risk. However, after adjusting for Bishop score on admission, they found no significant difference in cesarean rates among the three groups. They found that Bishop score <5 was the predominant risk factor for cesarean delivery.[76]

To make a cervix more favorable, ripening methods can be used. Such methods include administration of exogenous prostaglandin analogs (e.g. misoprostol, prostaglandin gel), or placement of balloon catheters above the internal cervical os to facilitate local endogenous release of prostaglandins.[75] Prostaglandins activate metalloproteinases which degrade collagen in the cervix resulting in cervical softening, effacement, and dilation. Cochrane Reviews from 2001 and 2012 of studies of mechanical methods of induction, including studies of nulliparous and multiparous women, found that use of mechanical methods was associated with a decrease in the cesarean delivery rate compared to oxytocin alone in women with an unfavorable cervix.[79,80] Cochrane Reviews from 2003, 2009 and 2014 of studies of vaginal prostaglandin for induction of labor at term, which include studies of both nulliparous and multiparous women, found that vaginal prostaglandins compared to placebo or oxytocin alone increases the likelihood of vaginal delivery within 24 hours of induction initiation, but does not affect the overall cesarean delivery rate and does increase the risk of uterine tachysystole with associated fetal heart rate changes.[81-83]

It is also possible to use a combination of ripening and induction methods if another method fails. One observational study of nulliparous and multiparous women with low Bishop scores who failed induction with misoprostol (i.e. did not achieve regular contractions and cervical change with intravaginal misoprostol every 6 hours for 24 hours) and then had a transcervical Foley catheter placed, found that 83% of these patients went on to achieve vaginal delivery with no increase in neonatal morbidity. [84]

Table 4. Bishops Score to Assess the Readiness of Cervix for Induction of Labor[75]

	Points			
Cervical Exam	0	1	2	3
Dilation (cm)	Closed	1-2 cm	3-4 cm	5-6 cm
Effacement (%)	0-30%	40-50%	60-70%	80%
Station	-3	-2	-1,0	+1,+2
Consistency	Firm	Medium	Soft	---
Position	Posterior	Mid	Anterior	---

When a cesarean delivery occurs after induction, but before the active phase, it is often due to a diagnosis of “failed induction.” The length of time before a diagnosis of “failed induction” has varied significantly over time. In a study published in 2000, Rouse et al. suggested that induction should only be determined to have failed after a minimum of 12 hours of oxytocin administration with ruptured membranes if the cervix had not achieved a dilation of at least 4 cm and 90% effacement or 5 cm regardless of effacement.[85]

A 2005 study by Simon et al. showed that half of nulliparous women in labor after induction remained in the latent phase (defined as ending at 4 cm cervical dilation and 80% effacement or 5 cm cervical dilation regardless of effacement) for at least 6 hours and nearly one-fifth for 12 hours or greater.[86]

In 2012, Harper et al. found that latent labor is significantly slower in both multiparous and nulliparous women being induced compared to women in spontaneous labor. After 6 cm, rates of cervical dilation are similar to women in spontaneous labor, but before then it may take over 8 hours for an induced nulliparous patient to progress from 3 cm to 4 cm, and almost 17 hours to progress from 4 cm to 10 cm. Before 6 cm of dilation induced nulliparous patients needed about 1.5 to 5.8 hours longer to complete each centimeter of dilation compared to spontaneously laboring nulliparous patients, while induced multiparous patients needed about 2.5 to 7.7 hours more compared to spontaneously laboring multiparous patients. [87] (See Table 5, Figure 4)

Table 5. Time from 4 cm of cervical dilation to 10 cm[87]

Nulliparous		Multiparous	
Induced	Spontaneous	Induced	Spontaneous
5.5 (16.8)	3.8 (11.8)	4.4 (16.2)	2.4 (8.8)

Median hours (95 percentile) from 4 cm to 10 cm

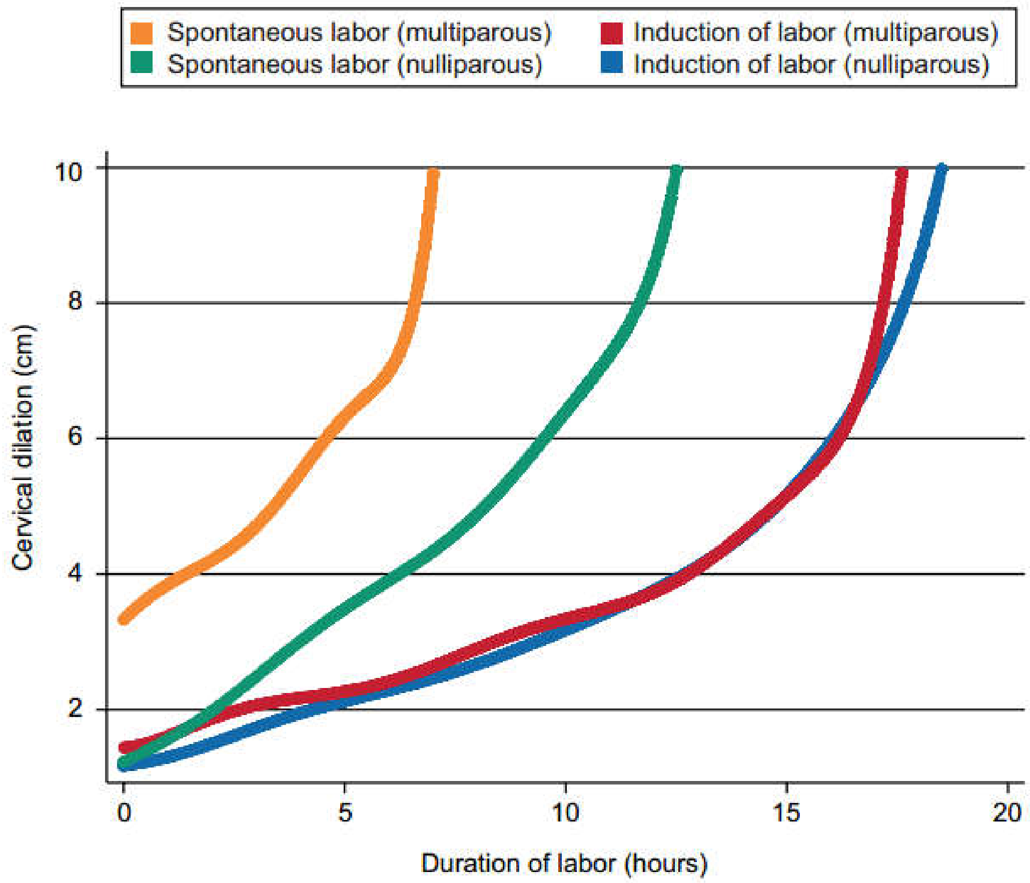


Figure 4 Average labor curves comparing induction versus spontaneous labor[87]

Though latent labor is longer in induced women, vaginal delivery is still highly attainable. One study found that nearly 40% of the women who were still in the latent phase (defined as ending at 4 cm cervical dilation and effacement of at least 90%, or at a cervical dilation of 5 cm regardless of effacement) after 12 hours of oxytocin and rupture of membranes went on to have a successful vaginal delivery.[88] Another study, found that over 50% of induced women with a first stage of labor longer than 24 hours delivered vaginally, and over 60% when only considering multiparous women.[89] Most recently, Grobman et al. found that 96.4% of induced women reach the active phase (defined as 5cm) by 15 hours, and that 40% of induced women whose latent phase lasted for 18 or more hours still had a vaginal delivery. Importantly, maternal hemorrhage and chorioamnionitis increased in frequency as the length of the latent phase increased (though absolute numbers remained small), but perinatal outcomes were statistically stable over time.[90]

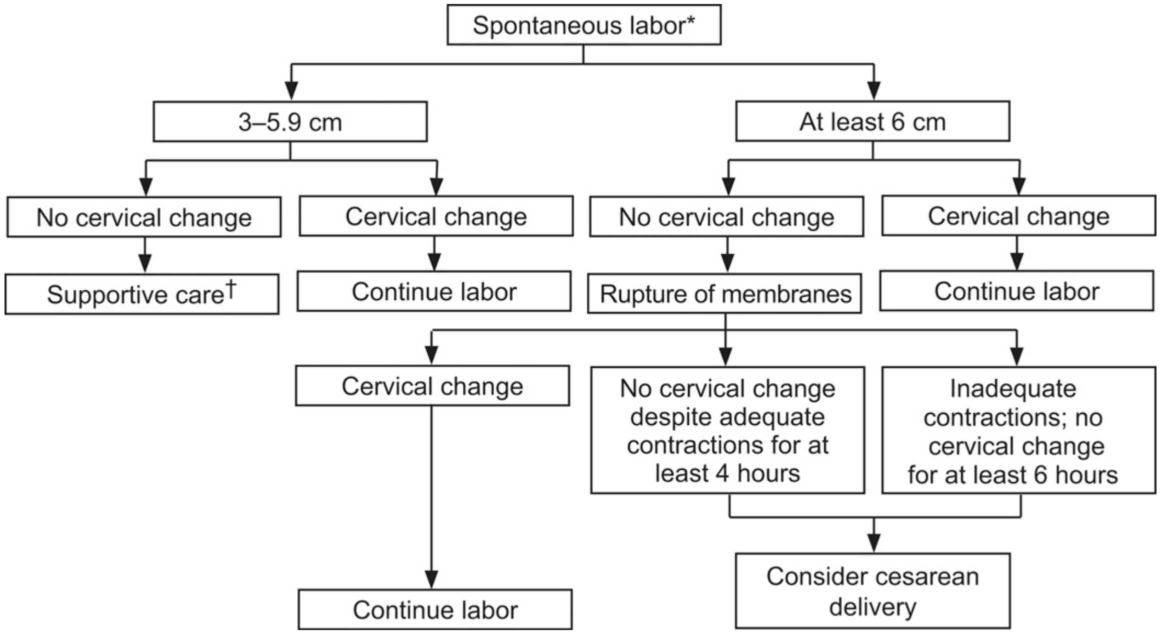
NEW RECOMMENDATIONS FOR LABOR MANAGEMENT

In 2012 a summary by Spong et al. of the Society for Maternal-Fetal Medicine, Eunice Kennedy Shriver National Institute of Child Health and Human Development, and American College of Obstetricians and Gynecologists workshop recommended allowing a woman to continue to labor if maternal and fetal wellbeing remained stable.[1] Said another way, the decision to move to cesarean delivery should not be solely based on the amount of time elapsed. Largely based on this publication, ACOG/SMFM Obstetric Care Consensus by Caughey et al. established new practice recommendations for labor management in 2014.[41]

Arrest of dilation

Spong et al.: First-stage arrest is when a woman is at least 6 cm dilated with membrane rupture and no cervical change for at least 4 hours of adequate contractions (e.g., >200 Montevideo units) or 6 hours of inadequate contractions.[1] (See Figure 5 for algorithm for managing the first stage of spontaneous labor.)

Caughey et al.: Cesarean delivery in the first stage of labor for active-phase arrest should only be performed when women are at least 6 cm dilated with rupture membranes and fail to dilate further after at least 4 hours of adequate uterine activity or at least 6 hours of oxytocin administration with inadequate uterine activity.[41]



Arrest of descent

Spong et al.: Second-stage arrest is when no descent or rotation has occurred for 4 hours or more in nulliparous women with an epidural, 3 hours or more in nulliparous women without an epidural, 3 hours or more in multiparous women with an epidural, 2 hours or more in multiparous women without an epidural.[1]

Caughey et al.: Before determining that arrest in the second stage has occurred, at least two hours of pushing in multiparous women and at least three hours of pushing in

Figure 5 Proposed algorithm for managing spontaneous labor by Spong et al. [1]

nulliparous women should be allowed. More time can also be allotted if the fetus is malpositioned or there is another process that may prolong the labor, such as epidural anesthesia.[41]

Failed induction of labor

Spong et al.: Failed induction of labor is a failure to generate regular (e.g., every 3 min) contractions and cervical change after at least 24 hours of oxytocin administration, with artificial membrane rupture if feasible.[1] (See Figure 6 for algorithm for management of induced labor.)

Caughey et al.: Allow ≥24 h in the latent phase, with oxytocin administration for at least 12-18 h after membrane rupture before deeming induction failure.[41]

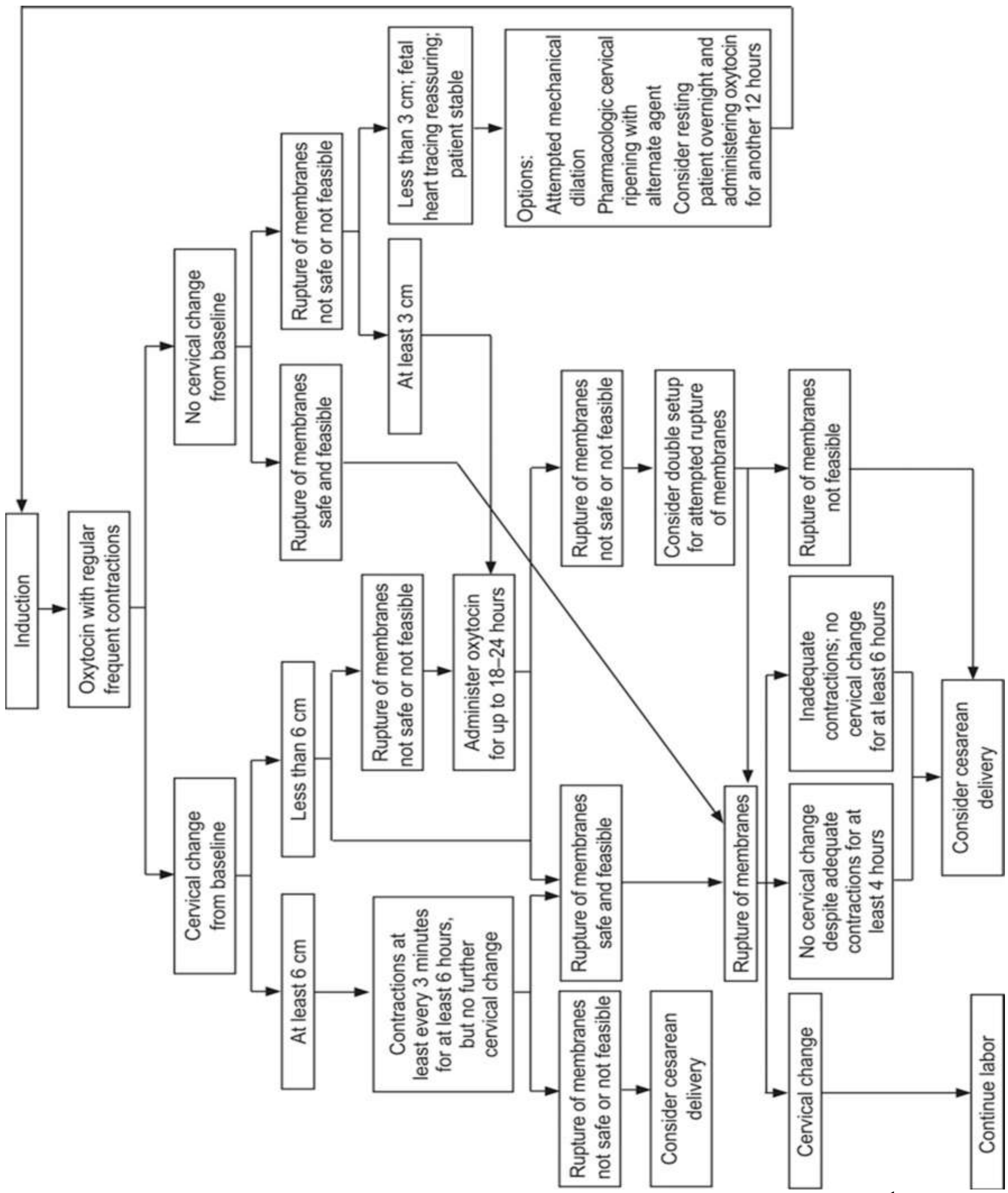


Figure 6 Proposed algorithm for management of induced labor by Spong et al.[1]

POTENTIAL ROLE OF RECOMMENDATIONS

These guidelines were intended to reduce cesarean delivery rates by decreasing the diagnosis of labor arrest disorders by changing the criteria in recognition of new analyses of modern labor patterns. However, this hinged on adoption of new criteria by clinicians in real time during the management of real labors.

A recent study at Yale New Haven Hospital among 22,265 births during this time frame by Cross et al. found the cesarean rate decreased from 36.5% in 2009 to 32.4% in 2013, with 74% of the decrease attributable to a decrease in primary cesareans from 25.4% to 20.4%. As an indication, the diagnosis of labor arrest contributed the largest proportion (46%) to the decrease in the primary cesarean rate.[40] This led us to wonder about the temporal and quantitative impact of the emerging publicized work of Zhang et al. describing modern labor curves and the 2012 SMFM guidelines on the diagnosis of labor arrest and failed induction prior to cesarean. These recommendations potentially affected rates of primary cesarean delivery and the numbers of cesarean delivery that met the new criteria for labor arrest. By examining cesarean deliveries over this time period, we could also measure the proportion of births that did not meet the new criteria for labor arrest and thus estimate the achievable scope of potential improvement.

STUDY AIMS AND HYPOTHESIS

Because cesarean delivery is associated with significant morbidity, especially maternal morbidity in subsequent pregnancies, it is important to limit its use to ensure the benefits outweigh the risks. Cesareans for labor arrest currently make up the largest proportion of primary cesarean delivery in the United States. New diagnostic criteria to limit this diagnosis have the potential to decrease the primary cesarean delivery rate.

We aimed to better understand primary cesarean for labor arrest. In this retrospective analysis we examined how rates of labor arrest in the first and second stage and failed induction changed over time and if new guidelines in 2012 impacted the rate of primary cesarean delivery due to these indications. We also aimed to identify predictors of meeting baseline criteria based on these guidelines and to characterize the proportion that is yet modifiable by full adoption of the guidelines. Such efforts could help to design and focus processes that may help to further safely reduce the primary cesarean rate due to labor arrest and failed induction, and in turn, the overall primary cesarean delivery rate and the incidence of perinatal morbidity.

We hypothesized that cesarean delivery for labor arrest and failed induction would decrease and that the proportion meeting the new diagnostic criteria would increase over time with year being a significant predictor. Other potential factors associated with meeting diagnostic criteria included maternal and obstetric characteristics such as body mass index, parity, type of obstetric provider, dilation upon admission, and use of epidural.

STUDY DESIGN

To investigate primary cesareans due to labor arrest, we conducted a retrospective cohort study of all births (n=17,877) at Yale New Haven Hospital between January 1, 2010 through December 31, 2013. Yale New Haven Hospital is a tertiary level academic center that serves a diverse urban and suburban population and is the main referral center within a 50-mile radius of New Haven, Connecticut. While one-third of the patients are cared for by full-time faculty of the Yale School of Medicine (referred to as hospitalists here within), two-thirds are cared for by private community providers. The demographics and the cesarean rates in this sample are generally representative of the population in Connecticut and nationally to yield relevant data on labor arrest and cesarean delivery.

We examined sub-groups of arrest of dilation, arrest of descent and failed induction, and used logistic regression to identify predictors of meeting baseline criteria for these indications from 2010 to 2013. Data on all births were collected, including mode of delivery, and, if via cesarean section, the indication for cesarean section that was documented by the physician. Indications for cesarean delivery are recorded in the medical record and the labor log, and subsequently by a nurse administrator exactly as documented by the physician in the medical record. Since 1996, total number of live births, cesarean births, and vaginal birth after cesarean have been recorded this way. Indications for each cesarean have been compiled since 2003. To confirm that indications recorded by the nurse administrator were consistent with indications given by the physician in the medical record, labor log indications for our study period were compared with physician indicated reasons in the medical chart and total number of data points were compared with nurse administrator counts. Any discrepancies were reviewed with the research team to clarify and re-assign primary indication for cesarean. This data was used to calculate number of live births, total cesarean delivery rate, and total primary cesarean delivery rate.

More detailed maternal demographic data and obstetric-fetal characteristics were collected for subjects with one of three physician-documented indications for cesarean: arrest of dilation, arrest of descent, or failed induction of labor. This included date and time of delivery, maternal race, age, pregnancy history (GTPAL prior to delivery), prior spontaneous vaginal deliveries (SVD), body mass index (BMI), attending surgeon at cesarean delivery (hospitalist or community), gestational age of fetus at delivery, singleton or multiple gestation, birth weight of neonate(s), and reason for induction of labor if labor was induced. Date and time of delivery was initially obtained from paper labor logs, while all other data was obtained from electronic medical records (EMR).

In addition to items listed above, data was collected from the EMR regarding the criteria for labor arrest and failed induction including date and time of: admission, oxytocin administration, rupture of membranes, sterile vaginal exam (SVE) on admission, and maximum cervical dilation before cesarean; numbers of centimeters dilated on admission and maximal dilation before cesarean; reason for induction, if induced; and type of operative delivery attempted if an attempt was made.

To find the time arrested in the first stage, duration at maximal dilation was determined by calculating the time elapsed between the first time a patient was found to be at maximal dilation and the last time a patient was found to be at maximal dilation. If the patient was not recorded to previously be at maximal dilation, maximal dilation - 0.5cm was used to determine first time point. For example, if maximal dilation was 7 cm, the first time the patient was found to be 7 cm or 7 cm – 0.5 cm (6.5 cm/6-7 cm) was recorded for the first time point. On occasion, the patient was not previously recorded to be at maximal dilation or maximal dilation - 0.5 cm. In this instance, maximal dilation – 1 cm was used to determine the first time point. For example, if maximal dilation was 8 cm, but the patient was not previously recorded as being 8 cm or 7.5 cm (7-8 cm), the first time the patient was 7 cm was used as the first time point.

To find the time arrested in the second stage, duration of second stage was determined by calculating time elapsed from first time recorded at full dilation to time of delivery.

To find the length of induction, duration of oxytocin administration was determined by calculating the time elapsed from the onset of oxytocin administration to delivery.

Due to non-normal distributions of the length of time arrested in first or second stage and the length of induction, averages of these times were not used in analysis. Instead, median durations for each category were calculated for every year and compared using the Kruskal-Wallis test.

Cesarean delivery rates were calculated as number of cesarean births divided by total live births.[91] Overall primary cesarean rate and primary cesarean rates for each selected indication (arrest of dilation, arrest of descent, and failed IOL) were calculated annually by number of primary cesarean deliveries divided by total women at risk that year period (i.e. no personal history of cesarean delivery).[60] Change in rates over time were examined by including time (year) in logistic regression models as a continuous variable (time trends) and categorical variable (to examine distinct years).

Baseline criteria for failed induction and labor arrest were defined based on guidelines by Spong et. al. in the 2012 Summary of a Joint Eunice Kennedy Shriver National Institute of Child Health and Human Development, Society for Maternal Fetal Medicine, and American College of Obstetricians and Gynecologists Workshop.[1] The proportions of cesarean deliveries meeting these criteria each year were calculated.

Minimum criteria for our study:

Arrest of dilation: at least 4 hours at a final dilation greater than or equal to 6cm.[A]

Arrest of descent: at least 4 hours at full dilation for nulliparous women with an epidural, at least 3 hours at full dilation for nulliparous women without an epidural, at least 3 hours full dilation for multiparous women with an epidural, and at least 2 hours at full dilation for multiparous women without an epidural.

Failed induction: at least 24 hours of oxytocin or at least 12 hours of oxytocin with rupture of membranes.

A. While Spong et.al. proposes a 4-hour minimum in the case of adequate contractions, defined as > 200 Montevideo units, and a 6-hour minimum if contractions are inadequate, we found that patient charts lacked consistent documentation regarding adequacy of contractions and we therefore chose to use the more liberal minimum of 4 hours.

Multiple logistic regression modeling was used to examine the use of cesarean delivery over time for indications of labor arrest and failed induction and to identify predictors of meeting baseline criteria for these indications over the 4-year period.

Variables used in logistic regression modeling for all three indications were year, race (African American, Asian, Hispanic, white, other), age, BMI (<30, 30-40, >=40), history of prior vaginal delivery, gestational age (<37, 37-38, 38-39, 39-40, 40-41, 41-42, >=42 weeks), and attending (hospitalist, private). In addition, maximum centimeters of dilation before cesarean was used in failed induction of labor modeling. This was not used for arrest of dilation or arrest of descent as final dilation was part of the outcome criteria for these two categories. Centimeters of dilation on admission was used in logistic regression for arrest of dilation and descent. In addition, epidural use was also used in modeling for arrest of descent.

Project design and development was by Dr. Jessica Illuzzi, Dr. Christian Pettker, Dr. Sarah Cross and Jessica Greenberg. Data collection for arrest of dilation or descent and failed induction was performed by Jessica Greenberg with guidance from Dr. Sarah Cross, and assistance from medical student Sarah Abelman, who collected data on epidural use. Data collection for number of total births, total cesareans, and primary cesareans by Cheryl Raab. Jessica Greenberg analyzed data with excel and SAS 9.4 with assistance from Dr. Jessica Illuzzi. The Yale University Human Investigation committee approved this study.

STUDY RESULTS

Of the 17,877 live births, 5,866 (32.8%) were cesarean births, of which, 3,327 (18.6%) were primary cesareans. Three categories of physician-documented indications for primary cesarean were examined further: arrest of dilation (n = 654), arrest of descent (n = 406), and failed induction of labor (failed IOL, n = 66), totaling 1,126 and representing 33.8% of all primary cesarean deliveries from 2010 through 2013. (See Table 6 for demographic information.)

The rate of total primary cesarean delivery decreased from 23.5% in 2010 to 21.1% in 2013 ($p<0.03$). Over the same period, primary cesarean delivery due specifically to arrest of dilation or descent and failed induction decreased from 8.5% in 2010 to 6.7% in 2013 ($p<0.005$). (See Figure 7)

Table 6. Demographic and Obstetrical Characteristics for Primary Cesarean Delivery Due to Failed IOL, Arrest of Dilation, or Arrest of Descent

	2010	2011	2012	2013
	n=312	n=273	n=284	n=257
Race				
White	190 (60.9%)	167 (61.2%)	182 (64.1%)	156 (60.7%)
African American	43 (13.8%)	51 (18.7%)	37 (13.0%)	44 (17.1%)
Hispanic	48 (15.4%)	32 (11.7%)	38 (13.4%)	35 (13.6%)
Asian	19 (6.1%)	13 (4.7%)	17 (6.0%)	11 (4.3%)
Other	9 (2.9%)	9 (3.3%)	6 (2.1%)	6 (2.3%)
BMI				
<30	114 (36.5%)	117 (40.7%)	92 (32.4%)	90 (35.0%)
>=30, <40	150 (48.1%)	124 (45.4%)	144 (50.7%)	128 (49.8%)
>=40	48 (15.4%)	38 (13.9%)	48 (16.9%)	39 (15.2%)
Prior SVD	35 (11.2%)	25 (9.2%)	25 (8.8%)	25 (9.7%)
Maternal age	66 (21.2%)	57 (20.9%)	54 (19.0%)	73 (28.4%)
<35	246 (78.9%)	216 (79.1%)	230 (81.0%)	184 (71.6%)
>=35, <40	55 (17.6%)	41 (15.0%)	41 (14.4%)	57 (22.2%)
>=40	11 (3.5%)	16 (5.9%)	13 (4.6%)	16 (6.2%)
Multiple gestation	6 (1.9%)	1 (0.4%)	2 (0.7%)	7 (2.7%)
Gestational age				
<37 weeks	17 (5.5%)	5 (1.8%)	9 (3.2%)	10 (3.9%)
>=37, <38 weeks	12 (3.9%)	11 (4.0%)	11 (3.9%)	8 (3.1%)
>=38, <39 weeks	32 (10.3%)	21 (7.7%)	30 (10.6%)	34 (13.2%)
>=39, <40 weeks	74 (23.7%)	59 (21.6%)	60 (21.1%)	60 (23.4%)
>=40, <41 weeks	86 (27.6%)	97 (35.5%)	71 (25.0%)	83 (32.3%)

>=41, <42 weeks	85 (27.2%)	74 (27.1%)	94 (33.1%)	58 (22.6%)
>=42 weeks	6 (1.9%)	6 (2.2%)	9 (3.2%)	4 (1.6%)
Birth weight				
<2500g	13 (4.1%)	4 (1.5%)	8 (2.8%)	11 (4.2%)
2500-4499g	294 (92.5%)	259 (94.5%)	267 (93.4%)	245 (92.8%)
>4500g	8 (2.5%)	11 (4.0%)	10 (3.5%)	8 (3.0%)
Induced	165 (52.9%)	141 (51.7%)	160 (56.3%)	142 (55.3%)
Attending				
Private	240 (76.9%)	209 (76.6%)	222 (78.2%)	194 (75.5%)
Hospital	72 (23.1%)	64 (23.4%)	62 (21.8%)	63 (24.5%)

Data are n (%) for all primary cesarean deliveries due to failed induction, arrest of dilation, and arrest of descent. Some columns may not equal 100% because of missing data.

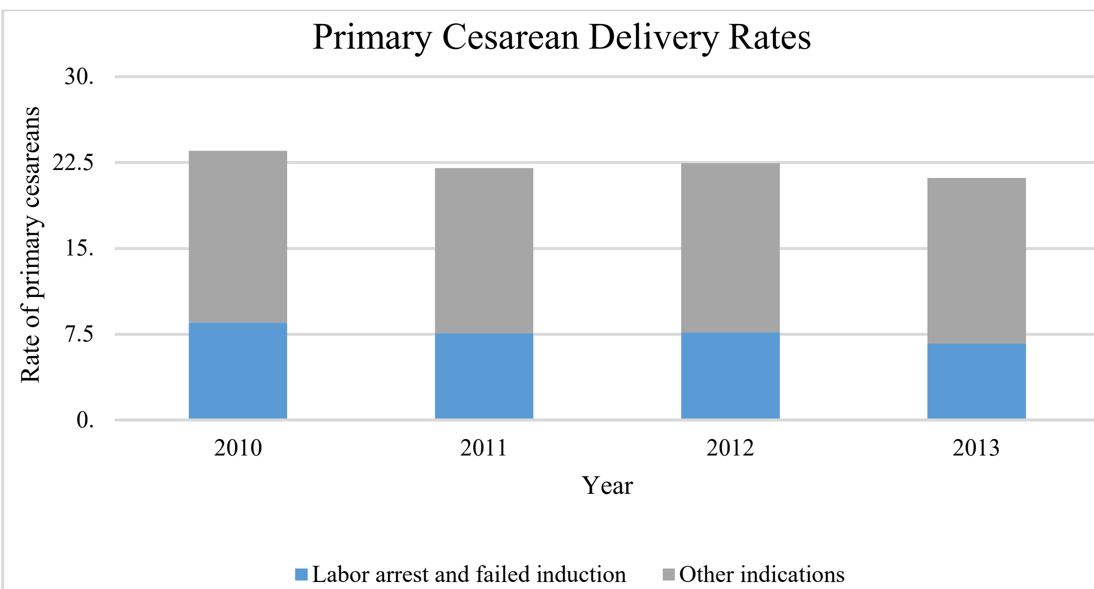


Figure 7 Each bar represents the primary cesarean delivery rate for that year. The blue area of the bar represents primary cesarean deliveries due to labor arrest and failed induction.

Arrest of dilation

Primary cesarean delivery due to arrest of dilation decreased from 5.1% in 2010 to 3.4% in 2013 ($p<0.0005$, See Figure 8). No significant difference in rates was seen comparing 2011 to 2010 (OR 0.92, 95% CL 0.75-1.14) or 2012 to 2010 (OR 0.86, 95% CL 0.69-1.07), but there was a significant difference between 2013 and 2010 (OR 0.67, 95% CL 0.53-0.84). The rate of meeting the minimum criteria of at least 4 hours at a final SVE $\geq$ 6 cm before a cesarean delivery for arrest of dilation changed significantly over time ($p=0.003$) increasing from 18.8% in 2010 to 34.9% in 2013 (See Table 7, Figure 9). Year, admission SVE, and attending were found to be significant predictors of meeting these criteria. There was an increased odds of meeting criteria in 2012 compared to 2010 (OR 2.15, 95% CL 1.25-3.68) and 2013 compared to 2010 (OR 2.26, 95% CL 1.30-3.95), but not in 2011 compared to 2010 (OR 1.59, 95% CL 0.92 – 2.72). With every increase in 1 cm of admission SVE, there was an increased likelihood of meeting criteria: 1.49 (95% CL 1.32 – 1.67). Hospitalist cases were more likely to meet criteria for arrest of dilation compared with private cases: 4.00 (95% CL 2.60 – 6.16). Of the 654 cesarean deliveries performed for arrest of dilation, 79.7% (n=521) were private cases and 20.3% (n=133) were hospitalist cases.

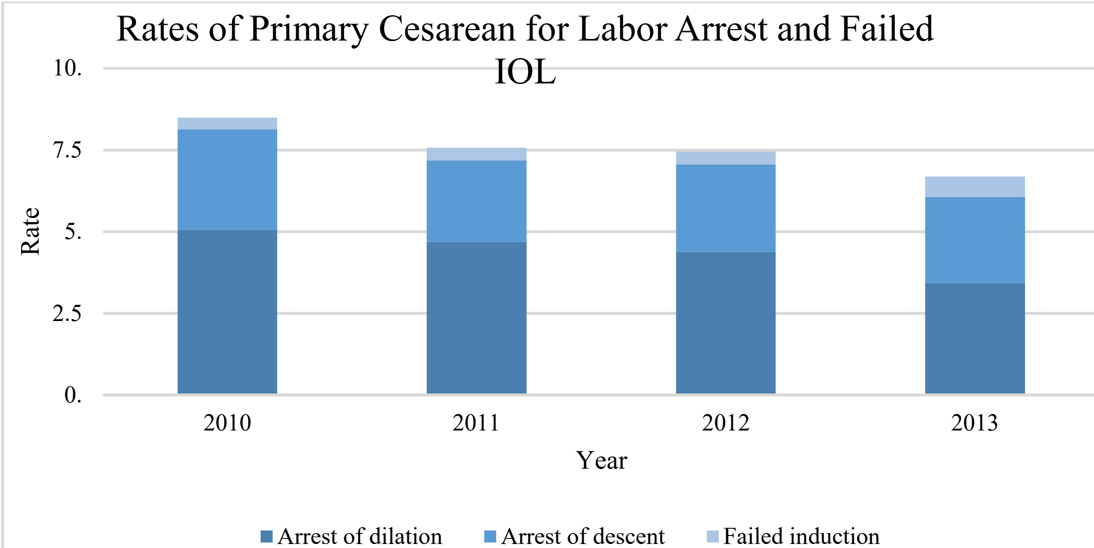


Figure 8 Each bar represents the primary cesarean delivery rate combined for labor arrest and failed induction that year. The dark blue area of the bar represents primary cesarean deliveries due to arrest of dilation, the medium blue area of the bar represents primary cesarean deliveries due to arrest of descent, and the light blue area of the bar represents primary cesarean deliveries due to failed induction.

Table 7. Percent of cesareans performed for arrest of dilation that met criteria.[A]

	2010	2011	2012	2013
Overall	18.8%	29.0%	29.3%	34.9%
Private	14.0%	23.3%	23.0%	27.2%
Hospitalist	38.9%	50.0%	56.3%	62.1%

A. >= 4 hours at an SVE >= 6 cm

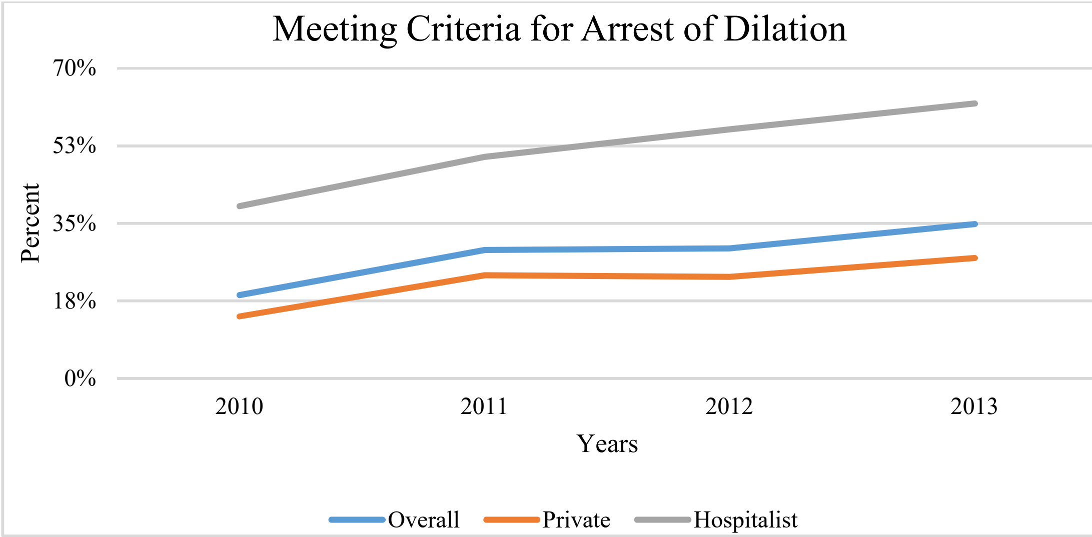


Figure 9 Percent of cesareans for arrest of dilation that met criteria.

A subset of those diagnosed with labor arrest are subjects who did not ever reach 6 cm of cervical dilation. Based on the new criteria, these parturients are not in active labor and therefore should not be diagnosed with labor arrest until other criteria have been met. Of cases performed for arrest of dilation, 39.2% of cases were performed before 6 cm (latent labor) in 2010 and 31.8% of cases were performed before 6 cm in 2013. This rate was relatively stable over time (p=0.30) and year did not significantly predict a patient being at least 6 cm. Admission SVE, prior SVD, BMI, and attending type were are predictive of being at least 6 cm. With every increase in 1 cm of admission SVE, there was an increased likelihood of being at least 6 cm: 1.5 (95% CL 1.4 – 1.7). Prior vaginal delivery increased odds of being at least 6 cm: 3.4 (95%CL 1.6-7.1). Morbid obesity (BMI $\geq$ 40) decreased the odds of being at least 6 cm by more than half (OR 0.58, 95% CL 0.37-0.91) compared to obesity (40>BMI $\geq$ 30) and a little less than half compared to a BMI < 30 (OR 0.49, 95% CL 0.30-0.8). No difference was seen between obesity and a BMI < 30 (OR 0.84, 95% CL 0.57-1.25). Hospitalist patients were more likely to be at least 6 cm compared with private patients: 2.4 (95% CL 1.5-3.8). In 2013, 64.1% of private patients were at least 6 cm where 82.8% of hospitalist patients were at least 6 cm.

The median time at maximal dilation over the four-year period increased from 3.6 hours in 2010 to 4.9 hours in 2013 ($p<0.03$). (See Table 8, Figure 10.)

Table 8. Median hours at maximal dilation before cesarean for arrest of dilation.

	2010	**2011**	**2012**	**2013**	**P value**
All	3.6	4.3	4.6	4.9	**0.03**
Private	3.5	4.0	4.5	4.4	0.11
Hospitalist	5.1	5.8	6.1	6.0	0.30

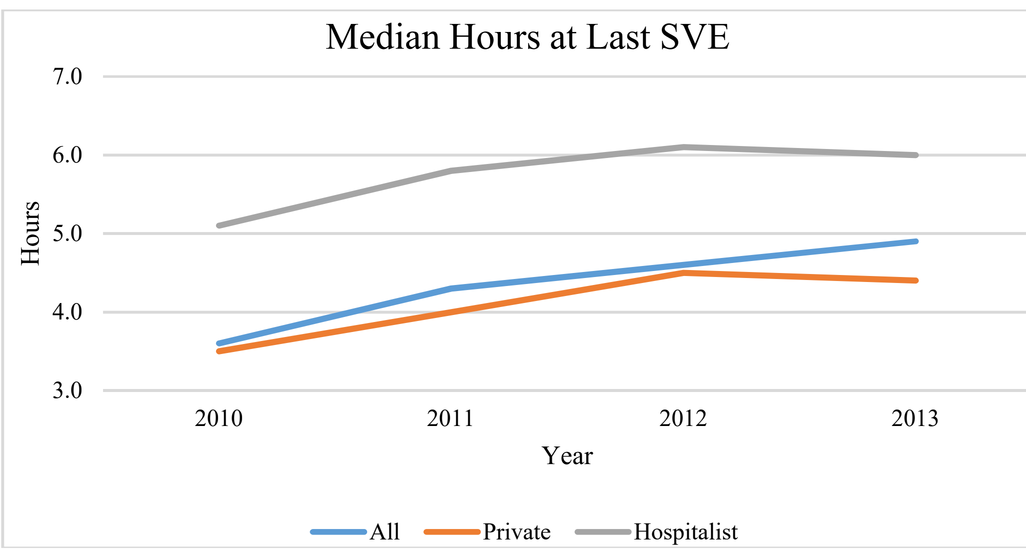


Figure 10 Median hours at maximal dilation before cesarean for arrest of dilation.

Arrest of descent

Primary cesarean delivery due to arrest of descent remained relatively stable at 3.1% in 2010 and 2.6% in 2013 (p=0.3). (See Figure 8.) No significant difference was found between 2011 and 2010 (OR 0.81, 95% CL 0.61-1.07), 2012 and 2010 (OR 0.87, 95% CL 0.66-1.14), or 2013 and 2010 (OR 0.85, 95% CL 0.65-1.12). However, the percent of cases that met the minimum criteria for arrest of descent (at least 4 hours at full dilation in a nulliparous woman with an epidural, at least 3 hours in a nulliparous woman without an epidural, at least 3 hours in a multiparous woman with an epidural, or at least 2 hours in a multiparous woman without an epidural) did significantly change over time (p<0.007), increasing from 57.8% in 2010 to 71.0% in 2013 (See Table 9, Figure 11). Year, admission SVE, not having an epidural, and attending were significant predictors of meeting criteria. Meeting criteria was more likely in 2013 compared to 2010 (OR 2.06, 95% CL 1.13-3.76), but not in 2012 or 2011 compared to 2010 (OR 0.94, 95% CL 0.84-1.05; OR 0.87, 95% CL 0.48-1.59). With every increase in 1 cm of admission SVE, there was an increased likelihood of meeting criteria: 1.16 (95% CL 1.04 – 1.30). Having an epidural decreased the odds of meeting criteria by 0.35 (95% CL 0.15-0.83). Again, hospitalist cases were more likely to meet criteria for arrest of descent than private attending cases: 2.44 (95% CL 1.41 – 4.21). Of the 406 cesarean deliveries performed for arrest of descent, 75.6% (n=307) were private cases and 24.4% (n=99) were hospitalist cases.

The median time at full dilation before cesarean varied significantly over the four-year period (p<0.01) with an increase in median time at full dilation from 4.0 hours in 2010 to 4.6 hours in 2013. See Table 10, Figure 12). The number of attempted operative deliveries before cesarean compared to 2010 remained stable except for an increase in 2012 ($p<0.05$, See Table 11).

Table 9. Percent of cesareans performed for arrest of descent that met criteria.[A]

	2010	2011	2012	2013
Overall	57.8%	56.2%	63.4%	71.0%
Private	50.0%	49.2%	61.3%	67.1%
Hospitalist	79.3%	75.0%	71.4%	83.3%

A. >= 4 hours if nulliparous with epidural, >= 3 hours if nulliparous without epidural, >= 3 hours if multiparous with epidural, >= 2 hours if multiparous without epidural

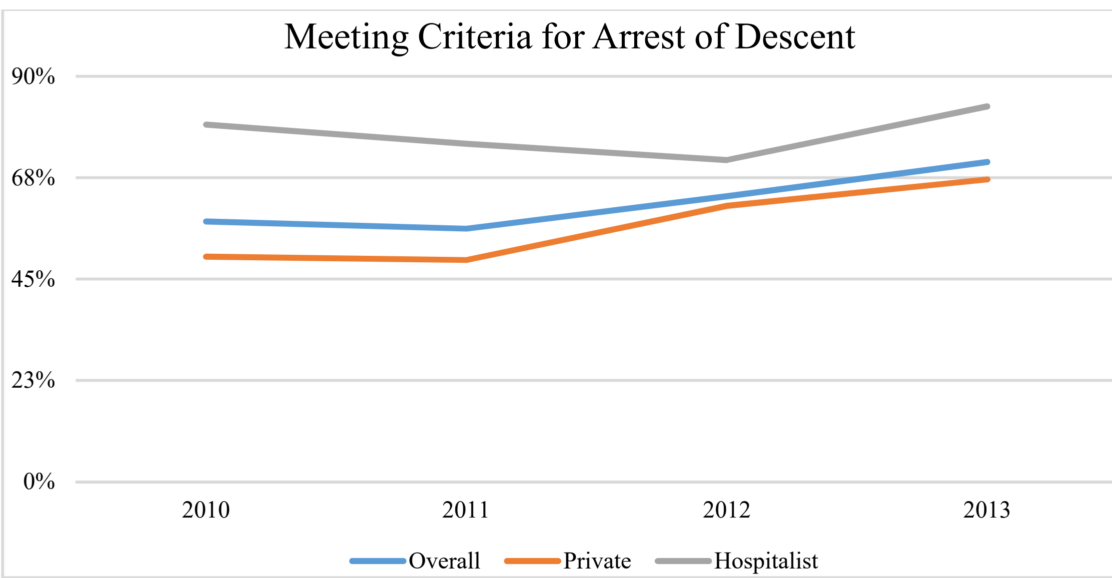


Figure 11 Percent of cesareans for arrest of descent that met criteria.

Table 10. Median hours at full dilation before cesarean for arrest of descent.

	2010	2011	2012	2013	P value
All	4.0	4.0	4.3	4.6	**0.03**
Private	4.0	3.7	4.2	4.5	**0.05**
Hospitalist	4.5	5.3	4.9	5.5	0.09

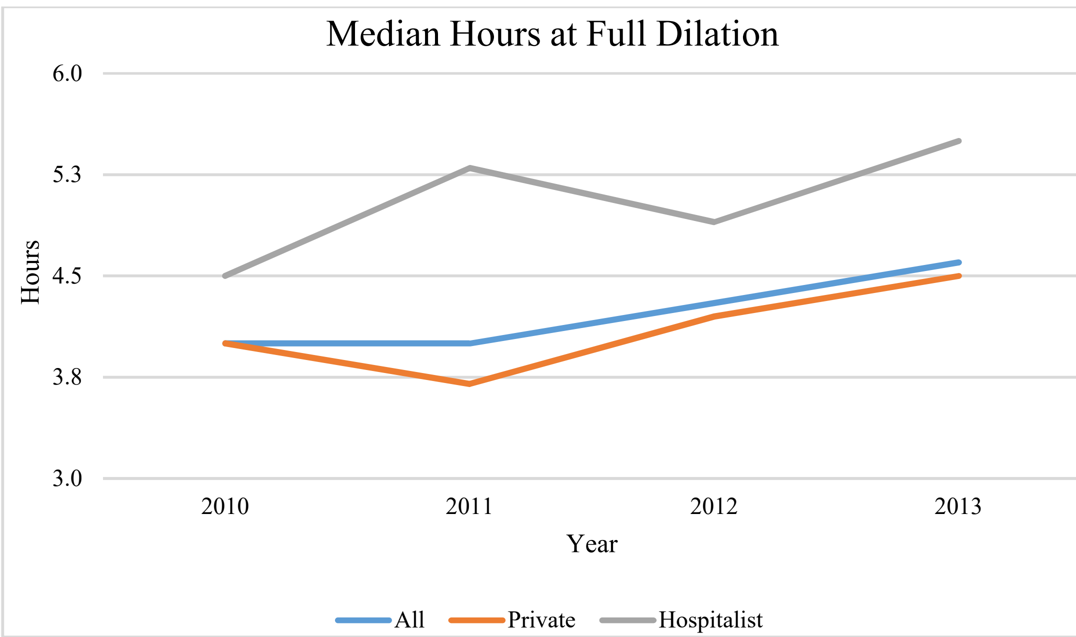


Figure 12 Median hours at full dilation before cesarean for arrest of descent.

Table 11 Attempted operative delivery before cesarean for arrest of descent.

	2010	2011	2012	2013
Attempted operative delivery	3 (2.65%)	7 (7.78%)	10 (9.80%)	4 (3.96%)

Failed induction

The rate of primary cesarean delivery due to failed induction remained relatively stable at 0.4% in 2010 and 0.6% in 2013 ($p = 0.6$). (See Figure 8.) No significant difference in the rate was found between 2011 and 2010 (OR 1.10, 95% CL 0.52-2.34), 2012 and 2010 (OR 1.11, 95% CL 0.53-2.34), or 2013 and 2010 (OR 1.77, 95% CL 0.90-3.48). The percent of primary cesarean deliveries for failed induction that met the minimum criteria of at least 24 hours of oxytocin or 12 hours of oxytocin with rupture of membranes also did not change significantly over the 4 years ($p=0.64$); on average 55.4% met criteria (61.5% met criteria in 2010 and 50.0% met criteria in 2013, See Table 12, Figure 13). Type of attending was the only significant predictor of meeting these minimum criteria. Hospitalist cases were almost seven times as likely to meet criteria for failed labor induction than private attending cases (OR 6.87, 95% CL 2.20 - 20.93). Of the 66 primary cesareans performed for failed induction during this time-period, 56.1% (n=37) were private cases and 43.9% (n=29) were hospitalist cases. The median duration of oxytocin administration before cesarean delivery over the four-year period was 18.8 hours and did not significantly vary over the 4 years ($p=0.79$).

Table 12. Percent of cesareans performed for failed induction that met criteria.[A]

	2010	2011	2012	2013
Overall	61.5%	42.9%	66.7%	50.0%
Private	60.0%	45.5%	16.7%	28.6%
Hospitalist	71.4%	33.3%	100.0%	80.0%

A. >= 24 hours of oxytocin or >= 12 hours of oxytocin with rupture of membranes

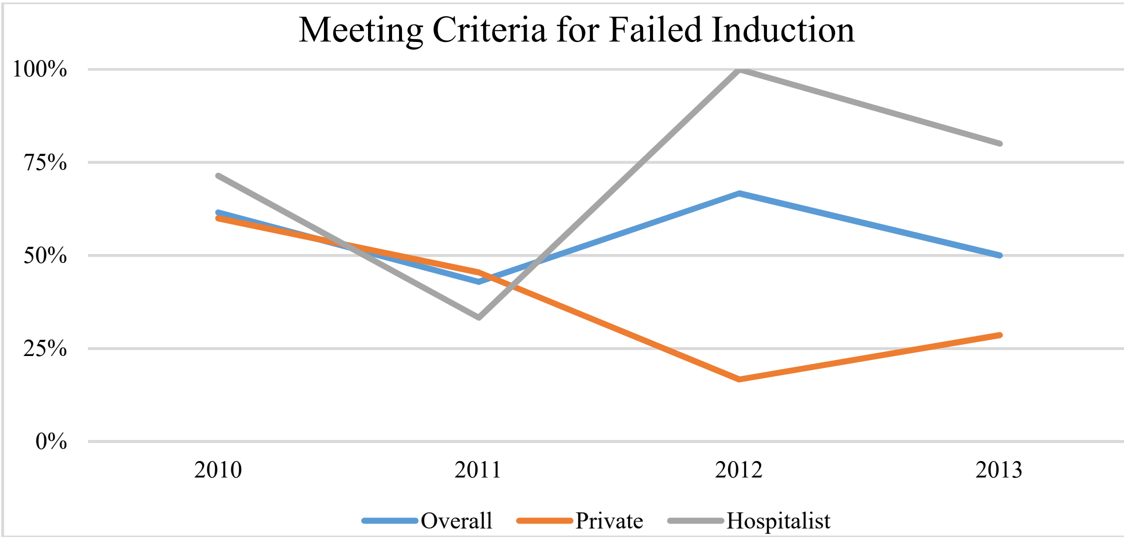


Figure 13 Percent of cesareans for failed induction that met criteria.

STUDY DISCUSSION

Among 17,877 live births at Yale New Haven Hospital, a major academic medical center in Connecticut, the primary cesarean delivery rate decreased from 23.5% in 2010 to 21.1% in 2013 ($p<0.03$). A woman was 0.87 (95% CL 0.78-0.97) times as likely to have a primary cesarean delivery in 2013 compared to 2010. When examining primary cesarean deliveries indicated for labor arrest disorders (arrest of dilation or descent and failed induction of labor), this same trend was found, with a significant decrease from 8.5% in 2010 to 6.7% in 2013 ($p<0.005$). A woman was 0.77 times as likely to have a primary cesarean delivery for labor arrest or failed induction in 2013 compared to 2010 (95% CL 0.65-0.92). Of these three categories, a decrease in primary cesarean delivery specifically due to arrest of dilation from 5.1% in 2010 to 3.4% ($p<0.0005$) in 2013 contributed significantly to the overall reduction, with a significantly decreased risk of cesarean (OR 0.67; 95% CL 0.53-0.84) in 2013 compared to 2010. Said another way, a woman was two-thirds as likely to have a primary cesarean delivery due to arrest of dilation in 2013 compared to 2010. Therefore, a decrease in the overall rate of primary cesarean delivery due to disorders of labor arrest was attributable to a decrease in the primary cesarean delivery rate for arrest of dilation.

The observed decrease in primary cesareans due to arrest of dilation coincides with the publication of Spong et al. recommendations in 2012 which redefined active labor as beginning at 6 cm instead of 4 cm, allowing women more time in latent labor.[1] The percent of cases that met minimum criteria for arrest of dilation, defined as no cervical change for at least 4 hours with at least 6 cm of dilation, increased significantly from 18.8% in 2010 to 34.9% in 2013, with cases over twice as likely to meet minimum criteria in 2013 vs. 2010. Of note, during the 4-year period, a substantial number of cesareans for arrest of dilation were performed before 6 cm, suggesting many cesareans were inappropriately performed in latent labor. The percent of cases where a woman was at least 6 cm dilated remained relatively stable during this time, and on average 62.3% of cesareans performed for arrest of dilation were performed at a dilation of at least 6 cm regardless of the time spent at final dilation. This means that over 37% of the women were technically still in latent labor when the cesarean was performed for arrest of dilation. Many of these women may have been able to avoid cesarean delivery if allowed more time to enter active labor. The median time before declaring an arrest of dilation increased over the four-year period from 3.6 hours in 2010 to 4.9 hours in 2013. While physicians may be giving women more time to labor in 2013 compared to 2010 before declaring arrest of dilation, the same percentage of women are sectioned for arrest of dilation before they actually enter active labor (≥6 cm).

While primary cesarean delivery for arrest of descent did not change significantly from 2010 to 2013, the percent of cases that met minimum criteria (defined as full dilation for at least 4 hours in a nulliparous woman with an epidural, 3 hours in a nulliparous woman without an epidural, 3 hours in a multiparous woman with an epidural, or 2 hours in a multiparous woman without an epidural) significantly increased from 57.8% in 2010 to 71.0% in 2013, with cases over twice as likely to meet minimum criteria in 2013 vs. 2010. In addition, the median total time at full dilation before cesarean for arrest of descent increased significantly from 4.0 hours in 2010 to 4.6 hours in 2013.

Though there was an increase in time allowed to laboring women in the second stage before cesarean and in cases meeting minimum criteria, the rate of primary cesarean delivery for arrest of descent did not change. This may mean that giving patients more time to labor does not avoid or mitigate arrest of descent. Conversely, it may mean that the minimum criteria are not stringent enough to prevent cesarean, and perhaps we should be allowing patients more time to labor than we currently do. It is also possible that patients that previously would have had a primary cesarean delivery for arrest of dilation were given more time to progress to fully dilated, but the labor continued to be dysfunctional and primary cesarean delivery for arrest of descent was necessary.

For cesareans performed for arrest of descent, operative delivery was only attempted 4.0% of the time in 2013. While this percentage is small, it may be that operative delivery was attempted at a far higher rate and was successful, as operative delivery is successful > 90% of the time,[92,93] therefore avoiding a cesarean for arrest of descent. However, 96% of the cesareans performed for arrest of descent did not have an attempted operative delivery before-hand. It is possible that with an increased attempt at operative delivery, there would be a reduction in cesareans performed for arrest of descent.

Primary cesarean delivery for failed induction did not change significantly over the four years. Given no significant change in rate, as expected, the percent of cases meeting minimum criteria (defined as at least 24 hours of oxytocin or 12 hours of oxytocin with rupture of membranes before cesarean) did not significantly change over this time, with on average 55.4% meeting criteria. Neither did the median hours of oxytocin administration before cesarean, with a median of 18.8 hours. The cohort for primary cesarean delivery for failed induction of labor may have been too small (n=66) to appreciate changes in care.

A previous study at Yale New Haven Hospital by Barber et al. published in 2011 found an increase in the primary cesarean rate from 2003 to 2009 was largely due to arrest of dilation with no contribution by arrest of descent.[60] This finding may have caused physicians to more closely examine their practices regarding arrest of dilation and contributed to the decrease in primary cesarean rate for that indication.

Across all three indications, we consistently find that cases are more likely to meet minimum criteria if the attending is a hospitalist. A case is four times as likely to meet minimum criteria for arrest of dilation, almost two and a half times as likely to meet minimum criteria for arrest of descent, and almost seven times as likely to meet minimum criteria for failed induction if the case was run by a hospitalist attending. In addition, a patient was almost two and a half times as likely to be at least 6 cm dilated when it was determined that her labor had arrested in the active phase if the attending was a hospitalist vs. a private. This means that the patient was two and a half times as likely to actually be in the active phase of labor when a cesarean was performed for arrest of dilation if the attending was a hospitalist. In 2013, only 64.1% of private cases had patients at least 6 cm when arrest of dilation was determined, while 82.8% of hospitalist cases had patients at least 6 cm.

The reasons for these observed differences may be multifactorial. The main role of a hospitalist is to care for inpatient obstetric patients, who are often laboring, as well as manage obstetric emergencies. [94] They may have a more focused experience and expertise in labor management compared with a generalist.[95] Moreover, during this era Yale New Haven Hospital hospitalist attendings were full-time faculty specializing in maternal-fetal medicine who may be more be more aware of the most recent literature and be compelled to change common practice due to pressure from academic colleagues. Generalist models of care vary greatly. Some providers cover the labor floor while also performing minor procedures in other parts of the hospital. Some are in the hospital only if their practice has a patient in labor and will call the next physician in only if a patient remains in labor after their coverage shift. In other hospitals, generalists may remain in outpatient settings while patients are in labor and communicate directly with the nurse regarding progress in labor. These different types of models may lead to differences in tolerance for deviations from traditionally "normal" labor patterns.

Previous studies have found that obstetric hospitalist models have lower cesarean rates than private obstetrician models.[96-98] Though one study of California community hospitals did not observe a decrease in cesarean delivery with a hospitalist model. However, it is important to note that they did observe a decreased risk of repeat cesarean with a laborist model due to twice the number of trials of labor attempted in VBAC parturients. The authors suggest that one reason for no observed difference in overall cesarean rates may be a high variation in laborist practice; for instance, unstandardized responsibilities, percentage of patients managed, and length of shifts. [99] What may matter more than the type of attendant is the individual attendant. While hospitalist models generally have lower cesarean rates, an investigation into one hospitalist model found that rates were highly variable among hospitalist physicians, from 12.5% to 35.9%, with no observed differences in patient population or outcomes. This suggests that interventions that guide or modify physician behavior may be useful tools in lowering the cesarean delivery rate.[95] Circulating individual physician and institutional cesarean delivery rates and implementing protocols has resulted in decreasing rates at other centers.[100-104] For example, developing a protocol for labor induction that outlines acceptable reasons, gestational ages, and methods for induction would standardize the approach to labor induction,[100] and has the potential to decrease rates.[103]

A greater cervical dilation on admission was found to increase the odds of meeting minimum criteria for both arrest of dilation and arrest of descent. It is well established that admission to the hospital before 4 cm of dilation is a risk factor for cesarean delivery.[105-107] These patients are more likely to receive oxytocin, artificial rupture of membranes, have abnormal fetal heart rates, and develop chorioamnionitis. It may be that women who choose to delay going to the hospital and arrive further along in labor need fewer interventions. In addition, greater cervical dilation on admission increased the odds of being at least 6 cm when a cesarean was performed for arrest of dilation. This makes intuitive sense; the closer the exam on admission to 6 cm, the less dilation needs to occur to meet that threshold, and fewer patients undergo cesarean during latent labor.

An epidural decreases the likelihood of meeting minimum criteria for arrest of descent. This may be because minimum criteria require that women with epidurals have more time to labor and waiting longer may be more difficult. In addition, patients that opt to not receive an epidural may be more interested in achieving natural birth and advocate more heavily for longer trials of labor before cesarean. Already having anesthesia in place may also remove a barrier to moving to cesarean.

An elevated body mass index greater than or equal to 40 decreased the odds of being at least 6 cm dilated at the time of cesarean for arrest of dilation in half compared to a BMI < 40. Physicians may be less likely to allow very obese patients the time needed for them to enter active labor, or women with higher BMIs need more time than those with lower BMIs to enter active labor. One study found that BMI ≥ 30 is associated with slower progression in the first stage of labor for both nulliparous and multiparous women. The authors suggest that obesity should be considered when defining normal labor and subsequent management.[108]

While history of prior vaginal delivery did not predict meeting minimum criteria for arrest of dilation, arrest of descent, or failed induction, it more than tripled the odds of being at least 6 cm at the time of cesarean for arrest of dilation. Said another way, being nulliparous tripled the odds of being <6 cm at the time of diagnosis of arrest of dilation. Previous studies have shown that multiparity decreases the risk of cesarean,[109,110] and that the odds of vaginal delivery after cesarean increase if the woman has previously delivered vaginally.[111] Taken together, physicians may intuit that it is more likely to have a vaginal delivery if the patient has delivered vaginally before. Therefore, the physician may be inclined to allow the multiparous patient to labor longer, knowing she is capable of vaginal delivery, and expecting it as the outcome.

We conducted this retrospective analysis to examine the diagnosis of labor arrest in the first and second stage and of failed induction prior to the use of cesarean delivery over time to estimate the proportional decrease attributable to the new guidelines and to identify and characterize the proportion that is yet modifiable by full adoption of the guidelines. Such efforts could help to design and focus processes that may help to further safely reduce the primary cesarean rate due to labor arrest and failed induction.

We found that primary cesarean delivery rates for these indications decreased from 8.5% in 2010 to 6.7% in 2013. Only 50.4% of these primary cesareans met minimum criteria in 2013. The decrease in primary cesareans for these indications was mostly due to the decrease seen in primary cesarean deliveries for arrest of dilation, which decreased from 5.1% in 2010 to 3.4% in 2013. As of 2013, only 34.9% of primary cesareans indicated for arrest of dilation, 71.0% for arrest of descent, and 50.0% for failed induction, met respective minimum criteria. This leaves a large proportion for improvement, and suggests that an even bigger decrease in the cesarean rate can be achieved if a greater effort is made to meet minimum criteria before moving to cesarean. It is possible that with stricter adherence to minimum criteria, decreases in arrest of descent and failed induction of labor cesarean rates will be achieved as well.

As of 2013, 65.1% of primary cesareans for arrest of dilation, 29.0% for arrest of descent and 50.0% for failed induction did not meet respective minimum criteria. These patients were more likely to be cared for by non-hospitalists and for the former two groups to have a lower cervical dilation on admission. Women who underwent cesarean for arrest of dilation prior 6 cm dilation (latent labor) were more likely to be nulliparous and have a BMI >40. Women who underwent cesarean for arrest of descent prior to meeting criteria were more likely to have an epidural. Devoting extra attention and developing strategies to target patients with these characteristics may yield improvements in cesarean rates for labor arrest disorders.

The most distinct and largest group of patients not meeting criteria for labor arrest disorders that is yet modifiable are those cared for by non-hospitalists. In 2013, 72.8% of non-hospitalist cases did not meet minimum criteria for arrest of dilation, while 37.9% of hospitalist cases did not meet minimum criteria. This discrepancy is important as 78.0% of the primary cesareans performed for arrest of dilation were by non-hospitalist attendings. While they are performing the large majority of cesareans for this indication, many fewer of their cases actually meet criteria for arrest of dilation. A similar picture is seen when looking at arrest of descent and failed induction. In 2013, 32.9% of non-hospitalist cases did not meet minimum criteria for arrest of descent, while 16.7% of hospitalist cases did not meet criteria for arrest of descent, and non-hospitalist attendings performed 76.2% of all primary cesareans for arrest of descent. In 2013, 71.4% of non-hospitalist cases did not meet criteria for failed induction, 20.0% of hospitalist cases did not meet criteria for failed induction, and non-hospitalist attendings performed 58.3% of primary cesareans for failed induction.

Thus, large changes in the proportion of women meeting criteria for arrest of dilation can potentially yield a significant decrease in the primary cesarean delivery rate. However, a system, hospital-wide approach is crucial to affecting change, and with a strong commitment from all providers outcomes achieved could be even greater.

SUGGESTED ACTIONS

While risks and benefits of cesarean delivery for the neonate and the mother depend largely on the indication and circumstances, it is clear that cesareans have a significant impact on future pregnancies. Previous cesarean delivery increases the risk for placenta previa, placenta accreta, uterine rupture and hysterectomy.[10] Placental abnormalities and uterine rupture are dangerous conditions that can lead to hemorrhage and result in death of the mother and/or fetus. About 11.4% of maternal deaths in 2011-2013 were due to hemorrhage.[112] In a time where maternal mortality is increasing in the United States,[112-116] and almost 60% of deaths are estimated to be preventable,[117] we must carefully consider how we can decrease risks. Preventing the first cesarean is one way to do this.

Patient Education

The education and preparation that a woman receives during her prenatal care can significantly impact her labor and delivery. Patients should be counseled that labor, especially for nulliparous women, can be long, and it may be more comfortable to labor at home for a significant portion of her labor.[100] She should be counseled that it is safe to do so.[118] At home she will be in a familiar space, move about as she pleases, have her whole support system with her, eat her own foods, and have no risk of interventions. It may be beneficial to include discussions on possible common interventions like electronic fetal monitoring, induction of labor, and cesarean so that patients have more time to ask questions and understand risks and benefits in a calm setting while not in pain.[100]

Additionally, there are many methods for managing labor pain besides an epidural and these methods, including their pros and cons, should be discussed in depth during prenatal visits.[118] Positions for laboring that encourage vaginal delivery should also be discussed with the patient during prenatal care. Simply walking and laboring in an upright position can decrease risk for cesarean delivery.[119] One study showed that use of a peanut ball in women laboring with an epidural significantly lowered the incidence of cesarean delivery; women that used the peanut ball were less than half as likely to undergo cesarean.[120]

Research suggests that continuous labor support by a doula can decrease the risk of cesarean delivery, among other interventions.[121,122] ACOG endorses the use of doulas for emotional support in an effort to limit interventions and reduce the cesarean rate, and suggest it may be useful to teach friends or family members of the patient labor support techniques.[118] During prenatal visits, physicians should inform patients about the potential benefits of doulas and provide contact information. Hospitals should consider integrating doulas into the obstetric care team.[100]

To ensure adequate patient education and minimize time conflicts and cost, online classes could be offered. Group prenatal care may also provide an efficient method for integrating education into prenatal visits.[100]

Use of Induction of Labor

From 1990 to 2015 induction of labor has increased from 9.5% of all births to 23.8%,[53,123] and some estimate that elective inductions account for half of all inductions.[78] Because the likelihood of vaginal delivery is decreased for those with induced labor versus spontaneous,[1] labor induction should be reserved for medical indications.[41] It may be useful for institutions to have a list of acceptable reasons for induction, and specific protocols for cervical ripening and induction.[1] When induction of labor is used, adequate time to enter labor should be allowed, with at least 12-24 hours of oxytocin administration after membrane rupture (and cervical ripening, if necessary).[1,41]

Managing Latent Labor

If a woman comes to the hospital <3 cm dilated she can be managed as an outpatient.[1] As active labor begins at 6 cm, if a woman is <6 cm she should be managed as in latent labor and given supportive care. Spong et al. suggests that if labor subsides at less than 6 cm of dilation, membranes remain intact, and maternal and fetal status is stable, a woman may be discharged.[1] ACOG suggests that women in latent labor can be managed as outpatients, with frequent contact and support if the patient desires, as long as maternal and fetal status are reassuring.[118]

Some cesarean deliveries for arrest of dilation occur when the patient has not yet reached 6 cm, or active labor. Therefore, she should not be judged by active labor standards and should instead be managed as in latent labor. This would allow her more time to labor and progress, and may avoid cesarean delivery.[1,41] A prolonged latent phase (traditionally thought of as >20 hours in nulliparas and 14 hours in multiparas[62]) is not an indication for cesarean delivery.[41]

Managing Active Labor

Once a woman enters active labor, she should be allowed to continuing laboring without cervical change for at least 4 hours with adequate contractions (>200 Montevideo units). If contractions remain inadequate, she should be allowed to continue laboring for at least 6 hours,[1] and an attempt should be made to achieve adequate contractions using oxytocin augmentation.[41,124] Together, this means that a woman should be allowed at least 4 or 6 hours to continue laboring without cervical change, but may labor longer as long as maternal and fetal status remain stable.[1]

Managing Second Stage

A woman in second stage should be allowed to labor for a minimum of 2 to 4 hours depending on parity and anesthesia use, but can continue laboring as long as the wellbeing of fetus and mother is stable.[1]

Operative vaginal delivery is an important alternative to cesarean delivery and it is appropriate to attempt before cesarean if there is skilled physician available and there are no contraindications, such as unengaged head.[125] Use of vacuum and forceps are considered safe,[41] but the number of physicians adequately trained in such methods is low. One study found that only 55% of OBGYN residents completing their training felt competent to perform a forceps delivery.[126] Since 1990, the number of forceps and vacuum deliveries has decreased. The use of either method decreased from 9.01% in 1990 to 3.14% in 2015, with forceps delivery accounting for 0.56% and vacuum delivery accounting for 2.56% of all deliveries.[53] Training and maintenance of these skills is essential to providing an alternative to cesarean delivery.[41]

Provider Education

To ensure that all providers at an institution know the most recent literature on labor management, the hospital should summarize and distribute recommendations. It should establish its own benchmarks and set attainable goals with examples of others who have achieved those goals. It may also be useful to compare the institution to other institutions and frequently track progress and provide feedback every 1 to 2 months. Making this data public may further encourage providers to improve their practice.[100]

It may be useful to track and distribute individual physician rates to illustrate how one physician is performing compared to others and encourage her to do better.[100] Suggested measures to track are induction and cesarean rates for individual physicians, including rate of non-medically indicated cesareans, rate of non-medically indicated inductions, and rate of cesareans performed for labor arrest or failed induction that do not meet minimum established criteria.[1]

THE TAKE AWAY

To optimize maternal and neonatal outcomes and avoid unnecessary morbidity and mortality, lowering the cesarean rate is of utmost importance. One way to lower the cesarean rate is to reduce the number of primary cesarean deliveries. New understanding of normal labor progression have led to improved guidelines regarding labor management. Adherence to these new guidelines allows women more time in labor, and potentially avoids unnecessary cesarean deliveries. An increase in the percentage of cases that meet minimum criteria for arrest of dilation is correlated with a decrease in the primary cesarean rate for this indication and the primary cesarean rate overall. Uptake and practice of these new guidelines is not uniform and non-hospitalist physicians may be less likely to adopt these new practices. To help decrease the primary cesarean rate, hospitals should take a system-wide approach to encourage all providers to practice based on new guidelines and standardize care.

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