Some intrapartum care practices promote vaginal birth, whereas others may increase the risk for cesarean section. Electronic fetal monitoring and use of the Friedman graph to plot and monitor labor progress are associated with increasing the cesarean section rate. Continuous one-to-one support and midwifery management are associated with lower cesarean section rates. This article reviews the evidence that links specific intrapartum care practices to cesarean section. Strategies that can be implemented in the current social and cultural setting of obstetrics today are recommended.

More than 4 million women give birth in the United States each year and slightly more than one-third of these women give birth by cesarean section. The rate of cesarean section rose from 21% in 1996 to 32.9% in 2009, and today, it is the most common surgical procedure performed in the United States. Because cesarean births are associated with short-term and long-term adverse health effects for the mother and infant, strategies that effectively lower the incidence of this procedure are urgently needed. To lower the total cesarean section rate, which is the sum of all repeat and primary procedures, decreasing the number of primary cesarean sections is a critical first step. This article reviews intrapartum management for nulliparous women at term with a singleton fetus in vertex presentation (NTSV) because this is the population in which the cesarean section rate varies widely. Recommendations for care practices that promote vaginal birth are presented.

Background: Indications for Intrapartum Cesarean Section

Several labor management practices are associated with an increased cesarean section rate, including, but not limited to, early admission, diagnosis of the active phase of labor at 3-4 cm dilatation, and continuous electronic fetal monitoring. In contrast, midwifery management and continuous support during labor are associated with lower cesarean section rates in both observational and randomized controlled trials (RCTs). Labor support practices, such as encouraging oral fluids, frequent ambulation, avoiding an epidural, and physiological management of the second stage, have been promoted as interventions that could lower the cesarean section rate; however, studies evaluating some of these specific interventions have had conflicting results. Thus, there is a plethora of intrapartum care practices that could influence the rate of cesarean section either singly or in concert. Identification of the most frequent indications for a primary cesarean section in low-risk women sheds some light on where to look first.

Barber et al analyzed the indications for 10,757 women who had cesarean sections performed between 2003 and 2009 in one large academic hospital. They found that fetal intolerance of labor (32%) and arrest of labor (18%) accounted for 50% of the increase in the primary cesarean rate. Similarly, Main et al analyzed the rates and indications for cesarean sections in California, which is where 1 of every 8 infants born in the USA is born. These authors looked specifically at the NTSV cesarean section rate that was 28.1% overall with regional variation that ranged from 21.5% to 33.5% and hospital variation that ranged from 10% to 50%. Fetal intolerance of labor and arrest of labor accounted for 40%-50% of all cesarean sections, and they exhibited the largest regional and interhospital variability.

Wide variability in practice is a well-known marker for medical practices that are underused in some settings and overused in others. In fact, the inverse relationship between quality health care and variation in practice has been
well documented. Thus, the diagnosis of fetal intolerance of labor and the management of dystocia are the 2 key areas where application of evidence-based strategies may have the most impact in lowering the rate of primary cesarean section. The third variable that affects intrapartum cesarean section rates is the influence of the provider.

Fetal Intolerance of Labor

Approximately 20%-30% of all NTSV cesareans are performed for fetal intolerance of labor. Continuous electronic fetal heart rate monitoring (EFM) is the norm for >90% of women who give birth in the United States. Nevertheless, the efficacy of EFM has not been proven.

The Evidence for EFM

The story of EFM is well known. In brief, EFM was adopted into clinical practice in the 1960s and 1970s before being assessed in randomized trials. The beliefs that variant fetal heart rate (FHR) patterns reflect fetal hypoxemia and that EFM could identify the fetus with impending asphyxia early enough to intervene were compelling, and this technology was rapidly embraced. The first studies of EFM compared outcomes in settings before and after the introduction of intrapartum monitoring and found that women who had continuous EFM during labor had fewer intrapartum stillbirths. It is important to note that a reduction in intrapartum stillbirth is still a true benefit of EFM.

The initial RCTs were conducted in the 1970s and 1980s. They found that EFM was associated with higher rates of cesarean section without a concomitant improvement in newborn outcomes. A Cochrane meta-analysis, which was last updated in 2006, compared 13 RCTs of continuous EFM with intermittent auscultation (IA) and confirmed higher cesarean section rates but no improvement in Apgar scores, perinatal mortality or rates of cerebral palsy in infants born to women in the continuous EFM. EFM is associated with a 50% reduction in the incidence of early neonatal seizures, but there were no differences between the EFM and IA groups in the rate of cerebral palsy when the infants with newborn seizures were reexamined at 4 years of age.

These results are frequently cited because the evidence that shows EFM increases the cesarean section rate without a concomitant improvement in newborn outcomes. On closer examination, there are multiple study design differences and problems that should disallow generalizing the results of these RCTs and meta-analysis to women in labor today for either recommending its use or recommending that it not be used. The RCTs included in the meta-analysis were all conducted between 1976 and 1994, which makes them >20 years old. The majority of these studies were conducted before the importance of FHR variability because an indicator of fetal hypoxemia was known; thus, the decision to do a cesarean section for fetal distress was made on the basis of decelerations with or without a diminution in baseline variability. Many of the studies used fetal scalp sampling as an auxiliary test, which is rarely used today in the United States. There was no standard terminology shared by the different study designs so even the definition of late decelerations was different from 1 study to the next. In addition, the studies differed in their inclusion criteria. Some included women at term only and others included preterm gestations.

Recently Chen et al used US birth certificate data from 2004 to compare outcomes in women who had EFM in labor vs those who were monitored via IA. The analysis included women who were 24-44 weeks’ gestation. They excluded stillbirths, infants with congenital anomalies, and women who had repeat cesarean sections. A higher cesarean section rate was found in the EFM group versus the IA group (2.8% vs 1.5%, respectively; relative risk [RR] = 1.81, 95% confidence interval [CI] = 1.74-1.88). However, early neonatal mortality (infant death at <6 days) for women who were ≥37 weeks’ gestation was lower in the EFM group (0.2% for EFM vs 0.3% for IA; RR = 0.65, 95% CI = 0.47-0.90). Neonatal seizures were less common in women who had obstetrical disorders, chronic medical conditions, or a preterm birth if monitored with EFM (0.7/1000 live births vs 1.1/1000 live births), but the incidence of neonatal seizures in women who were low risk were not different when compared by monitoring modality (0.5/1000 live births vs 0.5/1000 live births).

Because 89% of the women in the Chen analysis experienced EFM in labor, the numbers in the comparison groups were markedly different. Additionally, much of the data recorded on birth certificates have been shown to be unreliable. Thus, it is not clear if inherent bias in the data source benefits one monitoring modality or neither. Perhaps most importantly, intrapartum hypoxia is only one of many etiologies of early neonatal mortality. The results of this most recent study do not inform the debate about using EFM versus IA for low-risk women at term. In the end, the question of superiority of EFM versus IA has not been solved, and a randomized trial of sufficient power is unlikely to be completed given the resources that would be needed to conduct this study.

Today, EFM is often used as the poster child for a medical technology that was accepted in clinical practice despite having no documented benefits and the argument that EFM should be discarded frequently appears in the obstetrical literature. However, changing a practice that is currently standard of care is very difficult. Therefore, using current research findings to replace or alter the protocols used for intrapartum fetal monitoring in monitored women who are low risk for fetal acidemia at the onset of labor is more likely to be successful than a whole-scale change in practice.

FHR Monitoring Modalities That may Lower the Cesarean Section Rate

In the last decade, FHR research demonstrated that an umbilical artery pH value of <7.0 reflects an increased risk for hypoxic ischemic encephalopathy, and those FHR patterns that are most associated with low umbilical artery pH values were identified. Standardization in clinical practice also improved. In 2005-2006, the relevant professional associations all endorsed use of a standard terminology for FHR charac-
characteristics. In 2008, the workshop on FHR monitoring jointly sponsored by the National Institute of Child Health and Human Development and the American College of Obstetricians and Gynecologists recommended a 3-tier system for interpretation of FHR patterns, and in 2010, American College of Obstetricians and Gynecologists published a practice bulletin that includes additional recommendations which results in a four-tier system. In addition, there is a rapidly increasing body of evidence about the relationship between specific FHR patterns and fetal/newborn acidemia that if implemented into practice, may help lower the primary cesarean section rate.

5-Tier System for FHR Interpretation

The practice change that is most likely to have a positive impact on reducing the cesarean section rate is more refined interpretation of FHR patterns and institutionally developed protocols for management of abnormal FHR patterns. The 2008 National Institute of Child Health and Human Development FHR workshop recommended that FHR patterns be divided into 3 categories for interpretation on the basis of their association with fetal acidemia: I, normal; II, indeterminate; and III, abnormal. The FHR patterns in category I and category III are well-established markers for a non-academic fetus and a fetus with a significant risk for acidemia, respectively. Category II includes a heterogeneous group of patterns that vary with regard to their association with fetal acidemia, which makes this category difficult to use in clinical practice. However, there appears to be a dose-response relationship between time spent in category II during the last 2 hours before birth and an increased risk for lower Apgar scores and neonatal intensive care unit admission. The FHR patterns in category I and category III are well-established markers for a non-academic fetus and a fetus with a significant risk for acidemia, respectively. Category II includes a heterogeneous group of patterns that vary with regard to their association with fetal acidemia, which makes this category difficult to use in clinical practice. However, there appears to be a dose-response relationship between time spent in category II during the last 2 hours before birth and an increased risk for lower Apgar scores and neonatal intensive care unit admission. Recent studies of a 5-tier system that subdivides category II have shown that the 5-tier system more accurately reflects fetal acid-base status.

5-Tier System for FHR Interpretation

<table>
<thead>
<tr>
<th>Category I → IIA</th>
<th>Category IIA → IIB</th>
<th>Category IIC → III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderate variability</td>
<td>Minimal variability</td>
<td>Absent variability</td>
</tr>
<tr>
<td>No decelerations</td>
<td>Non-recurrent decelerations</td>
<td>Recurrent decelerations</td>
</tr>
<tr>
<td>Non-recurrent decelerations</td>
<td>No decelerations</td>
<td>Non-recurrent decelerations</td>
</tr>
<tr>
<td>Recurrent mild decelerations</td>
<td>Recurrent decelerations</td>
<td>Recurrent decelerations</td>
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Figure 1 Algorithm for interpreting fetal heart rate patterns. (Color version of figure is available online.) © Tekoa King.

IA Protocols

IA protocols could be established in settings that have the resources to offer women this modality. Maternal and newborn outcomes in women who give birth at home or in free-standing birth centers are cared for by intermittent monitoring through labor. Large observational studies of these settings have documented lower cesarean section rates and similar or improved newborn outcomes when compared with women with similar demographic characteristics who give birth in hospitals and monitored with continuous EFM. These cohort studies can at best detect an association between the type of intrapartum care and newborn outcomes. However, the results have been markedly consistent across different populations and when the analysis controls for possible confounders. It is important to note that positive newborn outcomes in settings that use IA only occur when the staff understands how to use IA, the institution has a workforce that allows the continuous presence of a nurse or midwife for women in active labor, and there is a policy and process in place for moving to EFM when abnormalities on IA are detected.

FHR Monitoring in the Latent Phase of Labor

A brief FHR tracing is often obtained on admission to rule out variant patterns that might require additional evaluation. However, a meta-analysis of 4 RCTs that measured the outcomes of low-risk women who had an admission test and those who were evaluated via IA (n = 13,000) found no difference in newborn outcomes and an increase in cesarean sections in the women how had the admission test
Although this is a statistically significant finding, it is difficult to justify not using EFM on admission to screen for the rare FHR pattern that indicates an increased risk for fetal acidemia given the current medicolegal climate in the United States. Nonetheless, women who are admitted in latent labor are more likely to have a cesarean section than women who are admitted in active labor, and there are no professional guidelines that recommend EFM for women who are in latent labor. Therefore, a shift from continuous EFM and bed rest to encouraging ambulation and maintaining comfort for women who require hospital care during the latent phase may help mitigate the cesarean section rate in this population.

**Labor Management Practices That Improve Vaginal Birth Rates**

Dystocia is the leading cause of primary cesarean sections today, accounting for approximately half of those performed during labor. Dystocia also accounts for the greatest variation in institutional cesarean rates. A brief review, the

<table>
<thead>
<tr>
<th>Author</th>
<th>N</th>
<th>Active Phase Hours, Mean (2SD)</th>
<th>Key Findings</th>
<th>Clinical Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Friedman</td>
<td>500</td>
<td>2.5 (12)</td>
<td>Frequent use of opioids, caudal anesthesia, oxytocin, and forceps different from today</td>
<td>The Friedman curve should not be used to monitor labor progress</td>
</tr>
<tr>
<td>Peisner and Rosen</td>
<td>1060</td>
<td>&lt;50% in active labor by 4 cm, 74% in active labor by 5 cm</td>
<td>Active phase not entered until 5-6 cm. Speed of cervical dilation progressively accelerates</td>
<td>Do not make the diagnosis of active labor until at least 5 cm</td>
</tr>
<tr>
<td>Zhang et al</td>
<td>26,838</td>
<td>4.4 (16.7)</td>
<td>Length of first and second stages are longer in women with conduction anesthesia</td>
<td>Cervical dilation in active phase of labor in women with conduction analgesia may take 0.5-1 hour longer than women who do not have conduction analgesia</td>
</tr>
<tr>
<td>Kilpatrick and Laros</td>
<td>2302</td>
<td>8.1 (16.6) no analgesia, 10.2 (19) conduction analgesia*</td>
<td>Length of active phase of labor was longer in Hispanic and American Indian women when compared with non-Hispanic white women</td>
<td>Racial differences in labor length need to be explored in more detail. Individual institutions can determine normal time frames for their setting</td>
</tr>
<tr>
<td>Albers et al</td>
<td>1513</td>
<td>7.7 (19.4)</td>
<td>Length of active phase of labor was longer in Hispanic and American Indian women when compared with non-Hispanic white women</td>
<td>Use of IA and ambulation during active labor in women without analgesia may shorten length of the first stage of labor</td>
</tr>
<tr>
<td>Albers</td>
<td>2511</td>
<td>7.7 (17.5)*</td>
<td>Midwifery-managed care. 43.7% used EFM, 61% women were ambulatory in labor. EFM and ambulation were associated with longer labors</td>
<td></td>
</tr>
<tr>
<td>Zhang et al</td>
<td>1329</td>
<td>5.5 (13.7)†</td>
<td>Marked interindividual variability in cm at which active phase starts (3-5 cm). Time interval of no change &gt;2 hours not uncommon before 7 cm</td>
<td>Allow at least 2 hours between each increment of cervical dilation before 7 cm</td>
</tr>
<tr>
<td>Jones and Larson</td>
<td>120</td>
<td>6.2 (13.4)</td>
<td>Hispanic population</td>
<td>Allow at least 2 hours between each increment of cervical dilation in late active phase of labor</td>
</tr>
<tr>
<td>Neal et al</td>
<td>7009</td>
<td>6 (13.4)</td>
<td>Systematic review included studies of women with analgesia and oxytocin augmentation; slowest normal rate of cervical dilation approximates 0.5-0.6 cm/h</td>
<td></td>
</tr>
</tbody>
</table>

EFM, electronic fetal monitoring; IA, intermittent auscultation.
*First stage of labor as defined by patient history.
†90th percentile.
indications for failure to progress and intrapartum care practices that are associated with lower rates of cesarean section, informs recommendations for changes in intrapartum management.

Failure to Progress in Labor

Dystocia is vaguely defined as slow or abnormal progression of labor. For decades, progress in labor has been measured to determine the statistical limits of normal via use of a time versus dilatation graph created by Emanuel Friedman in 1955.46 Friedman followed the progress of 500 primigravid women to determine the mean, median, range, and standard deviation of the first stage of labor. He divided the resulting sigmoid curve into the latent, active and transition phases “for purposes of mathematical simplification...”p569.46 Unfortunately, the intrapartum courses that informed the Friedman graph are not an accurate reflection of labor progress today.47-50 Even more interesting is that they were probably not an accurate depiction of labor in 1955.

Recent investigations have identified and corrected some of the problems inherent in Friedman’s work.48,51 Zhang et al50 repeated the analysis of labor progress using data from the National Collaborative Perinatal Project. Using a repeated measures analysis, they found that the latent phase of labor lasted longer than Friedman detected and that a deceleration phase did not occur. It is important to note that the data for this analysis came from a large prospective study of women who gave birth between 1955 and 1966, when intrapartum management was similar to the management experienced by the women in Friedman’s sample. Table 1 presents the results of contemporary studies on labor progress in primigravid women at term and summarizes the key findings.46,47-50,52-56 From a clinical perspective, it is clear that continued use of the Friedman curve to determine the limits of normal is resulting in iatrogenic intervention and overusage of cesarean section.

A Labor Curve for the Future

Neal and Lowe57 recently developed a partogram (Fig. 2) based on the following principles culled from an extensive review of the current research on labor progress: (1) Active labor must be accurately diagnosed before the rate of cervical dilation is used to assess labor progression. (2) In nulliparous women, 90% of women will have a linear dilation rate of at least 0.5 cm/h. (3) Cervical dilation accelerates progressively throughout active labor. (4) The time between each centimeter of dilatation is more variable in early active labor than it is in late active labor. The partogram includes a dystocia line that incorporates these 4 principles and additionally assumes any >4-hour delay in dilation after 5 cm is an indication for intervention.57 The results of clinical research using the Neal and Lowe partogram are anticipated. Until an improved labor graph is clinically available, discarding the Friedman curve and incorporating the key summary points listed in Table 242,45,58-66 are recommended when making clinical decisions about labor progress.

Intrapartum Care Practices That Lower the Cesarean Section Rate

Delayed admission until the onset of active labor, continuous supportive care, avoiding epidural analgesia, supporting adequate hydration, use of upright positions, and less use of amniotomy and oxytocin during labor all have some biologic plausibility for facilitating vaginal birth via support for physiological labor. Although there is some evidence for use of each of these practices, only continuous one-to-one support during labor has been shown to confer a statistically significant advantage.58 Table 2 summarizes the key findings from studies of labor practices that may be associated with a lower cesarean section rate.42,58-66 It is important to note that these management strategies are most often studied individually, which disallows assessment of any potentiating effect they may have on each other when offered in aggregate. To date, only studies of midwifery care have indirectly assessed intrapartum management that includes all these care practices as a comprehensive model of care.

The Role of the Provider

Many years of prospective and retrospective observational studies have consistently found midwifery care associated with a lower cesarean section rate when compared with physician-only management.9,38,67,68 There are 2 interrelated cri-
ties of this body of literature as a whole. First, most of the research on midwifery has included nonrandomized comparison groups, which suggests selection bias may slant the results in favor of midwifery care. To address this issue, many of these studies applied logistic regression models and/or specific selection criteria to comparison groups that accounted for confounders. In clinical practice, midwives in the United States care for a larger proportion of underserved women when compared with the case mix of obstetricians. This is a population that has been noted to have a higher a priori risk for cesarean section.\(^7,69,70\)

Secondly, women cared for by midwives who require a cesarean section are referred to a collaborating physician, which may result in the cesarean section being attributed to the physician versus the midwife. Thus, only studies that include an intention-to-treat analysis can address this problem. Hatem et al\(^8\) did conduct a meta-analysis of RCTs that evaluated outcomes by intention-to-treat and did not detect a difference in cesarean section rates when midwifery care was compared with physician-only care (11 trials, \(n = 11,897, \text{RR} = 0.96, 95\%\text{CI} = 0.87-1.06\)).

The meta-analysis did find that midwifery care was associated with improved outcomes in most other indices, including more spontaneous vaginal births (9 trials, \(n = 10,926, \text{RR} = 1.04, 95\%\text{CI} = 1.06-1.04\)). Despite the repute of the Cochrane meta-analysis process, these RCT results and the subsequent meta-analysis present an incomplete picture of midwifery care outcomes. Several different models of midwifery care were included in the RCTs, which were largely conducted in Europe. Intrapartum management with regard to the indications for cesarean section cannot be directly generalized to intrapartum care in the United States.

The research methodology questions about midwifery care may remain unsolved. It is not clear if women who chose midwives are inherently at lower risk for having a cesarean section in some intangible way that has not been measured, or if the midwifery model of care lowers cesarean section rates to a greater extent than has been measured given midwives have a higher proportion of women in their caseload who are at risk for cesarean section secondary to racial or socioeconomic disadvantage. Of more importance is the overall consistency of findings that midwifery care is associated with positive obstetrical outcomes that include higher vaginal delivery rates. Increased use of midwives in the United States is recommended.

### Conclusions

The cesarean section rate for low-risk women at term is almost twice as high as it should be. Many of the medical reasons for this crisis have been identified, including elective induction, early admission, EFM, and a graphic standard for labor progress that is outdated and inappropriate. A multi-pronged reality-based approach is going to be necessary to effect a positive change in the primary cesarean section rate.

<table>
<thead>
<tr>
<th>Management Practice</th>
<th>Key Findings</th>
<th>Clinical Implications</th>
</tr>
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<tbody>
<tr>
<td>Admit in active labor</td>
<td>Retrospective studies found admission after active labor is established results in less intervention and lower cesarean sections.(^{42,45}) One RCT of 209 women found a trend for fewer cesareans (7.6% in delayed admission group vs 10.6% in early admission group; (\text{OR} = 0.70, 95%\text{CI} = 0.27-0.81)).(^{58})</td>
<td>Avoid admitting women in latent labor and/or avoid EFM and bed rest in women who are admitted in latent labor</td>
</tr>
<tr>
<td>Ambulation and upright positions</td>
<td>Upright positions and freedom of movement are associated with less perceived pain, shorter labor, improved uterine contractility, and increased patient satisfaction.(^{59,60}) Trend toward lower cesarean section rates that is not statistically significant</td>
<td>Ambulation in active labor may shorten labor duration</td>
</tr>
<tr>
<td>Continuous labor support</td>
<td>Continuous support provided by a nonmedical person reduces cesarean section rate (16 trials, (n = 13,391; \text{RR} = 0.91, 95%\text{CI} = 0.83-0.99)).(^{60,61})</td>
<td>Continuous one-to-one support during labor</td>
</tr>
<tr>
<td>Epidural vs nonpharmacologic methods of pain control</td>
<td>The association between epidural analgesia and cesarean section is controversial, and most studies have significant crossover or statistically significant results that may not be clinically significant.(^{62,63}) RCTs that have found no association primarily use active management of labor protocols. It is possible that active management mitigates the effect of epidural analgesia on cesarean section rates.(^{64,65})</td>
<td>Encourage nonpharmacologic methods of pain relief for women who are interested in avoiding epidural analgesia</td>
</tr>
<tr>
<td>Oral hydration and nutrition</td>
<td>125 cc/h vs 250 cc/h is associated with shorter labors, less use of oxytocin, and a trend toward fewer cesarean sections.(^{66})</td>
<td>Encourage oral fluid and nutrition in labor</td>
</tr>
</tbody>
</table>

OR, odds ratio; RCT, randomized controlled trial; RR, relative risk.
Specific changes in intrapartum management need to be part of an overall program that includes education, opportunity, and incentives that are made available to providers and patients alike.26,71

In settings that rely on continuous EFM, adoption of a 5-tier system for interpretation and management will improve identification of the fetus who is at risk for significant acidemia. Discarding the Friedman curve and revising how labor progress is assessed can result in larger gains. Delayed admission of women in latent labor, diagnosis of the active phase after 5-6 cm, and extending the time frame for expected progress in the active phase of labor will result in significantly fewer primary cesarean sections.

Any changes in labor management that result in longer labors need to be counterbalanced with the addition of support measures that help women through this process. Prenatal education, policies that support women in latent labor who are not yet admitted, and one-to-one support during labor maybe essential. Expanded use of midwives, especially as laborists, needs to be explored because the midwifery model of care is the one model of intrapartum care that encompasses most of the individual components needed to provide better care to low-risk women during their labors.

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