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Induction of Labor and Cesarean: What is the True Relationship?

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Abstract: It is a commonly held belief that labor induction increases the risk of cesarean delivery; women who are induced are at higher risk of cesarean as compared with those in spontaneous labor. This comparison group is inaccurate, however, as women and providers cannot choose spontaneous labor as the alternative to labor induction. With expectant management, spontaneous labor may occur, but as gestation advances, pregnancy complications may occur, or women may progress postterm requiring induction at a later gestation. Using the proper comparison group, studies find that labor induction is actually associated with a small decreased risk of cesarean delivery.
Key words: induction of labor, elective induction, cesarean delivery, primary cesarean delivery

Introduction

The overuse of labor induction is often cited as a primary driver behind the rising rate of cesarean delivery in the United States. And it is easy to understand where this belief comes from. Cesarean delivery rates in the United States have risen by over 50% in the last 15 years and there has been a parallel almost doubling in the rate of labor induction.[1] This makes intuitive sense to both patients and providers: as we interfere more, especially on uncomplicated pregnancies, we expose these pregnancies to increasing numbers of interventions and ultimately increase the risk of cesarean delivery.

Moreover, this association between cesarean delivery and induction is reinforced by the everyday practice of obstetrics. On the labor floor, providers see a direct comparison between patients who are induced and patients who are in spontaneous labor. And indeed, the patients who are induced have a nearly 2-fold increased risk of cesarean delivery.[2] Further, for patients who start an induction with an unfavorable cervix, induction of labor (IOL) seems to impose an even greater increased risk.[3]

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Thus, reducing the rates of labor induction, especially among low-risk women, has been a key component to many policies aimed at lowering the rate of cesarean delivery, especially primary cesarean deliveries. Labor induction seems to be a clearly identifiable and potentially modifiable risk factor for cesarean delivery. In addition, there have been recent data and national focus around the neonatal complications of early term (37 + 0 to 38 + 6 wk) delivery.[4] The message is therefore clear and consistent: unnecessary inductions lead to poor outcomes for neonates (early term morbidity) and mothers (increased cesarean deliveries).

However, the association between cesarean delivery and IOL is not as clear as it first appears. Providers see the snapshot comparison: women in spontaneous labor as compared with women who are induced. Unfortunately, patients and providers cannot choose for a woman to be in spontaneous labor. Rather the choice that patients and providers face is between IOL now or continued expectant management of the pregnancy. During expectant management lots of things can occur. A woman may go into spontaneous labor, but at a later gestational age, and the risk of cesarean delivery increases with advancing gestation.[5] Or a pregnancy complication may occur (such as preeclampsia, oligohydramnios, fetal growth restriction, placental abruption, etc.) for which a woman may need to be induced or even if in spontaneous labor may have an increased risk for cesarean delivery. In addition, with increasing gestation, the fetal size generally increases, approximately 200 g (about half a pound) per week, and increased birth weight is associated with an increased cesarean rate. And finally, spontaneous labor may not occur before reaching a postterm gestation, necessitating an induction at that point.

In this article, we will explore the relationship between IOL and cesarean delivery. We will first review key retrospective data with the comparison group of spontaneous labor (induction vs. spontaneous labor). Second, we will review retrospective data with the more accurate comparison group (induction vs. expectant management). Third, we will review prospective data; there are a number of randomized controlled trials where IOL was the intervention studied. Thus, we are able to compare the rate of cesarean delivery in the IOL arm to the rate of cesarean delivery in the noninduced arm. And we will specifically address the idea of cervical status, as it may indeed be the women with the unfavorable cervices (ie, the ones who are least likely go into spontaneous labor on their own) that have the greatest cesarean delivery risk reduction with an IOL.

Retrospective Data: IOL Versus Spontaneous Labor

This is the largest body of literature, and perhaps the most intuitive comparison, women in spontaneous labor as compared with women with induced labors. For example, Heffner and colleagues conducted a retrospective cohort study of over 14,000 women between 36 and 42 weeks of gestation at 2 large teaching hospitals in Boston. They found that, independent of other risk factors, labor induction was associated with a 1.70-fold increased risk of cesarean delivery [95% confidence interval (CI), 1.48-1.95] in nulliparas and a 1.49-fold increased risk (95% CI, 1.1-2.0) in multiparas. Notably the absolute risk of cesarean delivery was low in both the induced and spontaneously laboring multiparas (4.5% vs. 2.5%, respectively).[6]

Several studies have confirmed that the elevated risk of cesarean delivery with IOL is seen more in nulliparous patients. For example, Heinberg et al[7] found that among multiparas undergoing elective

inductions, there was no increased risk of cesarean as compared with spontaneously laboring multiparous women. Similarly, Maslow and Sweeny[8] studied 1135 low-risk, singleton vertex pregnancies at 38 to 41 weeks' gestation at a single center. They found a 2.4-fold increased odds of cesarean delivery among nulliparous women (95% CI, 1.2-4.9), after adjusting for birth weight, maternal age, and gestational age, however, among multiparous women there was no associated increased risk of cesarean delivery with elective induction.

Given that parity seems to be a significant effect modifier in the relationship between induction and cesarean delivery, most studies have focused on the nulliparous population alone. For example, Ehrenthal et al[2] studied a retrospective cohort of 7804 nulliparous women at a large, regional obstetrical center with term, singleton, vertex fetuses of whom 43.6% were induced, 39.9% without medication indication. After adjustment for demographic and medical risk factors, labor induction was associated with an approximately 2-fold increased risk of cesarean delivery (aOR, 1.93; 95% CI, 1.71-2.2) with a population attributable risk of 20%. Similarly, Seyb and colleagues studied nulliparous women at term, including 1561 patients at a major urban hospital who predominantly received care from physicians in private practice. They divided their cohort into 3 groups: spontaneously laboring, medically indicated inductions, and inductions without medical indication (elective inductions). After adjusting for demographic and patient risk factors, women who were induced for medical indications had an increased risk of cesarean delivery as compared with those in spontaneous labor (aOR, 1.89; 95% CI, 1.12-1.38). Women who were electively induced had a similarly elevated risk of cesarean delivery as compared with spontaneously laboring patients (aOR, 1.69; 95% CI, 1.13-2.52).[9]

This elevated risk of cesarean delivery among induced nulliparas has been demonstrated even in populations with a much lower baseline rate of cesarean delivery. For example, Cammu and colleagues in Flanders, Belgium compared 7683 nulliparous women in spontaneous labor with term, singleton vertex fetuses to a similar group of 7683 nulliparous women who underwent an IOL. They found that among those induced, there was a 9.9% rate of cesarean delivery as compared with a 6.5% among those in spontaneous labor. The increased cesarean rates were mainly attributable to an increased rate of labor dystocia in the first stage of labor.[10]

Cervical status has also been shown to be a major contributor to the risk of cesarean delivery among induced patients. For example, Johnson and colleagues studied 7282 nulliparous women at term who were undergoing a trial of labor at a community hospital. Overall the cesarean delivery rate was 23.7% among the induced women as compared with 11.5% for women in spontaneous labor. Cervical status was found to play an important role; the rate of cesarean delivery amongst those induced with a favorable cervix (Bishop score < 5) was 18.1% as compared with 31.5% among those with an unfavorable cervix ($P < 0.01$).[11] Vrouenraets and colleagues found that cervical status was the single most important predictor of cesarean delivery. They performed a prospective cohort study of 1389 nulliparous women at term with singleton, vertex fetuses at 2 medical centers. They found a cesarean delivery rate of 12.0% among those in spontaneous labor as compared with 23.4% among those undergoing a medically indicated IOL and 23.8% among those with a nonmedically indicated IOL. After adjusting for Bishop score on admission, however, the differences in cesarean delivery rates among those induced or not were no longer statistically significant.[3]

Taken together, the retrospective data comparing women in spontaneous labors to women with induced labors tell a consistent story. IOL is associated with a nearly 2-fold increased rate of cesarean delivery. Multiparous women are at much lower baseline risk of cesarean delivery, and IOL does not appear to be a significant risk factor for them, as compared with nulliparous women. Moreover, cervical examination status plays a significant role: nulliparous women with an unfavorable cervix who are induced have the highest risk of cesarean delivery.

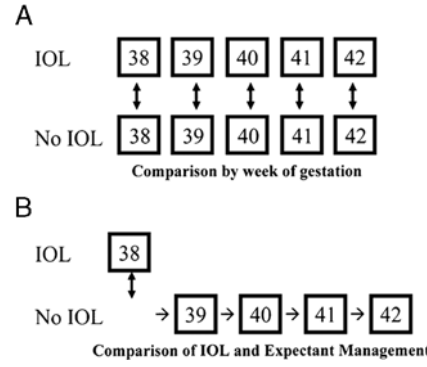

FIGURE 1. Comparison groups for induction of labor (IOL). A, Traditionally, IOL at a given gestational age has been compared with spontaneous labor at that same gestational age. B, Clinically, the decision is between IOL at a given gestational age or expectant management, which leads to delivery at a greater gestational age.

Retrospective Data: IOL Versus Expectant Management

All the above retrospective studies used spontaneous labors as the control group for inductions. However, as described in the introduction, this is not the clinically correct comparison group. Rather IOL should be compared with continued expectant management. Figure 1 displays these 2 different comparisons. There is a growing body of literature that compares labor induction to expectant management using retrospective data. Table 1 summarizes several of these key studies.

Caughey and colleagues first made this comparison in 2006 using retrospective data from a single tertiary care center. They included term, singleton, vertex pregnancies in women who did not have a prior cesarean or undergo an unlabored cesarean. For each week of gestation, they compared women who were induced at that week to all women (whether induced or in spontaneous labor) who delivered in the next week of gestation or beyond. For example, this would compare all women who were induced at 39 weeks to all women who delivered at 40 weeks or beyond. Using this comparison scheme, they found that IOL was not associated with an increased risk of cesarean delivery. For example, women induced at 39 weeks had a 14.3% risk of cesarean delivery as compared with a 15% risk with expectant management.[5] Cheng and colleagues similarly used national birth certificate data to create this same comparison. They included only nulliparous women with singleton, vertex pregnancies who delivered between 39 and 42 weeks of gestation. After controlling for maternal and obstetric risk factors, they found that women who were induced at 39 weeks' gestation had a 10% decreased odds of cesarean delivery as compared with women who delivered at 40 weeks or beyond. Similarly, women who were induced at 40 weeks had a 12% decreased odds of cesarean delivery.[12]

There is debate, however, about what gestational ages to include in the expectant management group. Most large databases only have gestational age to the week. Thus, the question is whether or not to include women who delivered that same week or only women who delivered at least 1 week later. Including women who delivered the same week may

TABLE 1. Retrospective Studies Comparing Induction of Labor to Expectant Management

References	Data Source	Total Sample Size	Included Populations	Analysis Scheme	Adjusted Risk of Cesarean Delivery in Induced vs. Expectantly Managed Group (OR; 95% CI)
Caughey et al[5]	Single tertiary care center	19,377	Term Singleton Vertex No prior cesarean No unlabored cesareans	All induced vs. women who delivered at the next gestational week or beyond	All women: 39 wk: 1.39 (1.08-1.80) 40 wk: 1.27 (1.00-1.62) 41 wk: 1.26 (0.99-1.61) Nulliparas: 39 wk: 1.54 (1.11-2.12) 40 wk: 1.63 (1.21-2.20) 41 wk: 1.33 (1.01-1.77)
Cheng et al[12]	Birth certificate data	442,003	Nulliparas Singleton Vertex 39-42 wk	All induced vs. women delivered at the next gestational week or beyond	39 wk: 0.90 (0.88-0.91) 40 wk: 0.88 (0.86-0.92)
Osmundson et al[13] Osmundson et al[14]	Single tertiary care center	396	Nulliparas 39 + 0-40 + 5 wk Elective inductions	Electively induced 39 + 0-40 + 5 vs. women who reached 39 + 0 and expectantly management	Favorable cervix: 1.03 (0.66-1.6) Unfavorable cervix: 43.1% vs. 34.3% ($P = 0.16$, aOR not available)
Darney et al[15]	California linked birth certificates/ hospital discharge data	362,154	Singleton Vertex No prior cesarean No fetal anomaly 37 + 0-41 + 6 wk	Electively induced vs. women delivered at the next gestational week or beyond	37 wk: 0.44 (0.34-0.57) 38 wk: 0.43 (0.38-0.50) 39 wk: 0.46 (0.41-0.52) 40 wk: 0.57 (0.50-0.65)
Bailit et al[16]	Maternal-Fetal Medicine Units Network (25 hospitals)	31,169	Nulliparas Singleton Vertex No anomalies 38 + 0-41 + 6	Electively induced vs. women who reached that gestational week and were expectantly managed	38 wk: 1.50 (1.08-2.08) 39 wk: 1.13 (0.94-1.36) 40 wk: 1.30 (1.15-1.46)
Glantz[17]	New York State birth certificates	38,147	Singleton Vertex Labored 37 + 0-42 + 6 wk	(1) All induced vs. women delivered that week or beyond (2) All induced vs. women delivered the next week or beyond	(1) 37 wk: 1.12 (0.92-1.36) 38 wk: 1.24 (1.08-1.43) 39 wk: 1.31 (1.18-1.47)

TABLE 1. (Continued)

References	Data Source	Total Sample Size	Included Populations	Analysis Scheme	Adjusted Risk of Cesarean Delivery in Induced vs. Expectantly Managed Group (OR; 95% CI)
					40: 1.57 (1.42-1.74) 41 wk: 1.45 (1.25-1.68)
					(2) 37 wk: 1.09 (0.90-1.33) 38 wk: 1.17 (1.01-1.35) 39 wk: 1.11 (0.99-1.25) 40 wk: 1.03 (0.92-1.16) 41 wk: 0.98 (0.71-1.35)
Stock et al[18]	Scottish birth record	1,271,549	Singleton No contraindication to labor 37+ wk	(1) Electively induced vs. women delivered that week or beyond (2) Electively induced vs. women delivered the next week or beyond	(1) 37 wk: 1.01 (0.88-1.16) 38 wk: 0.99 (0.91-1.08) 39 wk: 1.10 (1.02-1.19) 40 wk: 1.08 (1.03-1.13) 41 wk: 1.06 (1.02-1.11) (2) 37 wk: 1.02 (0.89-1.17) 38 wk: 1.03 (0.94-1.13) 39 wk: 1.08 (1.00-1.16) 40 wk: 0.83 (0.79-0.88) 41 wk: 0.66 (0.63-0.69)
Gibson et al[19]	Safe Labor Consortium (19 US hospitals)	131,243	Singleton Vertex No prior cesarean No chronic medical condition 37+ 0-41+ 6	Electively induced vs. women who delivered the next week or beyond	Nulliparas, unfavorable cervix: 37 wk: 0.40 (0.18-0.88) 38 wk: 0.65 (0.49-0.85) 39 wk: 0.47 (0.38-0.57) 40 wk: 0.69 (0.59-0.81) Nulliparas, favorable cervix: 37 wk: 0.16 (0.02-1.23)

TABLE 1. (Continued)

References	Data Source	Total Sample Size	Included Populations	Analysis Scheme	Adjusted Risk of Cesarean Delivery in Induced vs. Expectantly Managed Group (OR; 95% CI)
					38 wk: 0.43 (0.21-0.86) 39 wk: 0.50 (0.39-0.63) 40 wk: 0.69 (0.55-0.87)

erroneously include women who were in spontaneous labor at the same time as a women who was induced, or even potentially a few days before. But leaving this week out would also erroneously exclude women who went into labor after, but within the same gestational week. Glantz[17] explored the impact of varying these approaches. They used birth certificate data from New York State and looked at vertex, singleton pregnancies that delivered between 37 and 43 weeks of gestation. Including only women who delivered the next week or beyond in the expectant management group they found no difference between the cesarean delivery rates in those induced versus those expectantly managed [odds ratios (ORs) ranged from 0.98 to 1.17 and were mostly not significant]. However, if women who delivered in that same gestational age week were included in the expectant management group, then there was an increased risk of cesarean delivery with labor induction (ORs ranging from 1.12 to 1.57 and mostly statistically significant). Stock et al[18] found similar results when looking at birth records in Scotland. IOL was associated with a lower rate of cesarean delivery at 40 and 41 weeks when the expectant management group included only those women who delivered the next week or beyond (aOR, 0.83 and 0.66, respectively; $P < 0.01$ for both). However, when they also included women who delivered that same gestational week in the expectant management group the odds were reversed (aOR, 1.02 and 1.08, respectively; $P < 0.01$). Thus, it appears that who exactly is included in the expectantly management group has a potential impact on the findings.

IOL may only be a true clinical choice for women without medical indication. Thus, studies have tried to analyze the impact of labor induction for those undergoing an elective induction alone. Darney et al[15] used linked birth certificate and discharge data to analyze the effect of elective induction. They looked at women who were delivered between 37 and 42 weeks of gestation, excluding breech presentation, multifetal gestations, fetal anomalies, and women with a prior cesarean delivery. They compared women who were electively induced at a given week of gestation to all women who delivered at the next week or beyond. Elective inductions were defined as per Joint Commission Criteria, which used ICD-9 billing codes to exclude any induction with a potential medical indication. Of note, however, by design there are women with a medical indication (eg, preeclampsia) that are included in their comparison group. Excluding these women from the comparison group would have biased the results by excluding potential consequences of expectant management. They found that elective induction at each week of

gestation was associated with a significantly reduced odds of cesarean delivery, ranging from a 56% reduction at 37 weeks to a 43% reduction at 40 weeks. For nulliparous women, the risk reduction was somewhat less (23% to 34%) as compared with multiparous women with a prior vaginal delivery (49% to 59%). Bailit and colleagues similarly examined the impact of elective induction using data from the Maternal-Fetal Medicine Unit. Unlike Darney and colleagues, they did not find a reduced risk of cesarean with elective induction for nulliparous women, however, they found no increased risk with elective induction at 39 weeks (aOR, 1.13; 95% CI, 0.94-1.36).[16]

Gibson et al[19] similarly studied elective inductions only. They used a database from the Safe Labor Consortium, which includes 19 US hospitals. They tried to recreate a comparison group of women who would potentially have been candidates for an elective induction by only including women who were singleton, vertex, 37+ weeks gestation, without a prior cesarean delivery, and without any medical condition that would have arisen before term (such as chronic hypertension, diabetes, fetal anomalies, etc.) but they did include medical conditions that could have arisen during expectant management (such as preeclampsia, fetal distress, etc.). This database also allowed for stratification by parity and cervical examination status. They compared women electively induced that week to women who delivered the next week or beyond. For nulliparous women with an unfavorable cervix, there was a decreased odds of cesarean delivery with labor induction at 37 to 40 weeks (aOR, 0.40 to 0.69; $P < 0.01$ for all). In fact, there was a decreased odds of cesarean delivery with labor induction for each group, regardless of parity or cervical examination status.

Osmundson and colleagues[13,14] analyzed the effect of elective induction through slightly different methodology. They included 396 women at a single institution who were nulliparous with a single, vertex gestation and reached 39 weeks of gestation with a known cervical examination conducted between 38 + 0 and 38 + 6 weeks. They compared women who were electively induced anytime between 39 + 0 and 40 + 6 weeks to all other women. For women with a favorable cervix (Bishop score of ≥ 5), there was no statistically increased risk of cesarean delivery among those women who were electively induced (OR, 1.03; 95% CI, 0.66-1.60). For women with an unfavorable cervix there was an increased rate of cesarean delivery among those who were electively induced (43.1% as compared with 34.3%), however, this did not reach statistical significance ($P = 0.16$).

Overall, the retrospective data that use expectant management as a comparison group also tells a consistent story. IOL does not appear to increase the risk of cesarean delivery, and in fact may decrease the risk slightly. This decreased risk is seen regardless of parity, cervical examination status, or whether the induction was elective.

Prospective Data: Randomized Controlled Trials of IOL Versus Expectant

There are a growing number of randomized-controlled trials where IOL is the intervention, thus the actual clinical comparison (induction vs. expectant management) is made in a prospective fashion. Many of these studies, and the largest of the studies, have been done on the late term (41 wk gestation) or postterm (42 0/7 wk and beyond) populations. For example, Hannah et al[20] looked at IOL in 3407 women who were ≥ 41 weeks. These women were randomly assigned to IOL or expectant management. The cesarean delivery rate was significantly lower in the group that was induced (21.2% vs. 24.5%; $P = 0.03$).

Other trials have been done among women with particular medical conditions at term, for which there is equipoise about whether IOL or expectant management is the best option. For example, there was a trial in the Netherlands of 756 patients with gestational hypertension or mild preeclampsia at 36 to 41 weeks of gestation.[21] Women who were induced had a lower rate of cesarean delivery (14% vs. 19%) although this did not reach statistical significance ($P = 0.085$). Similarly, there was a trial of 200 women with insulin-requiring diabetes at 38+ weeks' gestation.[22] Women who were induced had a lower rate of cesarean delivery (25%) as compared with those who were expectantly managed (31%), but this difference did not reach statistical significance. A trial of 650 women in the Netherlands with intrauterine growth restriction diagnosed at 36 weeks or beyond also demonstrated no difference in the cesarean delivery rate (14.0% amongst those induced vs. 13.7% in those expectantly managed).[23]

Nicholson and collaegues have published several articles regarding the impact of their labor induction timing protocol, which they term the active management of risk in term pregnancies (AMOR-IPAT). This protocol calculates the optimal delivery timing, accounting for risk factors for the 2 major causes of cesarean delivery: cephalopelvic disproportion and placental insufficiency. On the basis of the score, an optimal gestational age at delivery is calculated and labor is induced at that time. Using this system, they found that labor inductions rates increased, by design, but cesarean delivery rates were lower or not different. In a retrospective case-control study of 100 actively managed patients and 300 controls, there was a lower rate of cesarean delivery (4% vs. 16%; $P = 0.01$) in those that were actively managed.[24] In a randomized trial of 270 women using the active management protocol, the cesarean delivery rate was no different in the actively managed group (10.3 vs. 14.9%; $P = 0.25$).[25] And looking at multiparous women alone, those that were actively managed had a lower rate of cesarean delivery (0.8% vs. 9.9%; $P = 0.02$).[26]

Although many of the patients in the AMOR-IPAT trials were relatively low risk, they still included women who had risk factors for cesarean delivery. There is very limited prospective data regarding the effect of labor inductions among a truly healthy population electively induced at <41 weeks. Amano and colleagues studied 194 uncomplicated nulliparous patients starting at 36 weeks and randomly assigned them to IOL at 39 weeks or expectant management until 42 weeks. However, they only analyzed mode of delivery for women who had spontaneous labor in the expectant management group, excluding those induced for late term, oligohydramnios, decreased fetal movement, or who chose an elective induction.[27] Given their analysis was not by intention to treat, it makes it hard to interpret their findings, although they did not find a statistically significant difference in the rate of cesarean delivery between the groups (6.4% among those induced vs. 5.6% among those expectantly managed). Nielson et al[28] randomized 226 patients with a favorable cervix at 38 to 39 weeks to elective induction at 39 weeks or expectant management. Among the 116 randomized to elective induction, 23 went into labor before the induction. Among the 110 randomized to expectant management 100 went into spontaneous labor and 10 had an indicated induction. There was no difference in the rate of cesarean delivery between the 2 groups: 6.9% in the induction group versus 7.3% in the expectant management group.

Several meta-analyses have been performed on trials were labor induction was the intervention (Table 2). The findings from the 4 meta-analyses are consistent:

TABLE 2. Meta-Analyses of Randomized Controlled Trials Comparing Induction of Labor to Expectant Management

References	No. Trials Included for Cesarean Delivery Comparison	Overall Odds of Cesarean Delivery (Induced Vs. Expectant Management)	Comments
Gülmezoglu et al[29]	21	0.89 (0.81-0.97)	16/21 trials 41 + wk No significant reduction for trials < 41 wk
Caughey et al[30]	9	0.78 (0.61-0.93)	Only analyzed elective inductions 6/9 trials 41 + wk No significant reduction for trials < 41 wk
Mishanina et al[31]	157	0.88 (0.84-0.93)	113 trials at 37-42 wk (no further gestational age stratification given)
Wood et al[32]	31	0.83 (0.76-0.92)	18/31 trials 41 + wk 10/31 trials with higher risk pregnancies

approximately a 20% reduction in the odds of cesarean delivery with IOL versus expectant management. Of note, however, the majority of the trials in all of these analyses were at 41 + weeks' gestation, both in terms of number of studies and the 41 + -week studies had the largest number of patients. Both medically indicated and nonmedically indicated inductions were included, except in the meta-analysis by Caughey at al,[30] which included only elective inductions.

Overall the prospective data, similar to the retrospective data with the correct comparison of expectant management, consistently finds that IOL is not associated with an increased risk of cesarean, and in fact may be associated with a slightly decreased risk of cesarean delivery.

Discussion

The relationship between IOL and cesarean delivery highlights the importance of having the correct comparison group. Women cannot choose to be in spontaneous labor, although this is the comparison that patients and providers see every day. Women who are induced are at approximately 2-fold increased risk of cesarean delivery, as compared with those in spontaneous labor. However, the true counterfactual is expectant management. When using this comparison, the association is reversed and in both retrospective and prospective trials it appears that IOL actually reduces the risk of cesarean delivery, by approximately 20% in meta-analysis. This is certainly not to say that there are not other downsides to labor induction (it is costly and uses more resources), just that it is unlikely to result in an increased risk of cesarean delivery, and may in fact lower the risk. With regards to costs, one cost-effectiveness study found that routine IOL at 41 weeks' gestation was cost effective at $10,945 per QALY.[33] However, in an evidence-based practice center review, elective IOL at 39 or 40 weeks' gestation was not cost-effective.[34]

Interestingly, we may have another association backwards as well: cervical status. In the retrospective data, that uses women in spontaneous labor as the comparison group, women with the highest risk of cesarean delivery were those induced who had an unfavorable cervix. And indeed, cervical examination status is a clinically significant consideration for providers when they decide to induce a patient or not, especially electively. For

example, the American College of Obstetricians and Gynecologist advise not to schedule elective inductions unless the cervix is "deemed favorable."[35]

However, in both the retrospective data with the correct comparison group (expectant management) and the prospective data, this association is not as clear. For example, in the retrospective data, Gibson et al[19] were able to stratify by both parity and cervical examination status when comparing women who were induced to those in spontaneous labor. Cervical examination status did not modify the relationship. Nulliparous women with a favorable cervix had a 50% reduced odds of cesarean delivery at 39 weeks, as compared with a 53% reduced odds for those with an unfavorable cervix. And in the prospective data, some of the trials stratified by cervical status at baseline in post hoc analysis. For example, in the HYPITAT trial (comparing labor induction to expectant management for women with mild gestational hypertension or preeclampsia) the rate of cesarean delivery was similar with labor induction regardless of cervical status (14.6 vs. 14.8%), but the rate of cesarean delivery for those managed expectantly was lower for those with a favorable cervix (18.2 vs. 21.1%), thus IOL was associated with a greater risk reduction in cesarean delivery risk among those with an unfavorable cervix.[36] Thus, it may in fact be the women with unfavorable cervixes that most benefit from labor induction. This makes sense if you think about the counterfactual; women with unfavorable cervixes are less likely to go into spontaneous labor, thus at higher risk for developing complications (due to the fact they are pregnant for longer) and at higher risk for undergoing an induction at 41 weeks or beyond.

There is still more research to be done. The majority of prospective work thus far has focused on either a population with medical conditions or at 41+ weeks of gestation. There is less certainty about the risks of labor induction for a healthy, low-risk population at <41 weeks. Although the retrospective data using expectant management as the comparison group still shows a reduced rate of cesarean delivery for these women, there is still a chance of residual confounding (ie, women induced without a medical indication may still be a somewhat different group than women who are expectantly managed). And there is also less certainly about the generalizability of the prospective findings, as the majority of studies having been done in tertiary care centers. It is possible that patients or providers in different hospital or call systems may have less patience for labor induction, and if the rate of cesarean delivery for failed inductions is even marginally different, this could still have a significant impact on the cesarean delivery rates.

Overall, however, there is a growing body of literature suggesting that we had the relationship entirely backwards. It does not appear that IOL is associated with an increased, but rather a decreased risk of cesarean delivery or at least no different. This finding was recently underscored as a recommendation in the Obstetric Consensus Care Document from ACOG and SMFM which identified routine IOL at 41 weeks' gestation as an approach to reduce the primary cesarean delivery.[37] Future randomized studies, especially on a low-risk population before 41 weeks, will help clarify this association. And perhaps the overall cesarean delivery rate could be reduced not by avoiding labor induction but rather by using it as tool it in a targeted fashion.

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