Elective induction: An analysis of economic and health consequences

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OBJECTIVE: Our purpose was to assess economic and health consequences of elective induction at term.
STUDY DESIGN: A decision-tree model incorporating a Markov analysis was used to compare the decision either to electively induce labor at term or expectantly manage the pregnancy until 42 weeks' gestation. Main outcome measures, stratified by parity, cervical ripeness, and gestational age at induction, were number of cesarean deliveries and costs to the health care system.
RESULTS: By use of baseline estimates, induction at any gestational age, regardless of parity and cervical ripeness, required expenditures from the medical system. Although never cost saving, inductions were less expensive at later gestational ages, for multiparous patients, and for those women with a favorable cervix. Sensitivity analysis demonstrated a robust model.
CONCLUSIONS: Elective induction of labor at term is not cost saving and results in a large excess of cesarean deliveries. Costs are significantly altered by the timing of the induction, parity, and cervical ripeness. (Am J Obstet Gynecol 2002;187:858-63.)

Key words: Decision analysis, induction of labor, cost, cesarean delivery

Between 1990 and 1998, the frequency of induction of labor has steadily increased.[1] The American College of Obstetricians and Gynecologists has not formally judged the appropriateness of this increase and, aside from recommending that a pregnancy does not proceed beyond 42 weeks, recognizes that the optimal management of women beyond 40 completed weeks of pregnancy is unclear and that "there is mixed evidence regarding which strategy is more cost-effective."[2]

Both strategies of pregnancy management at term—elective induction and expectant management—have their proponents. Those who favor induction before 42 weeks' gestation argue that adverse outcomes such as more cesarean deliveries (because of labor at greater gestational ages), stillbirth, and neonatal complications can be avoided, thereby lowering both morbidity and cost.[3,4] Conversely, those who support awaiting induction until 42 weeks' gestation point to studies that demonstrate an increased risk of cesarean delivery in women undergoing induction, as well as evidence that inductions are more costly due to increased use of hospital resources, regardless of the eventual mode of delivery.[5-8]

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One explanation for the divergent views regarding the cost and health outcomes of induction is the absence of a formal cost analysis. The literature that has assessed costs, with the exception of a Canadian study that only evaluated the incremental cost of induction at 41 weeks, has compared women undergoing induction with a cohort of different women in spontaneous labor at the same gestational age.[9] However, the alternative to an induction is not immediate spontaneous labor but is actually expectant management, the cost of which depends on the subsequent pregnancy course. The purpose of this study, therefore, was to assess the economic and health consequences of a policy of elective induction at 39, 40, and 41 weeks' gestation.

Material and methods

We examined a hypothetic cohort of 100,000 pregnant patients who entered a decision-tree model in which an initial decision was made either to induce labor at a given gestational age or to follow up the patient expectantly through the duration of pregnancy. The decision-tree model was constructed with use of TreePlan, version 1.61 (Decision Support Services, San Francisco, Calif).

For women undergoing expectant management, a Markov technique was used to follow up the patients through their continuing gestations (Fig 1). In this model, women who are expectantly managed, within the following week, could enter spontaneous labor, have abnormal antenatal testing and require induction of labor, or have an intrauterine fetal death. Women who do not

Table I. Probability estimates

Variable	*Baseline estimate*	*Range*	*References*
Nulliparous			
Cesarean delivery at 39 wk, spontaneous labor (%)	12.8	7.9-22.1	7, 10-13
Relative risk of cesarean delivery, induction			
Favorable cervix	1.4	1.1-1.7	6-8, 13
Unfavorable cervix	2.3	2.0-2.8	6-8, 13
Multiparous			
Cesarean delivery at 39 wk, spontaneous labor (%)	3.8	1.2-6.6	7, 10-13
Relative risk of cesarean delivery, induction			
Favorable cervix	1.1	1.0-1.4	7, 8
Unfavorable cervix	2.2	1.2-3.0	7, 8
Parity independent			
Relative risk of cesarean delivery, spontaneous labor			
39 wk	1.0	—	Referent
40 wk	1.1	1.0-1.2	6, 11
41 wk	1.3	1.2-1.5	6, 11
42 wk	1.5	1.4-1.7	6, 11
Meconium at 39 wk (%)	12.2	9.0-15.0	12
40 wk (relative risk)	1.4	1.1-1.8	12
41 wk (relative risk)	1.8	1.4-2.3	12
42 wk (relative risk)	2.3	1.9-3.1	12
Meconium aspiration syndrome if meconium (%)	2.4	0.9-4.5	13, 14
Spontaneous labor within 1 wk if favorable cervix (%)	70	60-80	15-17
Spontaneous labor within 1 wk if unfavorable cervix (%)	45	30-50	3, 4, 17
Unfavorable cervix becomes favorable within 1 wk (%)	15	10-25	4
Abnormal antenatal testing (%)	3.6	1.0-5.6	9, 18
Fetal death (%)			
39 wk	0.05	0.04-0.06	19
40 wk	0.09	0.08-0.10	19
41 wk	0.12	0.10-0.14	19
Cesarean delivery of fetal death (%)	0.0	0.0-4.0	2

Table II. Cost estimates

Variable	*Baseline estimate*	*Range*	*References*
Vaginal delivery ($)	3,456	2,733-4,291	20
Excess cost of induction resulting in vaginal delivery			
Favorable cervix (%)	15	10-20	5, 6, 8
Unfavorable cervix (%)	25	20-30	5, 6, 8
Cesarean delivery ($)	5,581	4,736-6,420	20
Excess cost of induction resulting in cesarean delivery			
Favorable cervix (%)	5	0-10	5, 6, 8
Unfavorable cervix (%)	15	10-20	5, 6, 8
Meconium aspiration syndrome ($)	31,725	16,537-67,407	21, 22
Cost of antenatal testing ($)	330	165-494	22

have any of these occurrences enter the next week of gestation, during which time the various outcomes could once again occur. All women who remain undelivered at 42 weeks of gestation undergo induction of labor.

Separate analyses were performed for week of gestation at the time of induction (39, 40, or 41 weeks), pregnancy history (nulliparous or multiparous), and Bishop score at the time of induction (≥5 or <5). Probability and cost variables entered into the model were obtained from published literature. Each variable was assigned a baseline estimate, as well as a low and high value for use in sensitivity analysis. The costs used were direct medical costs and were adjusted for inflation by use of the medical care component of the consumer price index to reflect 2001 dollars. When only charge data were available, a conversion to costs was made with a cost-to-charge ratio of 0.6. The point of view of this analysis is that of the medical system.

Probability estimates are summarized in Table I. As labor occurs at progressively later gestational ages, the risk of cesarean delivery increases as well.[6,11] Induction of labor in nulliparous women, compared with spontaneous labor, has also been a factor repeatedly associated with an increased risk of cesarean delivery, particularly in the presence on an unripe cervix.[7,10-12] The evidence that induction increases the risk of cesarean delivery in multiparous women is not as consistent.[7,8,10] Most studies, however, have not had the power to actually reveal a sta-

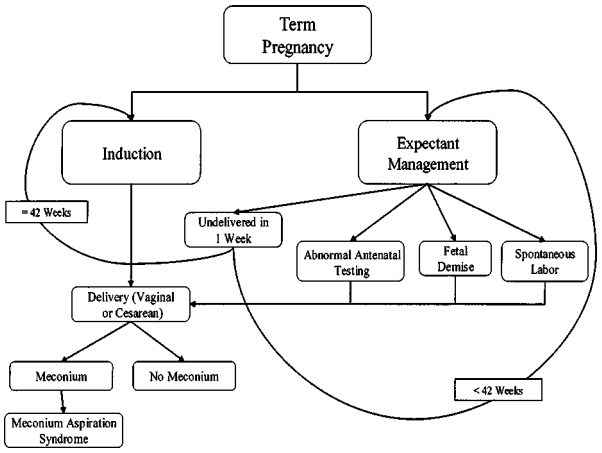

Fig 1. Health state transitions for women at term expectantly managed.

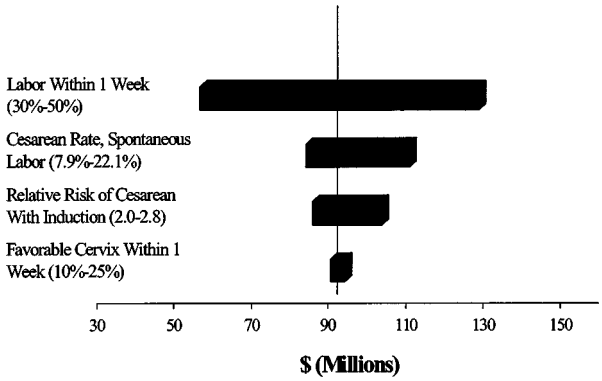

Fig 2. Tornado diagram demonstrating changes in total cost associated with changes of selected probability variable estimates for the cohort of nulliparous women with an unfavorable cervix with labor induced at 39 weeks' gestation.

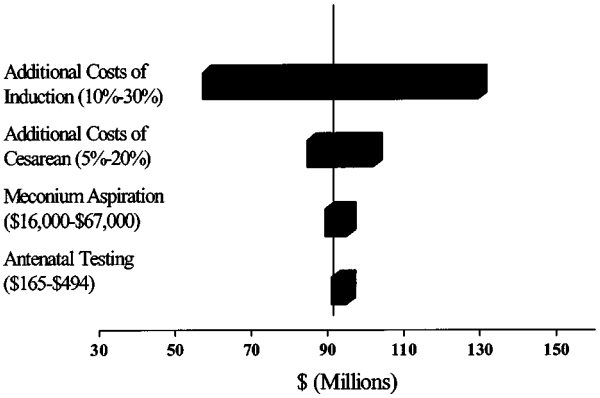

Fig 3. Tornado diagram demonstrating changes in cost associated with changes of selected cost variable estimates for the cohort of nulliparous women with an unfavorable cervix with labor induced at 39 weeks' gestation.

tistically significant increase; one study with enough power did in fact reveal an increased relative risk for cesarean delivery.[7] Therefore, for the baseline estimate, an increased risk of cesarean delivery for multiparous women was assumed, although the impact of this assumption was tested in the sensitivity analysis.

Some variables used in the model, such as the occurrence of an intrauterine fetal death, were not dependent on a patient's parity, and these probability estimates were the same for the nulliparous and multiparous cohorts.[18,19] Although the American College of Obstetricians and Gynecologists states that there is no unequivocal evidence that antenatal surveillance is beneficial before 42 weeks' gestation,[2] because monitoring is often performed before this time, twice weekly nonstress tests and one ultrasound evaluation of amniotic fluid volume were performed in the baseline model at 41 weeks; in the sensitivity analysis, we allowed for testing at 40 weeks of gestation.

Finally, the probability that a woman will spontaneously labor within 1 week is dependent on cervical ripeness. The results of Bishop, which have subsequently been confirmed, reveal that the proportion of women who will spontaneously labor within 1 week after the appearance of a favorable cervical examination is approximately 70%.[17-19] Women with an unfavorable cervix will spontaneously labor within 1 week at a lower rate of 45%, although those women with an unfavorable cervix who remain undelivered may develop a favorable Bishop score.[3,4,17-19]

Costs are summarized in Table II. Because of possible variation in costs resulting from differences in practice style and region, costs both above and below the baseline were examined in the sensitivity analysis.[20] Several articles have documented that induction of labor incurs additional costs regardless of the eventual mode of delivery because of increased uses of medical resources, such as epidural analgesia, intravenous oxytocin and fluids, cervical ripening agents, and increased time on labor and delivery.[5,6,8] Based on the information in these articles, excess costs of induction were estimated for different modes of delivery. The excess cost of meconium aspiration syndrome was ascertained by multiplying the average length of hospital stay for a neonate with severe respiratory failure with the estimated daily cost of neonatal intensive care.[21,22]

Results

The average costs and health outcomes for both induction and expectant management of 100,000 nulliparous women with an unfavorable cervix at 39 weeks of gestation are shown in Table III. With use of baseline estimates, elective induction would result in a cost to the medical system of nearly $100 million and >12,000 excess cesarean deliveries. Alternatively, by undergoing induction, 133 fetal deaths are prevented. The summary of the baseline incremental costs and health outcomes, strati-

Table III. Results for 100,000 nulliparous women with an unfavorable cervix induced at 39 weeks 0 days of gestation

Management decision	*Cost ($ million)*	*Cesarean deliveries*	*Fetal deaths*
Induction	503	29,440	0
Expectant	412	17,346	133
Incremental difference	91	12,094	–133

Table IV. Incremental cost and health outcomes for 100,000 women stratified by gestational age, parity, and cervical ripeness

	Incremental cost ($ million)	*Excess cesarean deliveries*	*Decrease in fetal deaths*
Nulliparous			
39 wk, unfavorable cervix	91	12,094	133
40 wk, unfavorable cervix	71	10,351	156
41 wk, unfavorable cervix	39	8,171	120
39 wk, favorable cervix	49	4,257	88
40 wk, favorable cervix	48	4,008	126
41 wk, favorable cervix	29	3,745	120
Multiparous			
39 wk, unfavorable cervix	75	3,294	133
40 wk, unfavorable cervix	58	2,852	156
41 wk, unfavorable cervix	26	2,310	120
39 wk, favorable cervix	47	167	88
40 wk, favorable cervix	42	85	126
41 wk, favorable cervix	25	131	120

fied by gestational age at time of induction, parity, and Bishop score, is presented in Table IV. A policy of induction at any gestational age, regardless of parity or cervical ripeness, required economic expenditures by the medical system. The inductions most costly to the health care system are those performed in nulliparous women with an unfavorable cervix at 39 weeks of gestation. When nulliparous women with a favorable cervix undergo labor induction, the cost is approximately halved. A policy of induction of multiparous women with a favorable cervix at 41 weeks had the lowest incremental cost compared with an expectantly managed patient.

Univariate sensitivity analysis revealed a model that was robust because the cost results changed by no more than 25% despite altering each probability and cost variable across its entire range. The impact of selected variables on the final cost outcomes for nulliparous women with an unfavorable cervix with labor induced at 39 weeks' gestation is illustrated in Figs 2 and 3. In these figures, the bar represents the extent of change in the costs of induction as the named variables are altered across their specified ranges. Regardless of any estimate, no decision to induce labor was ever cost saving. Many excess cesarean deliveries for nulliparous patients continued to occur, although the final incremental difference in cesarean deliveries varied to a larger extent than the incremental costs. For example, when the lowest relative risk for induction-associated cesarean was used in nulliparous women with an unfavorable cervix, the excess number of cesarean deliveries fell to 5842. At no gestational age or degree of cervical ripeness did induction of labor in nulliparous patients result in fewer cesarean deliveries.

The multiparous cohort also showed a significant excess of cesarean deliveries when induction was performed in the setting of an unfavorable cervix. When labor was induced with an unfavorable cervix at 39 weeks of gestation, for example, these patients had >3000 additional cesarean deliveries. However, as the relative risk of cesarean delivery associated with induction became lower, the excess number of cesarean deliveries fell significantly; when the relative risk for cesarean delivery was 1.2, for example, only 108 excess cesarean deliveries occurred. Also, multiparous patients with a favorable cervix had many fewer cesarean deliveries as a result of induction. Even at 39 weeks of gestation, induction resulted in an excess of only 167 cesarean deliveries. When the low estimate of the relative risk for cesarean delivery associated with induction was used, multiparous patients with induction of labor at 41 weeks of gestation with a favorable cervix actually had 192 fewer cesarean deliveries. Inductions of the multiparous cohort, however, continued to require input of economic resources from the medical system; this finding was true in both the baseline estimate and throughout the sensitivity analysis.

The number of intrauterine fetal deaths at each gestational age is similar for either nulliparous or multiparous women, although this number is dependent on cervical ripeness. Depending on the gestational age at which the cohort of 100,000 women has labor induced, 85 to 133 intrauterine fetal deaths will occur.

Comment

Because of these opposing views regarding the propriety and costs of elective induction, this analysis was undertaken to formally assess the consequences of a policy of labor induction in term gestations. The results suggest that elective induction of labor results in significantly higher costs and a greater number of cesarean deliveries. The magnitude of these outcomes is somewhat dependent on the gestational age at which induction occurs, a patient's parity, and the Bishop score. In the nulliparous cohort, whether the cervix is favorable or unfavorable, induction of labor incurs a significant marginal cost and number of cesarean deliveries compared with that of expectant management.

The multiparous cohort is notable, resulting in many fewer cesarean deliveries than the nulliparous cohort, particularly when the former have a favorable cervix or a low relative risk for cesarean delivery associated with induction. However, the excess costs continue to be relatively high. In this cohort, magnitude of costs were not primarily driven by the number of cesarean deliveries but by the excess costs associated with induction, such as cervical ripening agents, time spent on labor and delivery, and the increased use of other medical resources.

Inductions, however, have potential tangible benefits with regard to perinatal outcome because delivery prevents the possibility of an intrauterine fetal death. Although the risk of this catastrophic complication is low in any given week in any given individual, the excess risk for 100,000 women who await labor is approximately 100 fetal deaths.

Inevitably, there are some events that are not included in this analysis. For example, we did not consider the possibility that some neonates were admitted transiently to the neonatal intensive care unit and the cost that might be incurred from such an admission. For that matter, we did not consider the additional costs that might be incurred in future pregnancies as a result of repeated cesarean deliveries when a trial of labor is refused. Also, we have used one value of the Bishop score to define a "favorable" and "unfavorable" cervix, although the single cutoff value that is best remains a matter of some controversy. Nevertheless, we included what we thought to be the most significant events that would have an impact on our decision analysis, and, given the robust nature of the model, there is reason to believe that these occurrences would not materially change the results.

This article cannot resolve the issue of whether these excess intrauterine deaths are a significant enough harm to justify the excess costs and potential maternal morbidity that their avoidance would entail. Exactly what the line of demarcation is that separates a reasonable from an unreasonable policy is difficult to ascertain, and individuals who read this analysis may interpret the results differently and continue to advocate their favored policies. However, the starting point for any discussion about a given management decision is an understanding of the magnitude of economic costs and health consequences incurred by the possible choices. The analysis with this model seeks to better quantify the benefits and harms of induction and contribute to the debate of how to balance the significant harm to few (ie, intrauterine fetal deaths) with the potential for lesser harm to many.

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