The relationship between maternal age and uterine dysfunction: A continuous effect throughout reproductive life

Denise M. Main, MD,[a, b] Elliott K. Main, MD,[a, b] and Dan H. Moore II, PhD[b]

San Francisco, California

OBJECTIVE: In a selected low-risk population with spontaneous term labor we sought to determine whether there was a continuous effect of maternal age on uterine function.

STUDY DESIGN: With our comprehensive computerized database and medical record system, we identified 8496 patients who were nulliparous and in spontaneous labor at term (≥37 weeks' gestation) with singleton fetuses in vertex presentation. This group was then analyzed according to maternal age for measures of labor dysfunction and rates of operative delivery. Analysis of variance and χ^2 statistics were used.

RESULTS: Use of oxytocin, duration of second stage of labor, cesarean delivery, cesarean delivery for failure to progress, and operative vaginal delivery rates were significantly increased with advancing maternal age ($P < .0001$). These increases appeared to be continuous functions beginning during the early 20s rather than new phenomena beginning after age 35 years.

CONCLUSION: Among nulliparous patients with uncomplicated labor there is a continuously increasing risk of uterine dysfunction related to maternal age. (Am J Obstet Gynecol 2000;182:1312-20.)

Key words: Advanced maternal age, cesarean delivery rate, labor abnormalities

Although many studies have demonstrated that women >35 years old are more likely to be delivered by the cesarean route than are younger women,[1-13] the basis for this difference is hotly debated. Older women more commonly have a number of pregnancy complications that increase the rate of cesarean delivery, including preterm delivery, multifetal gestation, fetal malposition, placenta previa, and medical illnesses.[8-11] However, even women >35 years old who do not have any of these high-risk conditions have more cesarean births than do younger women.[12, 13] Some investigators have suggested that older patients and their physicians are more anxious about their "premium pregnancies" and that this concern results in the higher cesarean delivery rates.[11, 14] Others, studying the labor patterns of relatively small groups of women, have suggested that there may be a direct aging effect on myometrial function.[13, 15, 16] Indeed, many muscles become less effective with increasing age, so why should we not expect to see some effect on the uterus?

From the Department of Obstetrics and Gynecology, California Pacific Medical Center,[a] and the Program in Outcomes Research, California Pacific Medical Center Research Institute.[b]

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Reprint requests: Denise M. Main, MD, Department of Obstetrics and Gynecology, California Pacific Medical Center, G 330, 3700 California St, San Francisco, CA 94118.

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The purpose of this study was to evaluate the effects of maternal age on uterine function in a large sample of low-risk women for whom we had detailed labor and delivery information. Our study group was racially diverse but predominantly middle-class. To exclude potentially confounding medical and obstetric complications and to eliminate the biases of induction management, only nulliparous women at term in spontaneous labor with singleton fetuses in the cephalic presentation were included. We chose as outcomes not only cesarean delivery rate but also more direct uterine measures, such as labor durations and need for oxytocin augmentation.

Material and methods

For data recovery and analysis we used a comprehensive maternal computerized database and medical record system, The Perinatal Data Center (Site of Care Systems, San Francisco, California). The Perinatal Data Center is used to summarize in detail the care of each labor and birth and to create discharge summaries, diagnosis summary sheets, and birth certificates; it also serves as the online medical record and coding system for all sick neonates. In addition the system creates all the obstetric statistics and billing information for the unit. To serve all these needs there are multiple data validation steps throughout the medical record process. We identified all 30,882 women who were delivered at California Pacific Medical Center between January 1, 1992, and December 31, 1998. Among these 30,882 deliveries 8496 nulliparous women who had singleton gestations at term (≥37 weeks' gestation) with cephalic presentation and spontaneous

Table I. Maternal race, ethnicity, and method of payment according to maternal age

	<20 y	*≥20 y, <25 y*	*≥25 y, <30 y*	*≥30 y, <35 y*	*≥35 y, <40 y*	*≥40 y*
No.	239	773	2376	3322	1498	290
Race (%)						
White	38.1	36.8	43.4	57.9	67.9	69.6
Asian	28.0	49.8	52.5	40.0	29.1	27.2
African American	30.1	9.7	2.7	1.5	1.7	1.7
Other	3.8	3.8	1.4	0.6	1.3	1.4
Ethnicity (%)						
Hispanic	18.4	10.0	5.7	3.7	4.6	1.7
Non-Hispanic	81.6	90.0	94.3	96.3	95.4	98.3
Payment (%)						
Private coverage*	42.7	59.2	81.2	91.8	93.3	94.5
MediCal	56.5	38.6	16.1	6.8	5.4	4.8
Self-pay	0.8	2.2	2.7	1.4	1.3	0.7

*Insurance or health maintenance organization other than MediCal.

Table II. Labor and delivery factors according to maternal age category

	<20 y	*≥20 y, <25 y*	*≥25 y, <30 y*	*≥30 y, <35 y*	*≥35 y, <40 y*	*≥40 y*	*Statistical significance**
Labor duration (min)							
First stage	689	628	639	641	706	716	$P = .009$
Second stage	64	71	83	92	103	102	$P < .0001$
Oxytocin (%)	28.6	29.3	34.8	39.4	45.4	49.5	$P < .0001$
Operative vaginal delivery (%)	14.2	16.9	21.3	26.5	29.8	29.3	$P < .0001$
Cesarean delivery (%)							
Total	5.9	6.0	9.1	12.7	16.6	22.8	$P < .0001$
Cephalopelvic disproportion or failure to progress	4.2	4.3	7.4	10.4	12.1	17.9	$P < .001$
Fetal distress	1.2	1.4	1.3	1.9	3.5	4.5	$P < .001$
Epidural anesthesia (%)	38.9	44.9	53.0	63.5	69.1	68.3	$P < .0001$
Birth weight (g)	3257	3304	3360	3387	3396	3384	$P < .0001$

*By χ^2 analysis.

labor at admission met the inclusion criteria. Exclusions included all inductions, elective cesarean deliveries, and major medical or obstetric complications.

The need for oxytocin augmentation during labor, the duration of the first stage of labor, and the duration of the second stage of labor were used to assess myometrial function. Overall success of labor was evaluated according to method of delivery, including total cesarean delivery rate, rate of cesarean delivery for cephalopelvic disproportion or failure to progress, and operative vaginal delivery rate. We also examined the rate of cesarean delivery for fetal distress. Potential confounding factors incorporated into the analysis included epidural anesthesia, infant birth weight, race and ethnicity, and insurance status. Analysis of variance, χ^2 statistics, and multiple regression modeling were used for analysis.

Results

Selected demographic characteristics of the study population are provided in Table I. Approximately 54% of the group were white, 42% were Asian American, and 3.5% were African American. As demonstrated in Table I, the proportion of African Americans was significantly higher in the younger age groups, whereas the whites were overrepresented in the older age groups ($P < .0001$). Women who reported their ethnic group as Hispanic were also more likely to be younger. Although almost 85% of the entire group had medical insurance or health maintenance organization coverage, younger women received MediCal support significantly more often ($P < .0001$).

Labor and delivery characteristics are shown according to maternal age category in Table II. The three indicators of myometrial function used in our investigation (duration of first stage of labor, duration of second stage of labor, and need for oxytocin augmentation) all increased significantly with increasing maternal age. Similarly, the rates of operative vaginal delivery, cesarean delivery for cephalopelvic disproportion or failure to progress, and cesarean delivery for all indications increased with advancing maternal age. Total cesarean delivery rates are displayed in Fig 1, and rates of cesarean delivery for cephalopelvic disproportion or failure to progress and for fetal distress are shown in Fig 2.

Of note, two potentially confounding variables, epidural anesthesia and birth weight, also increased

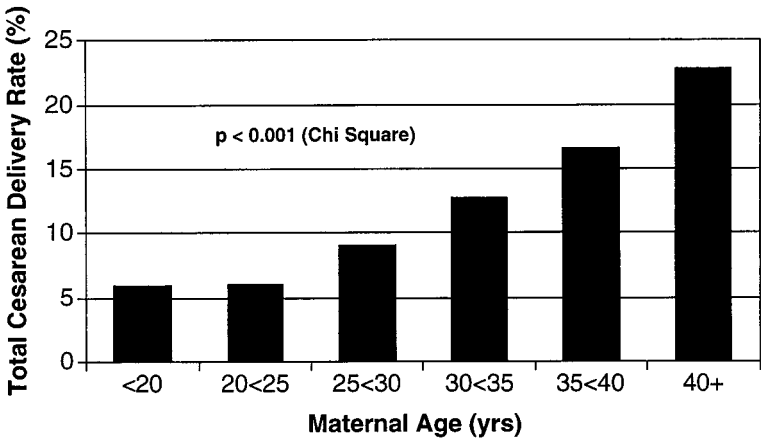

Fig 1. Effect of maternal age on total cesarean delivery rate. Rise was significant beginning at age 25 to 30 years, $P < .001$, by χ^2 test.

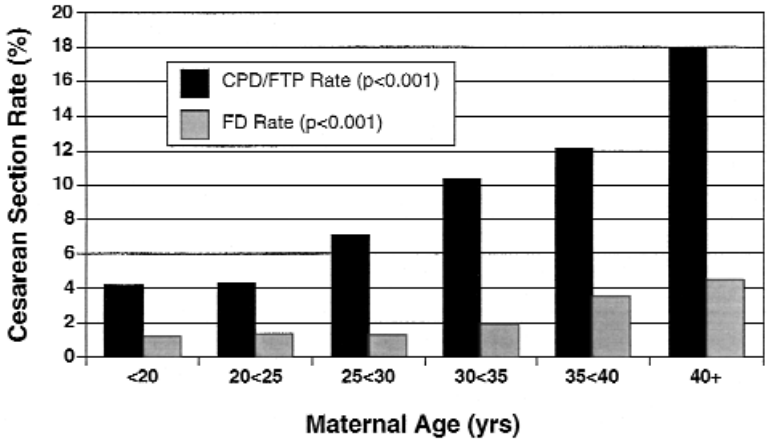

Fig 2. Effect of maternal age on rates of cesarean delivery for cephalopelvic disproportion or failure to progress (*black bars*, $P < .001$) and fetal distress (*gray bars*, $P < .001$). Note that rise in cephalopelvic disproportion or failure to progress rate was continuous from age 25 years, whereas fetal distress rate rose significantly only after age 35 years.

with advancing maternal age. To further investigate the potential interactions of epidural anesthesia, birth weight, race, ethnicity, and payor status with the effects of maternal age on the various labor and delivery factors a series of multiple logistic regression analyses were performed. In these analyses maternal age remained a highly significant predictor of duration of the second stage of labor, oxytocin augmentation, operative vaginal delivery rate, and cesarean delivery rate (all $P < .0001$ when maternal age was included as a continuous variable). The duration of the first stage of labor was not significantly related to maternal age. As demonstrated in Tables IIIA, IIIB, IIIC, and IIID, epidural anesthesia, birth weight, and race were also significant variables that were associated with some measures of both labor protraction and operative delivery. To provide an easier comparison, results are shown for the logistic regressions that treated maternal age and birth weight as categoric rather than continuous variables. Payment source is not included in any of the final models, because it was not significant in any. The rates of cesarean delivery according to age and race are demonstrated in Fig 3. Although maternal age remained a significant predictor for cesarean delivery for each race shown, its impact was most dramatic in our data set among Asian Americans. Similarly, although maternal age remained a significant factor for women without epidural anesthesia, its effect was more pronounced among recipients of epidural anesthesia, as shown in Fig 4.

Comment

Our study of a large number of low-risk term nulliparous women in spontaneous labor demonstrated an increasing need for oxytocin augmentation, a longer second stage of labor, more operative vaginal deliveries, and more cesarean deliveries for cephalopelvic dispropor-

Table IIIA. Results of logistic regression for predicting labor abnormalities and operative delivery: Significant factors found to predict cesarean delivery

Factor	*Odds ratio**	*95% Confidence interval*	*Statistical significance*
Maternal age			
≥20 y, <25 y	0.98	0.51-1.89	NS
≥25 y, <30 y	1.42	0.77-2.60	NS
≥30 y, <35 y	2.18	1.20-3.96	*P* = .01
≥35 y, <40 y	2.97	1.62-5.45	*P* < .0001
≥40 y	4.68	2.43-9.04	*P* < .0001
Birth weight >3800 g	2.25	1.91-2.67	*P* < .0001
Race or ethnicity			
Asian	2.25	1.92-2.63	*P* < .0001
African American	2.20	1.46-3.31	*P* < .0001
Hispanic	1.82	1.33-2.49	*P* < .0001
Epidural anesthesia	3.66	3.06-4.37	*P* < .0001

NS, Not significant.
*Each odds ratio is with respect to women <20 years old who were non-Hispanic white, were delivered of babies weighing between 2500 and 3800 g, and did not have epidural anesthesia. Medical payment was not included in this model because it was not significant.

Table IIIB. Results of logistic regression for predicting labor abnormalities and operative delivery: Significant factors found to predict augmentation with oxytocin

Factor	*Odds ratio**	*95% Confidence interval*	*Statistical significance*
Maternal age			
≥20 y, <25 y	.92	0.63-1.32	NS
≥25 y, <30 y	1.15	0.82-1.61	NS
≥30 y, <35 y	1.29	0.92-1.82	NS
≥35 y, <40 y	1.66	1.17-2.35	*P* =.005
≥40 y	2.05	1.35-3.12	*P* = .001
Birth weight >3800 g	1.50	1.31-1.72	*P* < .0001
Race or ethnicity			
Asian	1.58	1.41-1.76	*P* < .0001
African American	1.49	1.11-2.00	*P* = .008
Hispanic	1.47	1.17-1.85	*P* = .001
Epidural anesthesia	4.97	4.45-5.56	*P* < .0001

NS, Not significant.
*Each odds ratio is with respect to women <20 years old who were non-Hispanic white, were delivered of babies weighing between 2500 and 3800 g, and did not have epidural anesthesia. Medical payment was not included in this model because it was not significant.

tion or failure to progress and for all indications with advancing maternal age throughout the entire reproductive age range. It is important that there was not a sudden increase in these outcomes at the age of 35 years but rather a steady change beginning at the age of 25 years. This pattern suggests that there is a gradual decrease in myometrial function with increasing age, a finding that was proposed in earlier studies by Friedman and Sachtleben,[15] Cohen et al,[16] and Adashek et al.[13] In 1965

Table IIIC. Results of logistic regression for predicting labor abnormalities and operative delivery: Significant factors found to predict operative vaginal delivery

Factor	*Odds ratio**	*95% Confidence interval*	*Statistical significance*
Maternal age			
≥20 y, <25 y	0.97	0.63-1.49	NS
≥25 y, <30 y	1.19	0.80-1.78	NS
≥30 y, <35 y	1.46	0.98-2.17	NS
≥35 y, <40 y	1.68	1.12-2.52	*P* = .01
≥40 y	1.72	1.08-2.76	*P* = .02
Race			
Asian	1.40	1.25-1.57	*P* < .0001
African American	0.57	0.39-0.84	*P* = .004
Epidural anesthesia	2.76	2.45-3.12	*P* < .0001

NS, Not significant.
*Each odds ratio is with respect to women <20 years of age who were white and did not have epidural anesthesia. Medical payment and birth weight were not included in this model because they were not significant.

Table IIID. Results of logistic regression for predicting labor abnormalities and operative delivery: Significant factors found to predict duration of second stage of labor

Factor	*Odds ratio**	*95% Confidence interval*	*Statistical significance*
Maternal age			
≥20 y, <25 y	4.1	–5.0 to 13.1	NS
≥25 y, <30 y	11.3	2.7 to 19.3	*P* = .01
≥30 y, <35 y	19.7	11.2 to 28.2	*P* < .0001
≥35 y, <40 y	28.0	19.1 to 36.9	*P* < .0001
≥40 y	28.7	17.4 to 40.0	*P* < .0001
African American	–19.2	–27.2 to –11.2	*P* < .0001
Epidural anesthesia	33.8	31.0 to 36.7	*P* < .0001

NS, Not significant.
*Each coefficient is with respect to women <20 years old who were white and did not have epidural anesthesia. Medical payment and birth weight were not included in this model because they were not significant. Coefficient is added or subtracted from mean second-stage duration of 85.2 minutes.

Friedman and Sachtleben[15] demonstrated a modest increase in the duration of the deceleration phase and the second stage of labor among older gravid women but detected no difference in the length or slope of the active phase of labor. Cohen et al[16] demonstrated a highly significant correlation between age and protraction disorders, which was limited to nulliparous women and was not explained by increased anesthetic use. Both these detailed studies were limited by relatively low numbers of women delivering at age >35 years. Adashek et al[13] prospectively compared the labor and delivery courses of 74 women >35 years old with those of 275 women aged 20 to 29 years. They found that, although there were no differences in rates of oxytocin augmentation or epidural

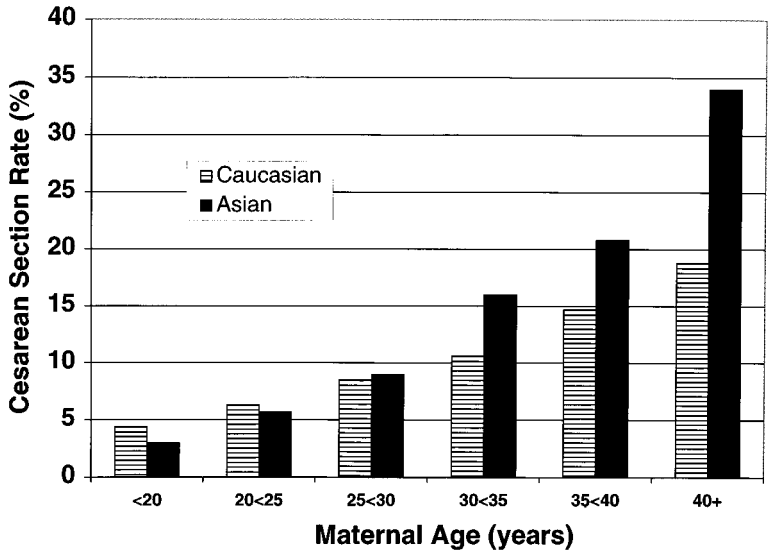

Fig 3. Effects of maternal age on cesarean delivery rates for white patients *(striped bars)* and Asian American patients *(solid bars).* Note that rise in cesarean delivery rate was continuous from age 25 years for both racial groups, although relative increase was greater for Asian American group.

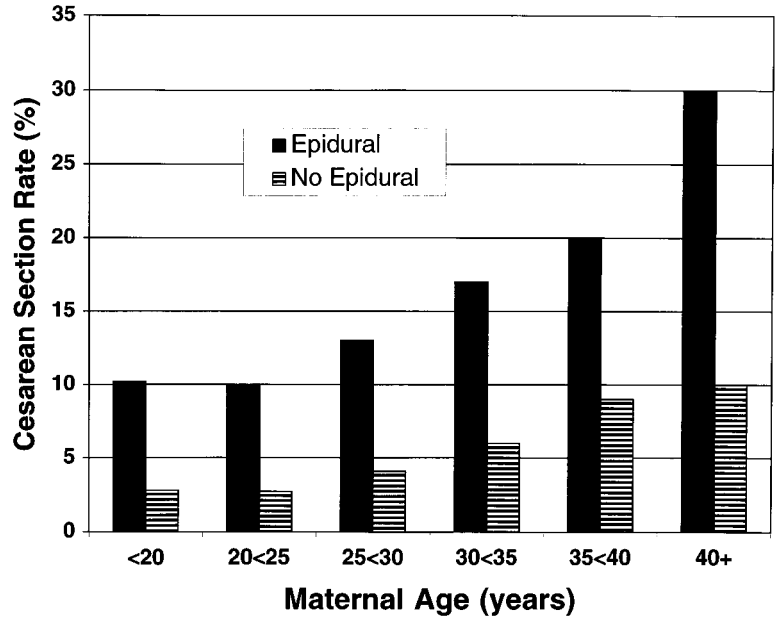

Fig 4. Effects of maternal age on cesarean delivery rates for women who received *(solid bars)* and did not receive *(striped bars)* epidural anesthetics. Note that rise in cesarean delivery rate was continuous from age 25 years for both groups, although relative increase was greater among those with epidural anesthesia.

anesthesia, the dose and duration of oxytocin used were significantly higher in the older group, and the older group as a whole had significantly more cesarean deliveries. There was also a trend toward increased duration of the second stage of labor.

It is not surprising that epidural anesthesia was associated with higher rates of labor protraction, higher rates of cesarean delivery, and longer second stages of labor, because many recent reports have noted such associations.[17-19] We were unable to determine in our investigation the timing of epidural use relative to augmentation of labor when both occurred during the same labor. Nonetheless, there was a significant independent maternal age effect. In our population more Asian Americans selected epidural anesthesia, and this preference may account for their relatively higher rates of cesarean deliver-

ies with respect to whites. An alternative explanation may be differences in maternal height and weight, which have been found to be significant predictors in some populations.[7] These factors were not available for analysis in our data set. Another factor that may have influenced this analysis is differences in labor management by individual practitioners. Because of the relatively small numbers of deliveries per physician we were unable to include providers in our logistic regression models. In our study group of nulliparous women with singleton vertex gestations and active spontaneous labor we also noted an age-related increase in the rate of cesarean delivery for fetal distress (Fig 2). This increase was more modest than that in the rate of cesarean delivery for cephalopelvic disproportion or failure to progress, and importantly it only became significant among women >35 years old. We did not study the potential interactions between labor abnormalities and fetal distress in this population.

Strengths of our analysis include the large number of carefully selected gravid women analyzed and the detailed information at our disposal. Most previous studies analyzed considerably fewer than 200 women >35 years of age. Studies with larger numbers used vital statistics records, which limited analysis of labor issues and prevented examination of such confounding factors as epidural anesthesia. Our ability to perform multiple logistic regression analysis on several key variables allowed us to identify the interplay of these obstetric factors. Unfortunately in this study, as for most investigations, it remained quite difficult to tease apart the interactive effects of oxytocin and epidural anesthesia.

In summary, it appears that the increase in cesarean delivery rate seen with advancing maternal age has several components. Undoubtedly maternal medical and obstetric complications account for a portion of the increase seen. Likewise, some women undergo elective induction or cesarean delivery because of real or perceived risks. Our data would suggest that the uterine muscle is not immune to aging effects seen in the rest of the body and that the older myometrium itself may contribute to a slower and more complicated labor, with a more frequent requirement for operative delivery. Of particular interest, this appears to be a gradual and continuous process beginning as early as the age of 25 years.

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Editors' note: This manuscript was revised after these discussions were presented.

Discussion

Dr Hanns C. Haesslein, Seattle, Washington. Kirz et al[1] in 1985 wrote succinctly and reassuringly about the mature gravid woman and the good pregnancy outcome that she can expect, at least in a tertiary obstetric center. In their article they also succinctly defined some of the probable causes for delayed childbearing[1]:

1. The postwar baby boom cohort
2. Career priorities
3. Advanced education
4. Infertility
5. Control over fertility
6. Late and second marriages
7. Financial concerns

This study by Main et al adds additional data and insight on one of the common questions asked by these "mature" women in our practices, "What influence will my age have on my labor and delivery?"

Their study used a large and complete database to identify 8496 nulliparous women in active labor carrying a single vertex fetus at term. Of special importance was the exclusion of major maternal and obstetric complica-

tions from this group. This left women who were essentially healthy on whom to focus our attention.

The main point of this article was devoted to the fact that in this group of selected nulliparous women the use of oxytocin, the rate of operative delivery, and the cesarean delivery rate rose not with sudden increases after the age of 35 years but from 6% to 22.6% continuously with increasing age. The major diagnoses contributing to this rise were cephalopelvic disproportion and failure to progress. With these data clearly showing a continuous increase in risk after the age of 25 years it appears that obstetricians do not use these diagnoses more readily only when managing the mature woman; rather, factors other than age play an important part. The diagnosis of fetal distress only increases above the commonly accepted rate of approximately 1.5% after the age of 35 years. Could this be where practitioners are quicker to resort to cesarean delivery? If so, it accounts for only a 2% increase in the total cesarean delivery rate.

This continuum of age-related increases in cesarean and operative delivery rates was seen in a group of patients who were selected not to have problems and who had a maximum birth weight spread between groups of only 142 g (5 oz). Can this difference really be clinically significant? Because diabetes was excluded from the cohort, it would be interesting to know whether this birth weight increase was related to body mass index, smoking rates, exercise patterns, or other factors somewhat under the control of the woman herself.

Central to this discussion is the question of uterine dysfunction. Main et al showed a 2-fold increase in operative vaginal delivery and an almost 4-fold increase in cesarean delivery rate for the mature nulliparous woman. They also showed that the first stage of labor appeared to have a duration distribution according to age that was bimodal. Both the group <20 years old and the group >35 years old had an increased duration of first stage of approximately 50 minutes, which is not quite statistically significant. Assuming that the definition of the first stage of labor was equal in all groups, a woman in her 20s would have an average labor length of approximately 700 minutes, whereas a woman >35 years old would labor for 810 minutes. That is nearly a 2-hour difference. Could the increase in epidural anesthesia in these two groups, from about 50% to nearly 70%, account for this? The study by Adashek et al[2] supports this concept while postulating from a small series of patients that the increase in duration of the second stage of labor might be because of increased fetal size (only 5 oz in this study) as well as to decreases in uterine contractility, pelvic compliance, and maternal expulsive effort.

It is possible that we need a different type of study to tease out the effects of age alone on the contractility of the myometrial smooth muscle cell. Huszar's excellent review[3] on the physiologic characteristics of the myometrium does not address the effects of aging on the complex cellular receptor changes and hormonal regulation during pregnancy of the uterine smooth muscle. It seems likely that aging decreases the ability of the uterus to work at the same efficiency. What remains unclear is whether this is clinically important.

The study determined the factors for which odds ratios predicted increased risks of oxytocin augmentation, cesarean delivery, an operative vaginal delivery and also a longer second stage of labor. Main et al used a comparison cohort of women <20 years old who were white, had babies between 2500 and 3800 g, and did not have epidural anesthesia.

Of all these factors the woman herself can only influence one, the use of an epidural anesthetic. I would like to comment on the question of perception of risk that a woman may have for these factors. Other than cesarean delivery, with its attendant pain, increased hospitalization, and possible impact on future delivery mode, does the average mature woman really care whether she receives oxytocin, has a few minutes of help from a vacuum or forceps, or has a second stage that lasts 20 minutes longer? She may well decide to accept these risks if she believes that painless childbirth is of true personal value.

It has always been the art of the obstetrician to discuss issues of possible increased risk in a supportive fashion. We can reasonably reassure the healthy mature woman that her perinatal mortality and morbidity for a genetically normal infant are not increased. We must still hesitate, however, about the influence of age on the process of labor given the data in this study. Whether any woman will really be deterred by a possible 2-hour increase in labor or by an increased likelihood of cesarean delivery when she has waited ≥35 years for her first birth does seem somewhat doubtful to me.

Perhaps we should suggest to the mature gravid woman who is discussing her first pregnancy that she consider using her personal resources to learn about pain control methods other than epidural anesthesia. This study would seem to support the concept that avoidance of epidural anesthesia is the only factor that can be personally influenced which might lead to less augmentation of labor, to less risk of labor protraction, and therefore to a lower cesarean risk.

I hope that Main et al will continue to use their comprehensive database to explore these types of issues. As a result of my review I have three questions for Dr Main:

1. Can you dissect your data to state what we should advise the mature gravid woman (>35 years) who is white, has an average-sized fetus, and does not plan to use epidural anesthesia with regard to her relative risks of cesarean and operative vaginal delivery?

2. Do your data lend any credence to the concept that a "premium pregnancy" bias existed in the management of the mature gravid woman, perhaps especially in your Asian American group?

3. Do you have any plans to look at the issue of uterine work capability with increasing age by studying a cohort of patients without either oxytocin augmentation or epidural anesthesia?

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Dr William M. Gilbert, Sacramento, California. Dr Main, I noticed that your cesarean delivery rates were about 5% among nulliparous women <20 years old and only 23% among those >40 years old. What was your overall hospital cesarean delivery rate? These numbers seem quite low when you consider numbers in the literature.

Dr A. Richard Graham, Seattle, Washington. This question is on behalf of my anesthesiologist friends, Dr Main, because they always want to know. Was the level of anesthesia evaluated when the epidural data were collected?

Dr Lyman A. Rust, Hanford, California. Dr Main, have you had any experience with intrathecal narcotics instead of epidural anesthesia? If you have not, do you think that this practice might have an effect on reducing the prolongation of the second stage?

Dr Frank R. Gamberdella, Santa Barbara, California. When you extracted the data, did you look at both maternal and fetal morbidity among those older primigravid mothers who were delivered vaginally, either spontaneously or by instrumentation, such as cephalhematoma, reduced Apgar scores, or significant perineal trauma?

Dr E. Paul Kirk, Portland, Oregon. Dr Main, could you comment on the potential role of induction in this patient population? It seems to me that there is a much higher use of antepartum surveillance and a much lower threshold for induction of labor among older patients, and I wondered whether that might be a factor.

Dr Mark D. Nichols, Portland, Oregon. Dr Main, do you have any information regarding the care provider and the relationship to the cesarean delivery rate, operative delivery rate, and epidural rate? Many studies have looked at the cesarean delivery rates in community hospitals and found that it was often provider dependent. Did you see that a certain cohort of providers had higher cesarean delivery rates or operative delivery rates and also whether certain providers had a higher rate of epidural anesthesia?

Dr David A. Luthy, Seattle, Washington. Dr Main, what proportion of your birth cohort were the women >35 years old, and was that similar to the proportion in California? Second, what contribution did these women make to your overall unplanned primary cesarean delivery rates? Third, how tight are your confidence intervals around your odds ratios?

Dr Douglas Der Yuen, Seattle, Washington. I am interested in the use of intrathecal narcotics as opposed to anesthetic agents, Dr Main, but I also wondered about the timing of epidural anesthesia, whether the agents were administered before or after the active phase, with 3 to 4 cm of dilatation? What percentages of epidural anesthetics were given before and after, and was that information broken down with respect to impact on operative delivery or cesarean delivery?

Dr Durlin E. Hickok, Seattle, Washington. I get a little nervous about studies that combine different racial groups, because certain labor and delivery characteristics may be different. Dr Main, did you analyze Asian American patients separately from white patients? Race could be an effect modifier rather than a confounder if you do not have that knowledge.

Dr R. Glen F. Steinke, Fresno, California. First, Dr Main, can you differentiate between uterine contractility and the pressure forces versus the resistance provided by the pelvis in terms of pelvic flexibility or pelvic compliance in these older parous patients? Second, I do not think that the problems with *premium* babies occur in terms of what happens during labor. Decision making during labor occurs relative to what is happening with the baby and the patient. The decision making that may be affected with *premium* babies is what is done before labor.

Dr Main (Closing). I will begin with Dr Haesslein's questions. First, what were the cesarean delivery rates according to maternal age for the subgroup of white women with average-sized fetuses who did not undergo epidural anesthesia? The 20- to 25-year-old women who met these criteria had a cesarean delivery rate of 3%, whereas the 35- to 45-year-old women who met these criteria had an 8.9% rate.

Dr Haesslein also asked for potential explanations of the increased rates of cesarean births among the Asian American women as compared with the white women in our study group. Dr Hickok asked whether we had analyzed the effects in the racial groups separately. We did, and the age effects were highly statistically significant in both groups. The data are shown in Fig 3 of the article. The higher cesarean delivery rate may be partially explained by the greater use of epidural anesthesia among the Asian American women. It may also relate to factors that we could not evaluate, such as maternal height and weight.

Drs Nichols and Haesslein asked about provider effects. We tried to look at provider effects informally, especially in the Asian American group, because there are a number of providers at our hospital who deliver Asian American patients almost exclusively. These providers as a group do not have a higher cesarean delivery rate than our overall group of providers. This is an important area to evaluate further.

Dr Haesslein also asked about cesarean delivery and operative delivery rates for the subgroup of women who received neither epidural anesthesia nor oxytocin augmentation of labor. In this group, the cesarean delivery rate went from 2.9% to 10.8% with increasing maternal age, and the operative vaginal delivery rate went from 9% to 20%. In addition the duration of the second stage of labor increased with advancing maternal age in this untreated subgroup.

There were several comments relating to level and timing of epidural anesthetic administration relative to cervical dilatation. We do not have this information in

our data set. Intrathecal narcotic agents were not commonly used during the study.

Dr Gilbert asked about the overall cesarean delivery rate in our hospital. This ranged from 18% to 21% during the study years.

We did not look at factors related to maternal or infant mortality. Those suggested by Dr Gamberdella would be interesting to evaluate.

I agree with Drs Steinke and Kirk that many *premium* baby decisions may be made before the onset of spontaneous labor and perhaps result in higher elective induction rates among these patients.

Dr Luthy brought up an important issue regarding the percentage of women >35 years old who were delivered at our hospital as compared with the overall percentage of deliveries of women >35 years old in the state. Our hospital rate is 26.7%, which is much higher than the California rate (which I believe is around 7%). This question points to one of the reasons that we consider this study to be important. Our purpose was to better study the effects of maternal age on myometrial function to try to determine whether maternal age should be considered an appropriate risk adjustment factor when cesarean delivery rates are compared among providers or hospitals.