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A comparison between ultrasound and a reliable last menstrual period as predictors of the day of delivery in 15 000 examinations

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ABSTRACT

In a non-selected population comprising 15 241 women, an evaluation was performed of the ultrasonic measurement of the biparietal diameter compared with a reliable last menstrual period as the basis for estimation of the day of delivery. In women with a reliable menstrual history and spontaneous onset of labor, the ultrasound estimate was the significantly better predictor of the day of delivery in 52% of cases, and the last menstrual period estimate was the better predictor in 46% of cases. The percentages of women who delivered within 7 days of the predicted day were 61 and 56% for the ultrasound and the last menstrual period estimations, respectively. There was a significantly narrower distribution of births according to the ultrasound estimate ($p < 0.001$). The proportion of estimated post-term births was 4% using the ultrasound method and 10% using the last menstrual period method ($p < 0.001$). Even when the difference between the methods in predicting the day of delivery was less than 7 days, the ultrasound method was better than the last menstrual period method. It is concluded that ultrasonic measurement of the biparietal diameter between 15 and 22 weeks of pregnancy is the best method for the estimation of the day of delivery and should be used as a routine procedure.

INTRODUCTION

Reliable information about gestational age is necessary for optimal obstetric management of pregnancies. Perinatal morbidity and mortality are associated with preterm delivery and intrauterine growth retardation. Reliable information about gestational age is the basis for calculation of fetal growth[1,2]. The correct management of preterm and post-term pregnancies is also dependent on such information.

The first day of the last menstrual period has been the accepted basis for calculation of the day of delivery. The unreliability of this method has been demonstrated by various authors[3–5], who found that 10–45% of women did not have useful information about the last menstrual period due to inability to remember the exact date, or because of amenorrhea, irregular menstrual cycles, use of oral contraceptive pills, or bleeding during pregnancy. Additionally, the rate of post-term pregnancy has been described as very high (5–14%) when the last menstrual period method has been used[6–8].

The first reliable method for predicting gestational age based on ultrasonic measurement of the biparietal diameter was described in 1969 by Campbell[9]. The reliability of this method in predicting the day of delivery has been demonstrated in several later studies[3,6,10–12].

Several studies have indicated that ultrasonic measurement of the biparietal diameter is better than the first day of the last menstrual period for predicting the day of delivery[3,6,8]. However, better results with the last menstrual period method compared to the ultrasound method have also been reported[13], and an apparent increase in the number of preterm deliveries when the ultrasound method was used has been shown[14]. There has been a continuous discussion about the reliability of the ultrasound method[5], and disagreement about which method to use when the difference in gestational age as determined by the two methods is less than a week[15,16].

Ultrasonography is now the method of choice in predicting the day of delivery in many countries. In Europe, fetal examination programs are officially available to all pregnant women in Germany, Norway, Iceland, Austria and Switzerland. Since ultrasound today is used extensively, it is important to examine whether it can be used as the method of choice in a large non-selected pregnant

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population. The purpose of this study was to compare the ultrasonic measurement of the biparietal diameter with the last menstrual period as the basis for estimation of the day of delivery, and to evaluate the precision of these methods as routine procedures.

SUBJECTS AND METHODS

The subjects comprised women residing in a geographically well-defined area consisting of nine municipalities surrounding and including Trondheim. The National Center for Fetal Medicine at the University Hospital in Trondheim is the only ultrasound unit in the area. According to the Norwegian Medical Birth Registry, 97% of the pregnant women living in this area who gave birth during the study period (1987–92) were delivered at the University Hospital. We found that, during the study period, 97% of these women had a routine fetal examination with ultrasound.

Routine fetal examination has been offered in Norway since 1986. In the Trondheim area, the women were referred for examination by their general practitioner, by the obstetricians in private practice or by the high-risk clinic at the University Hospital in Trondheim. The fetal examination was scheduled to take place at 18 completed weeks as determined by the last menstrual period or the best clinical assessment of gestational age. The ultrasound examinations were performed by specially trained midwives. A personal interview was carried out with the pregnant woman, to obtain data about the maternal status and information about the menstrual history. At the ultrasound examination, the number of fetuses, the fetal anatomy, the placental location, and the amount of amniotic fluid were assessed, and the biparietal diameter, the mean abdominal diameter and the femur length were measured. The information was registered in a computer database. After the delivery, additional pre- and postnatal data concerning the pregnancy, birth and neonatal development were registered.

The gestational age and the day of delivery were estimated by ultrasound for all the women, and those with a reliable last menstrual period date also had the day of delivery estimated on this basis. The biparietal diameter was measured from the outer to the outer contour of the parietal bone echo, and gestational age was calculated according to the laboratory's own standard. The mean of three measurements was used for the calculation. The estimated day of delivery was calculated when the biparietal diameter was in the range 35–60 mm; this range corresponds to 15–22 completed weeks of pregnancy. Hitachi EUB-410 and EUB-415 ultrasound scanners (Hitachi, Tokyo, Japan) with 5-MHz curvilinear transducers were used, with the sound velocity calibrated to 1540 m/s.

A total of 15 443 women attended the routine fetal examination. Of these, 202 (1.3%) showed a biparietal diameter > 60 mm and were not entered in the study. The exclusion criteria for the remaining women are shown in Figure 1. After various exclusions, the study population was 14 167 women. The last menstrual period was considered unreliable when no specific date for the last menstrual period could be recalled. The menstrual cycle was considered regular when the interval was 28 ± 4 days. The estimated day of delivery based on the last menstrual period was corrected for the cycle length. For clinical management of the pregnancy, the following standards were used. Term was assumed to be at 282 completed gestational days[5]; the infant was considered preterm when delivery occurred before 259 completed days[17], and post-term when the gestation lasted ≥ 296 days. The data were also calculated according to World Health Organization (WHO) standards, i.e. preterm before 259 days, term at 280 days and post-term at or later than 294 completed days.

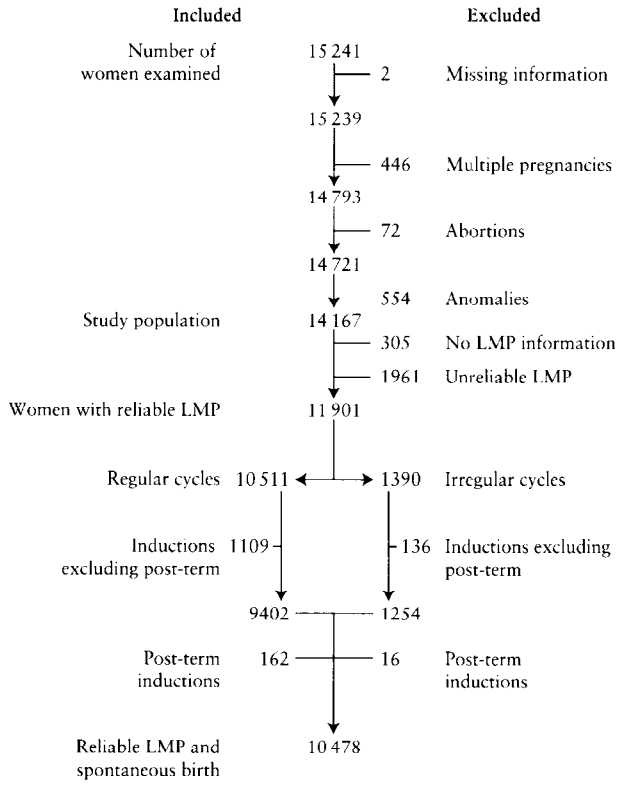

Figure 1 Patients entered into the study, patients excluded for various reasons, and numbers of inductions and spontaneous births, as indicated. LMP, last menstrual period

The clinical management of the pregnancy was based on ultrasound dating. In some patients who received the clinical diagnosis of post-term pregnancy, labor was induced, so that the number of spontaneous post-term deliveries according to ultrasound dating was consequently reduced. The total number of post-term births according to ultrasound dating was estimated as the number of spontaneous deliveries at or after 296 completed days, plus the number of inductions for supposed post-term pregnancy before, at or after 296 days. This ensured that none of the possible post-term deliveries were excluded from the group of estimated post-term deliveries. The total number of post-term deliveries according to the last menstrual period was estimated as the number of post-term deliveries, plus the number of inductions for supposed post-term pregnancy at or after 296 days.

Statistical evaluation was performed with the BMDP statistical package (BMDP Statistical Software Inc., Los Angeles, CA, USA). Equality of proportions between rows or columns in 2 × 2 tables was tested by Yates' corrected χ^2-test. Marginal probabilities were assessed by the test for marginal homogeneity in the 4 F program in the BMDP statistical package. Matched variables were tested by the separate variance *t*-test (mean), the sign test (median) or the Wilcoxon signed-rank test. Two-sample comparisons were performed using the Mann–Whitney rank-sum test.

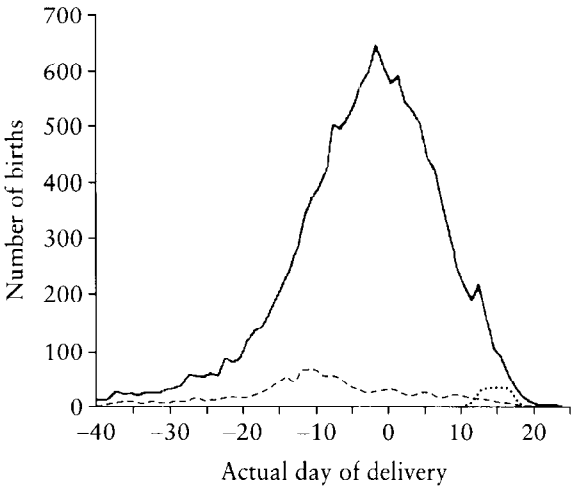

Figure 2 Distribution of births according to the estimated day of delivery (day 0) calculated from ultrasound for the study population of 14 167 women (all births, solid line). The general inductions (dashed line) and the inductions for the clinical diagnosis of post-term pregnancy (dotted line) are also shown

RESULTS

The estimated day of delivery was calculated from ultrasound measurements in 14 167 women. Of the 12 502 women with spontaneous onset of labor, 7635 (61.1%) gave birth within 7 days of the estimated day, while 10 966 (87.7%) gave birth within 14 days of the estimated day. In 559 cases (4.5%), the deliveries were preterm and, in 281 cases (2.2%), the deliveries were in the post-term period. The median day of delivery was 281 days, the mean 278.8 days and the mode 281 days. The distribution of delivery days is shown in Figure 2.

Labor was induced in 1665 (11.7%) of the 14 167 women. The reasons for induction are listed in Table 1. The clinical diagnosis of post-term pregnancy was made in 201 (12.1%) of the inductions. Of these, 50 were induced before 296 completed days and 151 at or after day 296 measured according to the ultrasound estimation.

Table 1 Induction of birth for the 14 167 women in the study population

Reason for induction	*n*	*% of inductions*	*% of study population*
Pre-eclampsia	320	19	2.3
Post-term	201	12	1.4
Fetopelvic disproportion	310	19	2.3
Intrauterine growth retardation	90	5	0.6
Previous Cesarean section	89	5	0.6
Poor obstetric history	75	5	0.5
Asphyxia	75	5	0.5
Miscellaneous	505	30	3.6
Total	1665	100	11.8

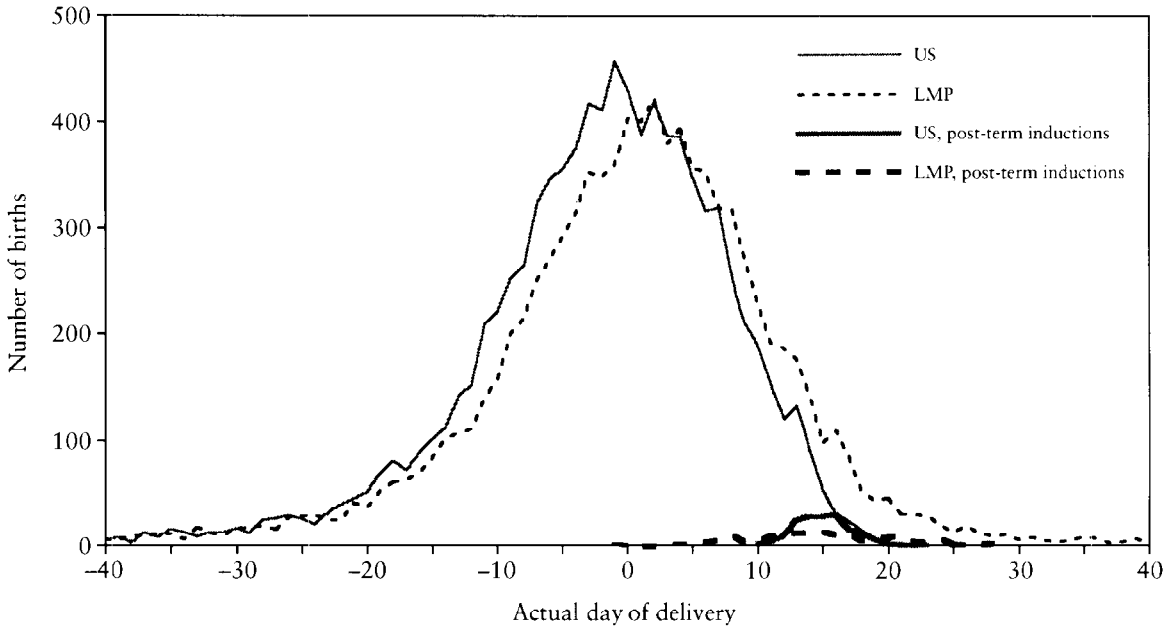

Figure 3 Distribution of spontaneous births according to the estimated day of delivery (day 0) calculated from ultrasound (US) and the last menstrual period (LMP) for 9240 women with regular menstrual cycles, including 162 deliveries induced due to the clinical diagnosis of post-term pregnancy

Table 2 Distribution of spontaneous births for women with regular menstrual cycles (n = 9402) and irregular menstrual cycles (n = 1254) according to the estimated day of delivery (282 days) based on the ultrasound and the last menstrual period (LMP) estimates. Inductions due to clinical diagnosis of post-term pregnancy are included

	Regular cycles			*Irregular cycles*		
	Ultrasound	*LMP*	*p*	*Ultrasound*	*LMP*	*p*
Median (days)	281	283	< 0.001	280	286	< 0.001
Mean (days)	279.1	281.8	< 0.001	278.1	286.2	< 0.001
Mode (days)	281	284		—	281	

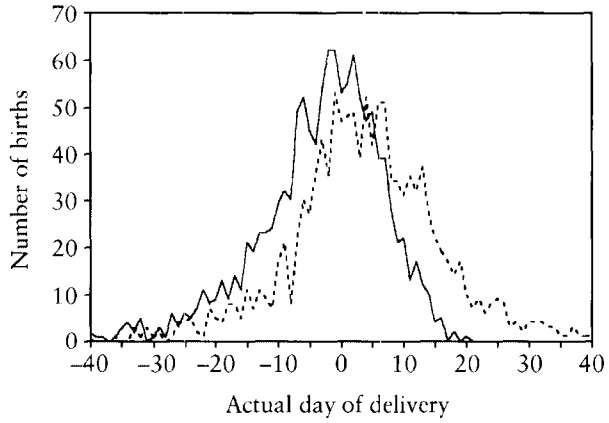

Figure 4 Distribution of spontaneous births according to the estimated day of delivery (day 0) calculated from ultrasound (solid line) and the last menstrual period (dotted line) for 1238 women with reliable last menstrual period, but irregular menstrual cycles

Excluding inductions for reasons other than the clinical diagnosis of post-term pregnancy there were 9402 women with a reliable date of the last menstrual period and with regular menstrual cycles. The distribution of births according to the ultrasound and last menstrual period estimates of the day of delivery is shown in Figure 3 and Table 2. For these 9402 women, the number of estimated post-term births was 918 (9.8%) according to the last menstrual period method and 387 (4.1%) according to the ultrasound method ($p < 0.001$). The onset of labor was spontaneous in 9240 of these women; in 162 women labor was induced due to a clinical diagnosis of post-term pregnancy. The distribution of spontaneous births for the women with regular cycles is shown in Table 3.

Excluding inductions for reasons other than clinical diagnosis of post-term pregnancy, there were 1254 women with a reliable date of the last menstrual period and with irregular menstrual cycles. The distribution of births according to the ultrasound and last menstrual period estimates is shown in Figure 4 and Table 2. For these 1254 women, the estimated number of post-term births was 251 (20.0%) according to the last menstrual period method and 38 (3.0%) according to the ultrasound method ($p < 0.001$). The onset of labor was spontaneous in 1238 of these women; in 16 women labor was induced due to a clinical diagnosis of post-term pregnancy.

The four medians for the births according to the last menstrual period and ultrasound estimates for women who had regular and irregular cycles were different ($p < 0.001$)

Table 3 Distribution of spontaneous births for women with regular menstrual cycles (n = 9240) according to the estimated day of delivery based on the ultrasound and the last menstrual period (LMP) estimates

	Ultrasound		*LMP*	
Delivery	n	%	n	%
± 7 days	5663	61	5202	56
± 14 days	8151	88	7729	84
< 259 days	380	4	376	4
≥ 296 days	225	2	821	9

from the estimated day of delivery (282 days) (see Table 2). To test for equality of variability between these last menstrual period and ultrasound estimates, the median in each group was calibrated to 282 days, and a matched-variable Wilcoxon signed-rank test was performed on the absolute value of the prediction error. The distribution of births according to the ultrasound estimate was significantly narrower, both for women with regular and with irregular menstrual cycles ($p < 0.001$). There was also a narrower distribution of births for the 9240 women with regular cycles compared to the 1238 women with irregular cycles according to the last menstrual period estimate ($p < 0.001$). There was no difference in the variability of the distribution of births for the ultrasound estimate according to whether the menstrual cycle was regular or not.

For the women with a reliable last menstrual period date and regular cycles, the ultrasound estimate of the day of delivery was later than the last menstrual period estimate for 5611 women (59.7%), and earlier for 3110 women (33.1%). In 681 cases (7.2%), there was no difference between the estimates. When there was a difference between the two methods in predicting the day of delivery, ultrasound was a better predictor than the last menstrual period. In 4514 of these cases (51.8%), ultrasound was the best method, and the last menstrual period was best in 4043 cases (46.4%) ($p < 0.001$). They were equally good in 164 cases (1.8%). As the difference in gestational age between the two methods increased, ultrasound gave a progressively better estimate, as shown in Figure 5. In the group (n = 7210) in which the difference in gestational age between the two estimates was ≤ 7 days, the number of estimated post-term births was 355 (4.9%) when the last menstrual period method was used and 320 (4.4%) when ultrasound was used ($p < 0.05$).

The distribution curves of spontaneous births for which the predicted day of delivery was different for each method

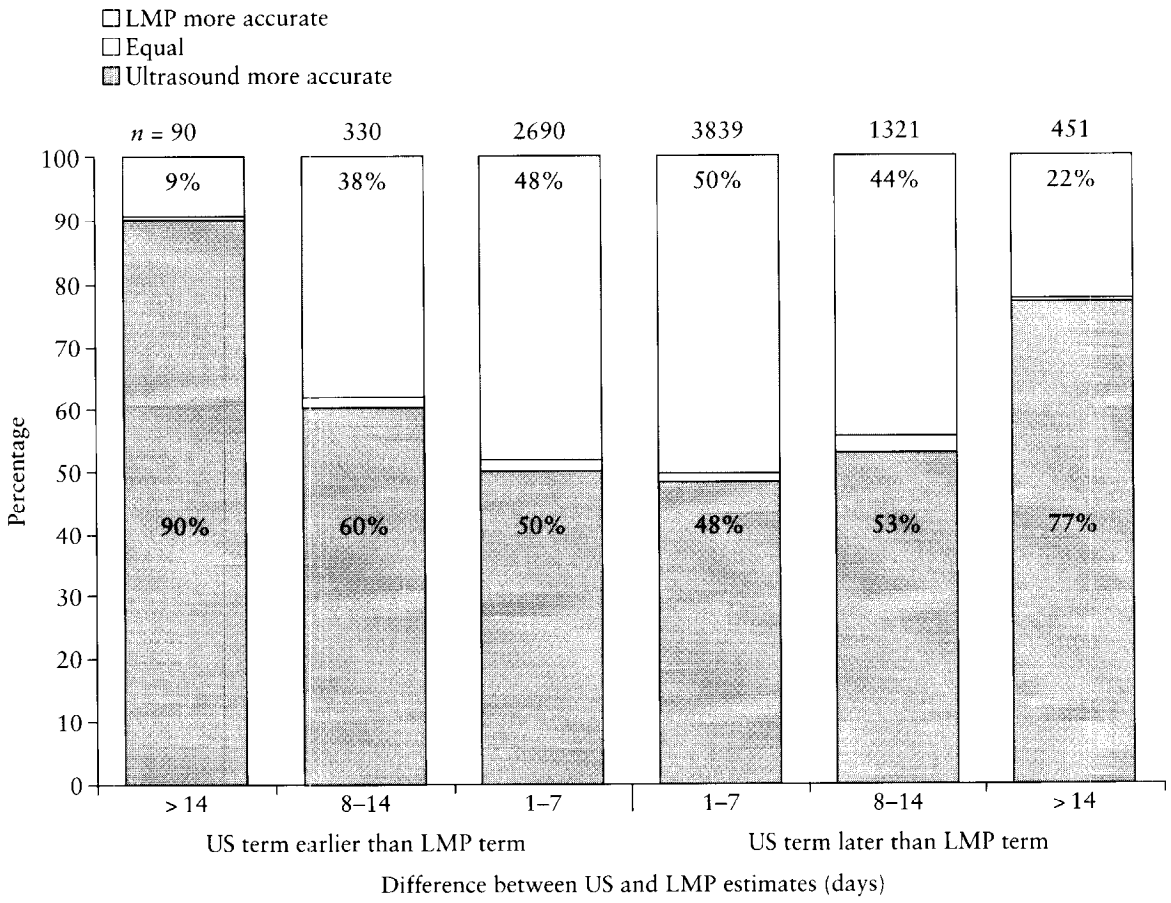

Figure 5 Comparison between the ultrasound- and last menstrual period (LMP)-based estimate of the day of delivery. The columns represent groups of women whose estimated day of delivery based on ultrasound was later or earlier than the LMP estimate

can be seen in Figure 6. The greater the difference between the estimates, the further away the actual day of delivery moved from the last menstrual period estimated day.

By the standard definition of the WHO, the normal length of human gestation is 280 days. Applying this gestational length to our population, the estimated frequency of post-term births at or after 294 days was 14% in the women with regular cycles and 26% in the women with irregular cycles, calculated from the last menstrual period date.

DISCUSSION

In this prospective study based on a large non-selected population, it was found that ultrasonic measurement of the biparietal diameter between 15 and 22 weeks of pregnancy was significantly better than the last menstrual period method for predicting the day of delivery.

The 'correct' day of delivery for any given fetus is not known, so it is not possible to apply a gold standard for the time of birth. In a Swedish study of more than 383 000 singleton pregnancies with reliable menstrual dates, the median duration of pregnancy according to the last menstrual period was 282 days, the mean 280.9 days and the mode 283 days[5]. It is not possible to tell which of these estimates was most representative for the normal pregnancy, because they were influenced by preterm births and births falsely registered as post-term. The median and the mode are, however, the most robust estimates. Both median and mean pregnancy durations according to last menstrual period were 1 day longer in the present study than in the Swedish study (see Table 2), indicating a small difference in the population samples. A possible explanation is the difference in the registration of the menstrual history; in the Swedish study the population was grouped as either certain or uncertain, without any further indication of regularity. In the present study, the median and mean pregnancy durations according to ultrasound were shorter than both the matched last menstrual period estimates and those of the Swedish study. However, they corresponded to the median and the mean days of delivery for the ultrasound estimate in women with regular menstrual cycles in another Norwegian study[8]. There are several explanations for the apparently more advanced gestational age according to the last menstrual period estimate. For example, in a cycle that leads to a pregnancy, the intervals may be delayed between last menstrual period and ovulation[18,19], possibly between ovulation and fertilization, and between fertilization and nidation, even in women with otherwise regular cycles.

The distribution of births according to the ultrasound method was negatively skewed, ending with a steep fall and

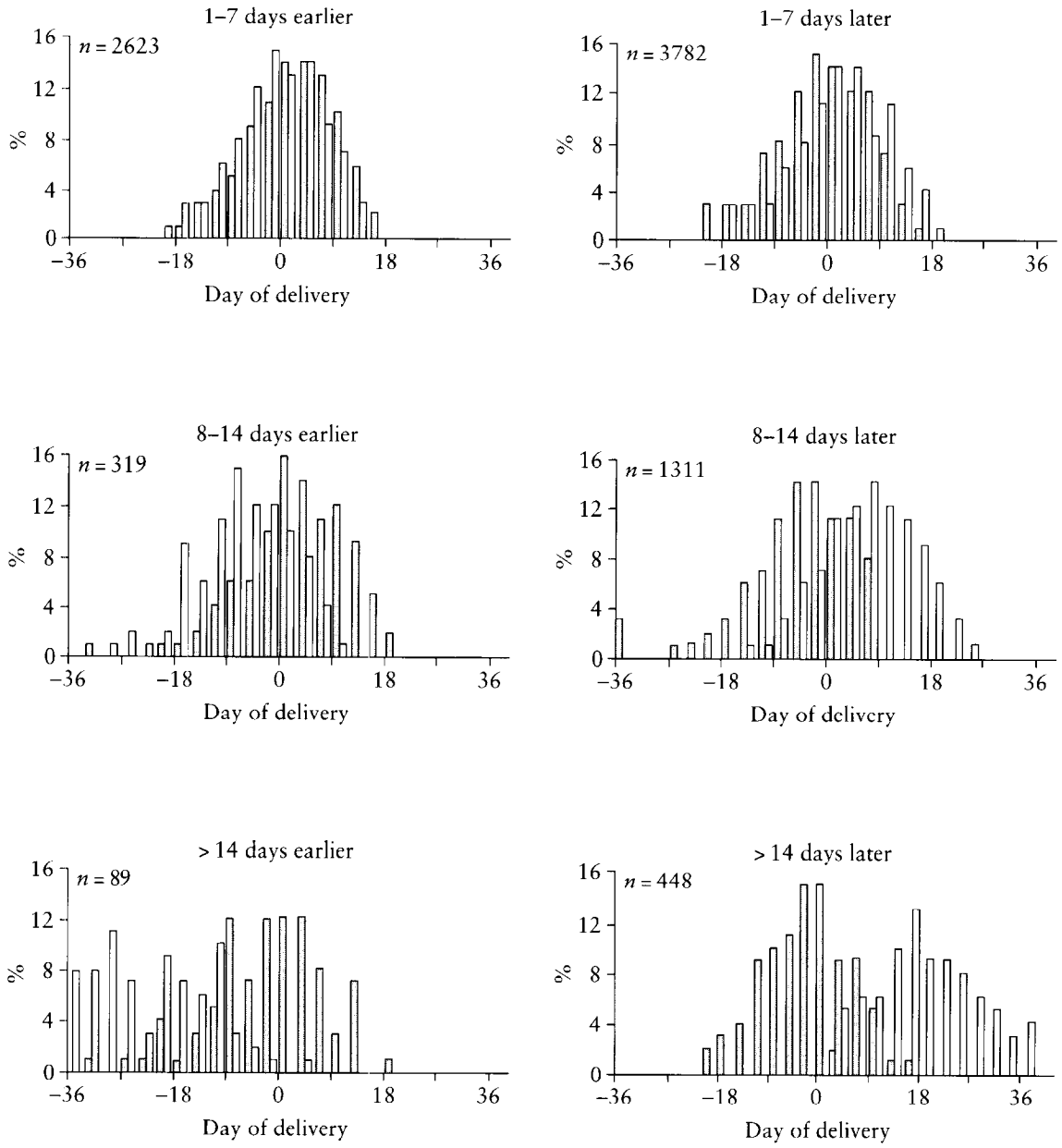

Figure 6 Group-wise distribution of spontaneous births according to the estimates based on ultrasound (gray columns) and last menstrual period (hollow columns) in women whose estimated day of delivery based on ultrasound was a later date or earlier date than the estimate of last menstrual period

only a few post-term births. According to the last menstrual period method, the distribution of births was closer to Gaussian. The most prominent difference in the distributions of births was the absence of the tail of post-term births for the ultrasound-dated pregnancies. The upper part of the distribution of the ultrasound-estimated births was to some extent curtailed by the inductions for post-term pregnancy, which could influence the comparison of the two methods. Therefore an estimated number of post-term births according to ultrasound was calculated as the sum of spontaneous post-term deliveries and the number of pregnancies where labor was induced due to the clinical diagnosis of post-term pregnancy, whether these inductions were done before, at or after 296 days. This reason for induction is dependent on the gestational age. Thus, a 'worst case' situation is created for ultrasound as 25% of the women classified as post-term on a clinical basis had an ultrasound-estimated gestational length of less than 296 days. According to the last menstrual period estimate, some women had a gestational length of less than 296 days at the time of induction for post-term pregnancy. If the induction had not been carried out, some of these women might have continued their pregnancy past 295 days and become post-term according to the last menstrual period estimate. They were, however, not included in the number of estimated post-term births according to last menstrual period. Thus a 'best case' situation is created for the last menstrual period method. In spite of this, the number of pregnancies classified as post-term was higher for the last menstrual period method, emphasizing the

significant difference between methods concerning post-term pregnancy.

The corresponding numbers of post-term deliveries for the spontaneous births only were also significantly higher for the last menstrual period estimate. This is in accordance with other reports[6–8] in which the number of post-term spontaneous births was 2.9–3.0% for the ultrasound method and 5.5–13.9 for the last menstrual period method.

As previously mentioned, the gestational length at term was assumed to be 282 completed days for both ultrasound and last menstrual period methods. When, in accordance with the WHO standards, a gestational length of 280 days for the last menstrual period estimate was used, the number of births at or after 294 days was 14% for the women with regular menstruations and 26% for the women with irregular menstruations. The results concerning the mean duration of gestation in this study (Table 2) and a Swedish study[5] indicate that the common assumption of a gestational length of 280 days based on the last menstrual period should be revised.

This study, comprising over 9000 women with spontaneous births and regular menstrual cycles in a non-selected population, did not show any difference in the rate of preterm delivery between the ultrasound and the last menstrual period methods. Our results therefore differ from those of a study in Alabama, USA[14], where the rate of preterm births rose from 12% to 17% after the introduction of ultrasound. Both rates are very high and might indicate a selection bias in the Alabama population rather than a true difference between the ultrasound and last menstrual period methods.

It is in the interest of the obstetrician to estimate a day which is as close as possible to the actual day of delivery, for as many women as possible. In this study we have shown that the variation of the births around the estimated day of delivery is significantly smaller for the ultrasound method than for the last menstrual period method. This has also been indicated in previous studies[3,8,15]. It has been alleged that the reduction in the number of post-term pregnancies is caused by a systematic left-shift of the births instead of a narrowing of the distribution curve[5]. The present study does not support this assertion.

When the routine ultrasound examination at 18 weeks showed a discrepancy between the last menstrual period estimate and the ultrasound estimate in predicting the day of delivery, the day estimated by ultrasound was later in 59.7% of the women. This corresponds to a Swedish study in which the day of delivery estimated by ultrasound was later in 64% of the women[15].

For those with a discrepancy between the last menstrual period estimate and the ultrasound estimate, the ultrasound estimate was a better predictor of the day of delivery for most of the deliveries. Similar results are also seen in a Swedish study[15,16]. In that study it was stated that the two methods were equally good when the difference in predicting day of delivery between methods was ≤ 7 days. This was supported in the present study with an equal number of births closest to the predicted day regardless of which of the methods was used; however, since the number of post-term pregnancies was significantly higher when the last menstrual period estimate was used, a positive effect of ultrasound was demonstrated even when the difference was ≤ 7 days.

Several authors have discussed the use of the last menstrual period or the ultrasound estimate to predict the day of delivery when the difference between the methods is small. Waldenström and colleagues[15] and Kieler and associates[16] argue that either method could be used if the difference is ≤ 7 days. However, to determine the cases in which last menstrual period estimates can be used, we use ultrasound, and since the last menstrual period method has not been proven to be better, we may as well use ultrasound for those cases too. The method which is best overall ought to be used in calculating the estimated day of delivery[20]. A significant discrepancy between the two methods, i.e. more than 14 days, should receive special attention. In these cases, a thorough anatomical evaluation of the fetus might be necessary to exclude malformations as a cause for the discrepancy.

It has been argued that the ultrasound method could not be better than the last menstrual period method since the biparietal diameter growth charts are based on the last menstrual period[4,5]. However, the biparietal diameter charts are usually derived from women with less cycle variability than is found in average women[3]. In addition, the ultrasound prediction is based on the regression of the data, further eliminating the effects of random cycle variations. On the negative side, the biological variation in the size of fetuses of the same age will produce different estimates of gestational age. However, there is reason to believe that this variation is small[21].

Previous studies[3–5] have shown that 10–45% of women have an unreliable menstrual history. These results are in accordance with ours.

In this study, the ultrasound and the last menstrual period methods have been evaluated prospectively in a large non-selected population. When the ultrasound method was used, the distribution of births was narrower and the number of post-term births was reduced in comparison with the last menstrual period method. Any shift in the distribution of births according to the ultrasound method, causing an increased rate of preterm delivery, could not be verified. The ultrasound method was better than the last menstrual period method for predicting the day of delivery; the greater the difference between the two methods, the better the ultrasound method turned out to be. Even when the difference in gestational age between methods was small, the ultrasound method had significant advantages regarding the post-term deliveries. The ultrasound method for predicting day of delivery can therefore be recommended as the method of choice.

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