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Computer-Aided Ultrasonic Fetometry in Advanced Pregnancy

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Abstract

In a prospective study of 1724 consecutive, non-selected singleton pregnancies with documented date of LMP, the distributions of newborn weight, body length and maturity in each of the six consecutive weeks of the normal range of birth occurrence ($37\,{}^{0}\!/_{7} - 43\,{}^{2}\!/_{7}$ weeks) were compared with results of own computer assisted method for prediction of birth-date and these newborn parameters without taking into account LMP. Their normal distributions on each week are different. Only in the 39th week they are fully symmetrical, whereas in the earlier or later weeks, there is a corresponding lesser or greater predominance values beyond the range of one standard deviation. Daily fetal weight increment in late pregnancy is irrespective of calendar gestational age but accordant to angular weight gain (kg/day) being fast (10.7 g), average (8.1 g) or slow (6.7 g). Predicted and actual fetal birth-weight, length and maturity do not differ statistically between each other. In $^{1}\!/_{3}$ of all study groups, the assigned term date was estimated with the accuracy of ± 2 days, and in the remaining 1/2 and 2/3, with the accuracy of ± 3 days and ± 4 days, respectively, regardless of whether growth was fast, regular or slow. A statistically significant correlation between actual (284.3 ± 9 days) and predicted (281.6 ± 14 days) gestational age ($r = 0.80$, $t = 32$, $p < 0.001$) was found.

Zusammenfassung

In einer prospektiven Untersuchung von 1724 Schwangerschaften wurde die Verteilung des Gewichts, der Größe und Reife in den sechs Wochen des normalen Spielraums des Geburtstermins ($37\,{}^{0}\!/_{7} - 43\,{}^{2}\!/_{7}$ Wochen) ausgehend vom Datum der letzten Menstruation verglichen

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mit den Ergebnissen unserer eigenen computerunterstützten Methode für die Vorhersage des Geburtstermins und der Neugeborenenparameter, wobei der Tag der letzten Menstruation nicht als Ausgangspunkt dient. Nur in der 39. Woche sind die Verteilungen symmetrisch, während in den früheren oder späteren Wochen die Werte differieren, und zwar über das Maß der Standardabweichung hinausgehend. Die tägliche Gewichtszunahme am Ende der Schwangerschaft hängt nicht von der kalendarischen Schwangerschaftsdauer ab, sondern von der individuellen Geschwindigkeit der Gewichtszunahme (kg/Tag), die schnell (10,7 g), mittel (8,1 g) oder langsam (6,7 g) sein kann. Bei diesem Verfahren differieren vorhergesagtes und tatsächliches Geburtsgewicht, Größe und Reife statistisch nicht. In einem Drittel aller Untersuchungsgruppen wurde der Geburtstermin mit einer Genauigkeit von ± 2 Tagen vorhergesagt, und in der restlichen Hälfte, bzw. den restlichen zwei Dritteln, mit einer Genauigkeit von ± 3 Tagen und ± 4 Tagen, unabhängig davon, ob die Wachstumsgeschwindigkeit schnell, durchschnittlich oder langsam war. Eine statistisch signifikante Korrelation zwischen wirklicher Schwangerschaftsdauer (284.3 ± 9 Tage) und vorhergesagter Dauer (281.6 ± 14 Tage) wurde gefunden ($r = 0.80$, $t = 32$, $p < 0.001$).

Introduction

The aim of this paper is to present a new computer-aided clinical method for the monitoring of fetal well being and prognosis of individual birth (date and newborn's state) in late pregnancy without taking into account the date of LMP[1–3].

Fetus is spacetime individual which is not well understood in medical practice. Time of fetal life is measured separately from its body parameters and only on the horizontal calendar scales of all contemporary ultrasound equipments and charts[5–10]. But such horizontal time is useless for dating of any individual pregnancy. First of all, it only provides that children born at the 37th week of pregnancy are delivered earlier from those of e.g. 42nd or 43rd week of pregnancy, and nothing more! What is more, small, average or large newborns can be delivered at the beginning as well as at the end of birth occurrence (it means between 37th–43rd week of pregnancy). This problem was artificially resolved by ending all horizontal scales at the 40th or 41st calendar week, therefore at least 30–50% of all deliveries are omitted owing their occurrence beyond this limit.

Material

In a prospective study of 1724 consecutive, non-selected singleton, uncomplicated pregnancies with documented date of LMP, the distributions of newborn weight, body length and maturity in each of the six consecutive weeks of the normal range of birth occurrence ($37\,^{0}\!/_{7}$–$43\,^{2}\!/_{7}$ weeks) were compared with results of my owncomputer assisted method for prediction of birth-date and these newborn parameters[1–3].

Results

Figures 1 and 2 show the Gaussian distribution of newborns according to their maturity in particular weeks of birth occurrence (Fig. 1) and relative distribution of newborns according to maturity taking into account their number in particular weeks as 100% (Fig. 2). As can be seen there is normal distribution of all newborns as well as their distribution in particular weeks. There are also very similar distributions of newborns' length (Figs. 3 and 4) and weight (Figs. 5 and 6).

The distribution of newborns maturity, length and weight on each birth week are slightly different. Only in the 39th week they are fully symmetrical, whereas in the earlier or later weeks, there is a corresponding lesser or greater predominance of values beyond the range of one standard deviation from the mean value.

Starting from the identical time of conception, the mature fetus can be born at the beginning (37th week) as well as at the end of the birth occurrence period (43rd week of calendar scale), but the fetal age has to be measured at the vertical axis as an inseparable dimension from size and growth. Using both axises: horizontal (calendar scale) and vertical (biological scale) we can also make division for fast, regular and slow growing fetuses (Fig. 7).

The same difference of various sets of ultrasound measurements corresponds to different angles, depending on the elapsed time between consecutive exams. Thus, the same absolute increase of measured ultrasonic parameters between serial measurements at the 1st and 2nd examination do not have a distinctive quality, but decisive is the angle at which growth line will take place over a known period of time. As the Fig. 9 shows, depending upon the rate of maturity with variable times of fertilization (C & D) birth may occur at the same moment, if they have variable rates of growth. However, fetuses with the same angle of maturity (A & C or B & D) are born following an equal period after the last exam. Under physiological conditions all parameters tested have the same rate of maturity (Fig. 8).

840 measurements of FL from previous mentioned clinical material demonstrate the difference between old and new method of pregnancy dating (Fig. 9). Figure 9 shows the distribution of femur length for fast (square signs), average at 39th week (triangle) or at 40th week (diamond) and slow fetal growth (star) for the calendar gestation weeks as it is in practice up to day. There is high, statistically significant correlation ($r = 0.91$) between values of FL and calendar time until 37th week, then it decreases to 0.54. But using angular growth rate, it means vertical scale of biological fetal age, computer-aided method gives us clear differentiation between measurements of different maturing fetuses (Figs. 10 and 11). There are highly significant correlations (over 0.93) and straight regression curves. The correct prediction of birth is shown on the Fig. 12, when all lines end at the mean birth-term values with the division for fast, average and slow growing fetuses (Fig. 12).

Serial ultrasound measurements at approximately 2 week intervals were performed in a double-blind comparative study of 610 Caucasian fetuses within the last six prenatal weeks. The results of the study demonstrate that without using LMP – the difference between assigned (14.2 ± 11.4) and actual periods to birth date (15.05 ± 11.4) was only 0.9 days ($t = 1.22$, NS). The average length of the pregnancy at the time of the last examination was 269.3 ± 13.1 days (range 217–310

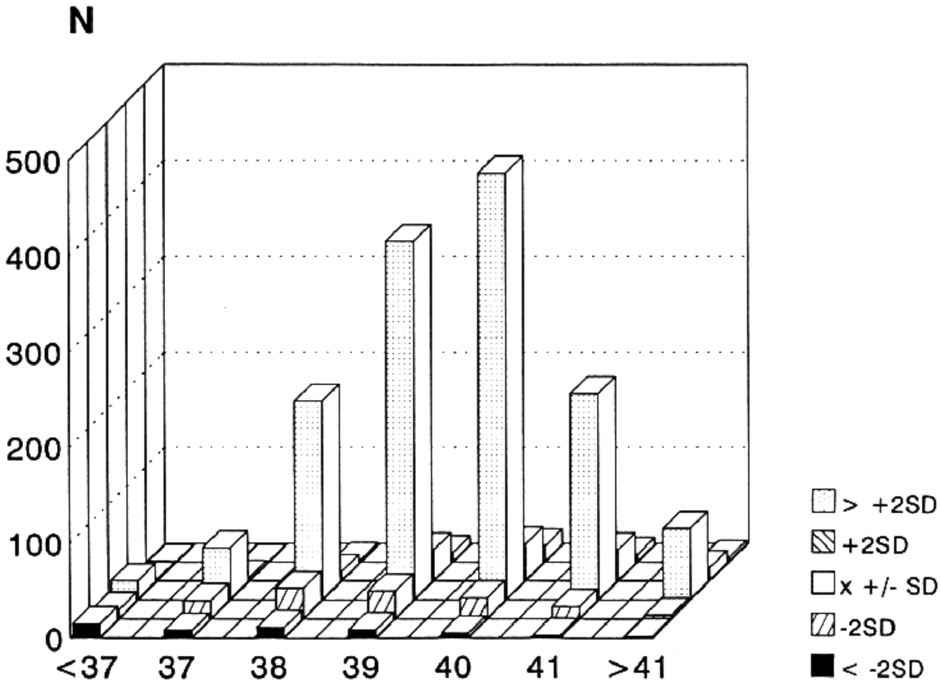

Fig. 1. Distribution of newborns according to their maturity in particular weeks of birth occurrence.

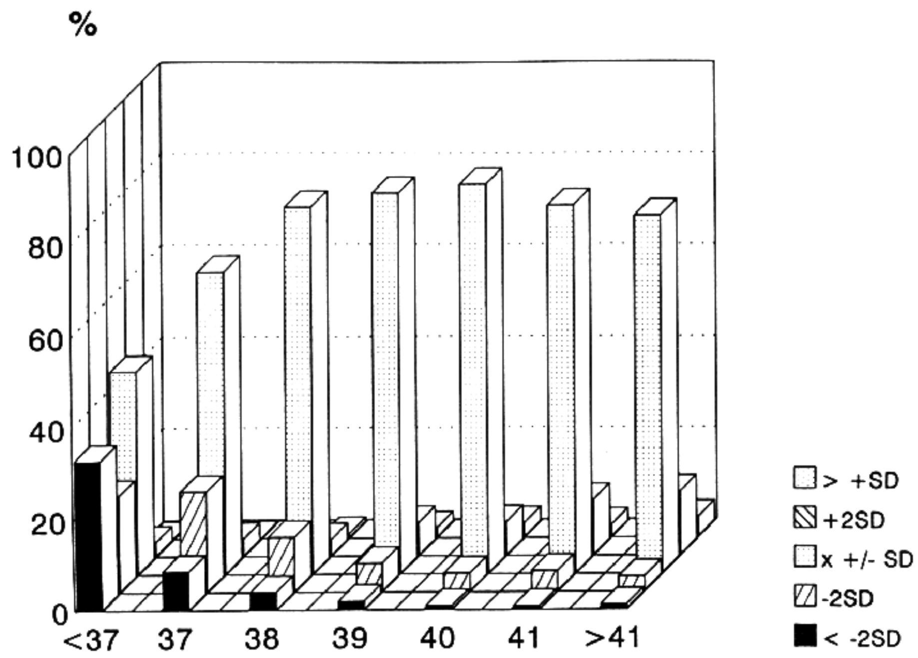

Fig. 2. Relative distribution of newborns according to their maturity in particular weeks of birth occurrence.

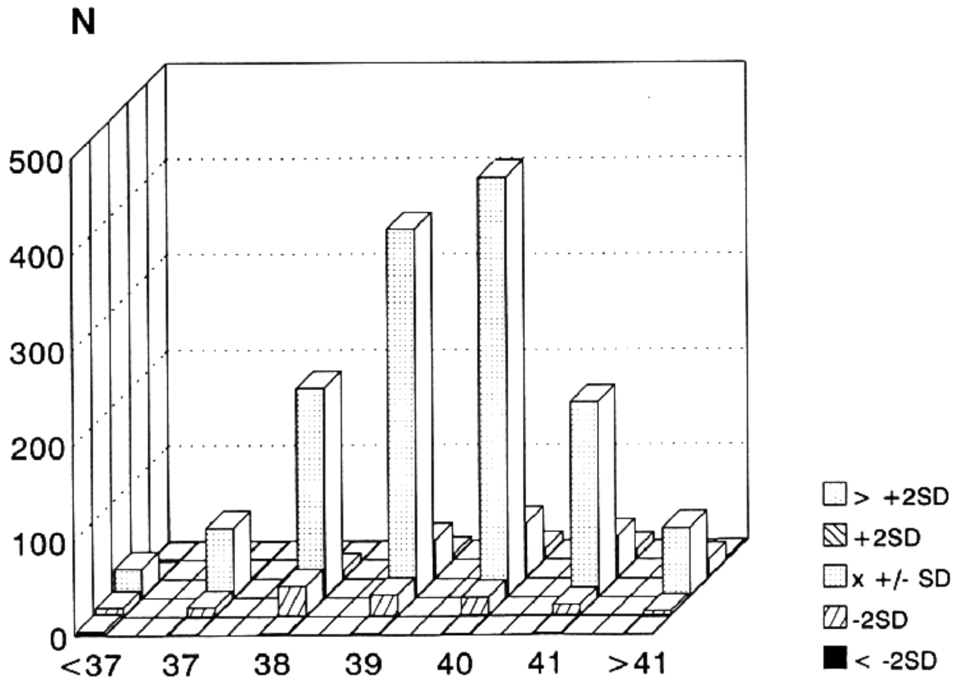

Fig. 3. Distribution of newborns according to their body length in particular weeks of birth occurrence.

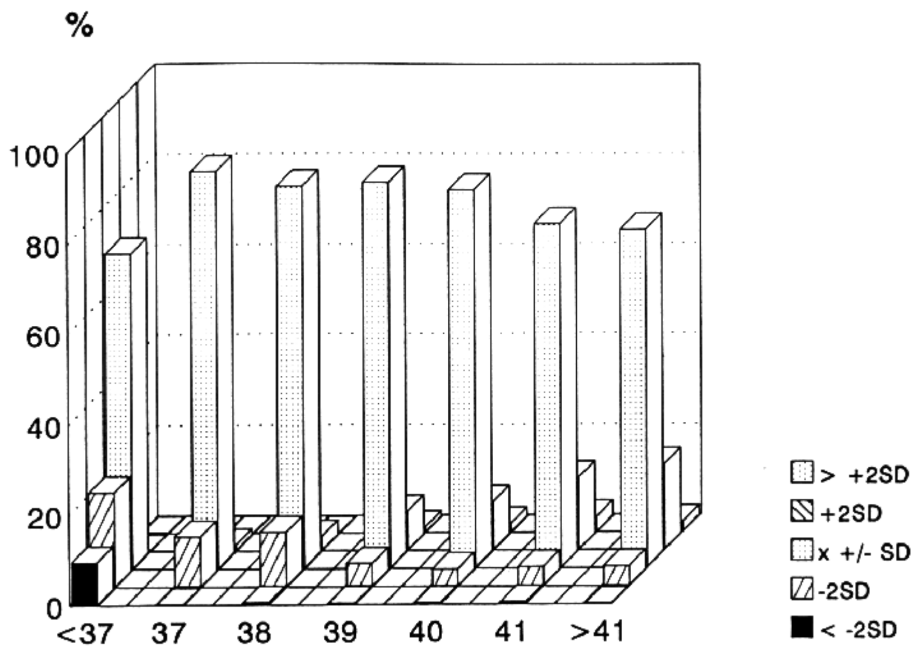

Fig. 4. Relative distribution of newborns according to their body length in particular weeks of birth occurrence.

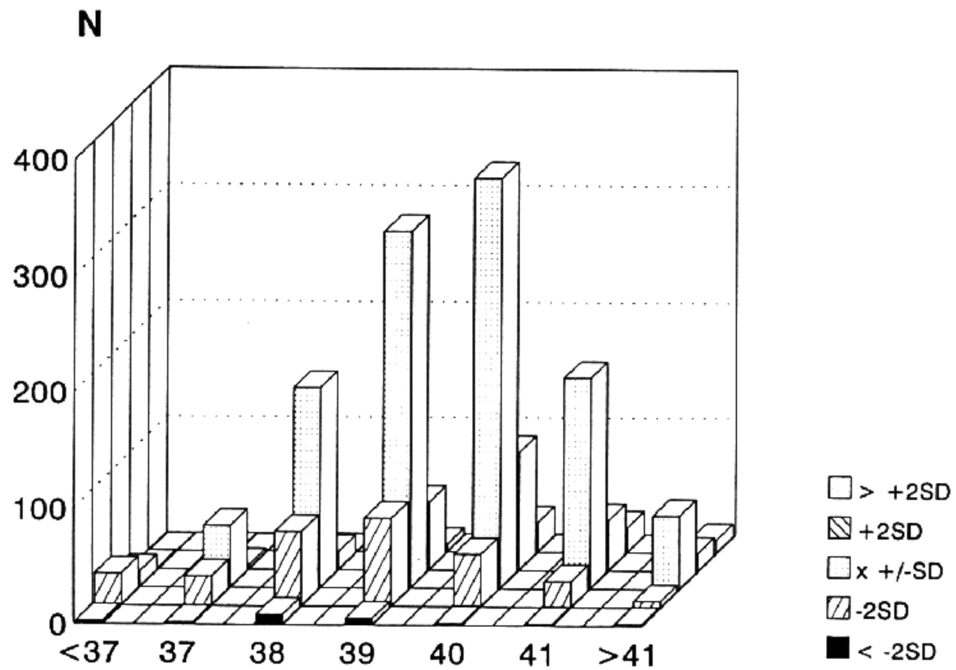

Fig. 5. Distribution of newborns according to their weight in particular weeks of birth occurrence.

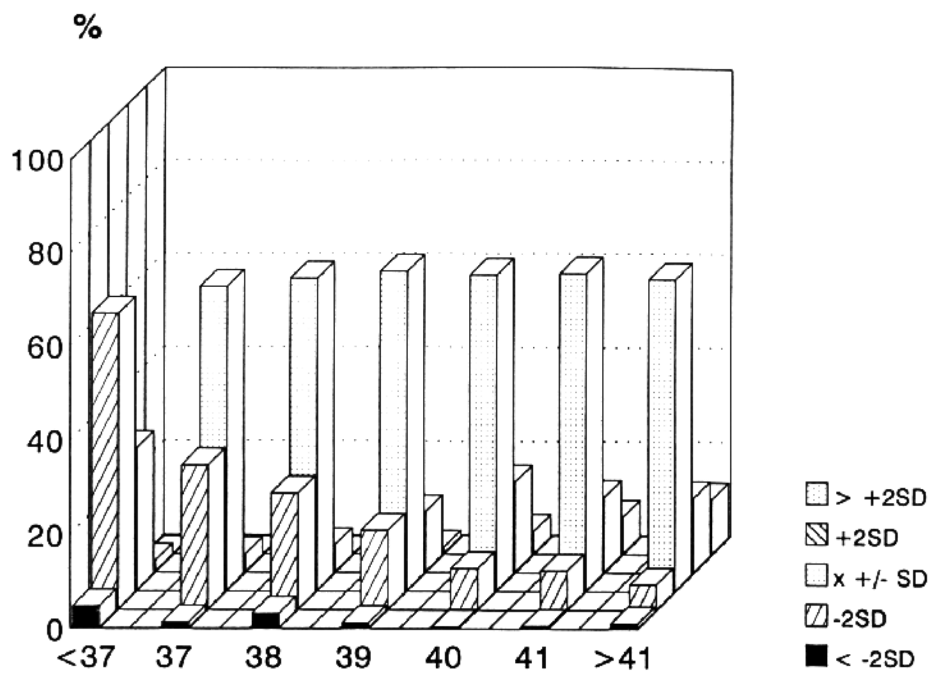

Fig. 6. Relative distribution of newborns according to their weight in particular weeks of birth occurrence.

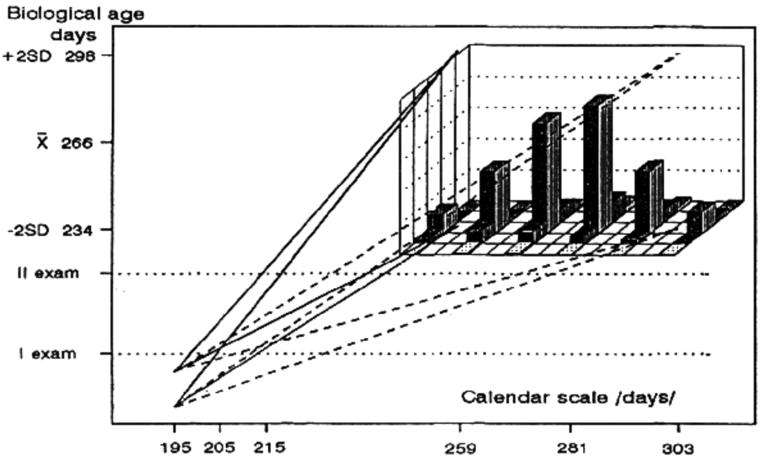

Fig. 7. Distribution of ultrasonic variables (x ± SD) within the last calendar days of pregnancy at I and II exams, and at birth.

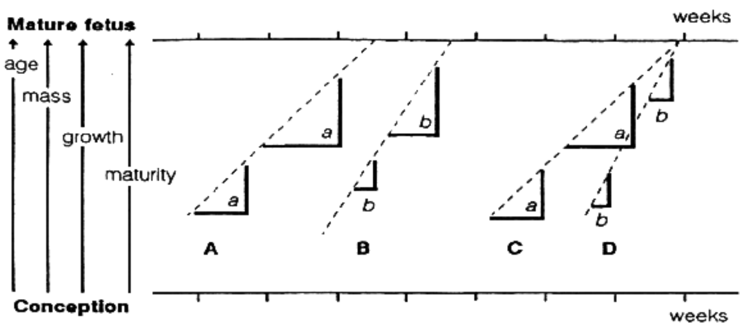

Fig. 8. Horizontal lines (—) indicate the periods between two exams. Perpendicular lines (|) describe the slow (a) and fast (b) gains of measured value.

days) which was calculated on the basis of fetal measurement to be 267.4 ± 18.1 days (t = 2.10, p < 0.05).

The mean birth-weight was 3404 g ± 277 g (range 2600–4600 g) and the mean difference between actual and predicted fetal birth weights was only 36g (t = 3, p < 0.01). The daily average weight increment (8.4 g/kg/day) was lower in fetuses born small compared to those born average or large irrespectively of calendar gestational length but according to their angular weight gain as fast (10.7 g/kg/day), regular (8.1 g/kg/day) or slow (6.7 g/kg/day) maturating infants.

In 1/3 of all study groups, the assigned term date was estimated with the accuracy of ± 2 days, and in the remaining 1/2 and 2/3, with the accuracy of ± 3 days and ± 4 days, respectively, regardless of whether growth was fast, regular or slow. A statistically significant correlation between actual (284.3 ± 9 days) and predicted (281.6 ± 14 days) gestational age (r = 0.80, t = 32, p < 0.001) was found.

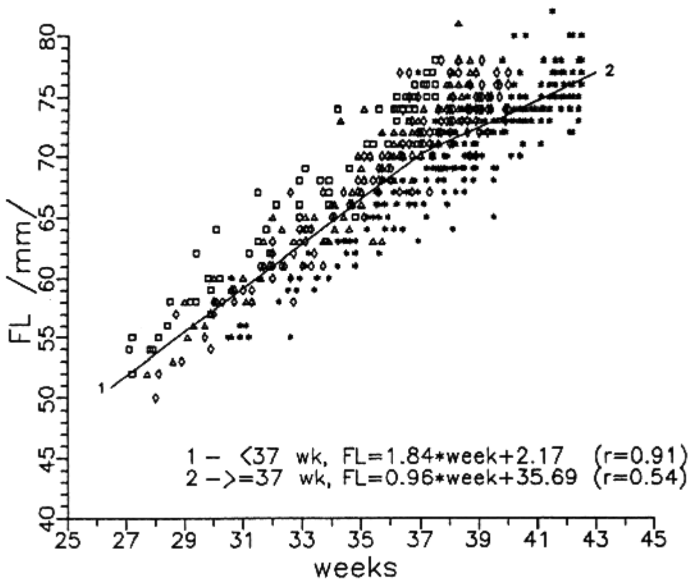

Fig. 9. Distribution of femur length for fast (square signs), average at 39th week (triangle) or at 40th week (diamond) and slow fetal growth (star) for the calendar gestation weeks.

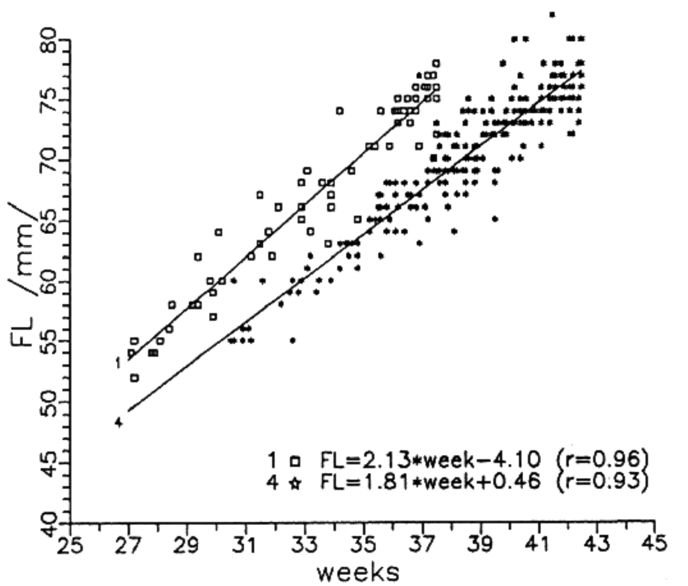

Fig. 10. Distribution of femur length for fast (square sign) and slow fetal growth (star) for the calendar gestation weeks.

Conclusions

In clinical practice even the most sophisticated ultrasonographic imaging equipment fails to provide more information than Naegele's Rule which determines the

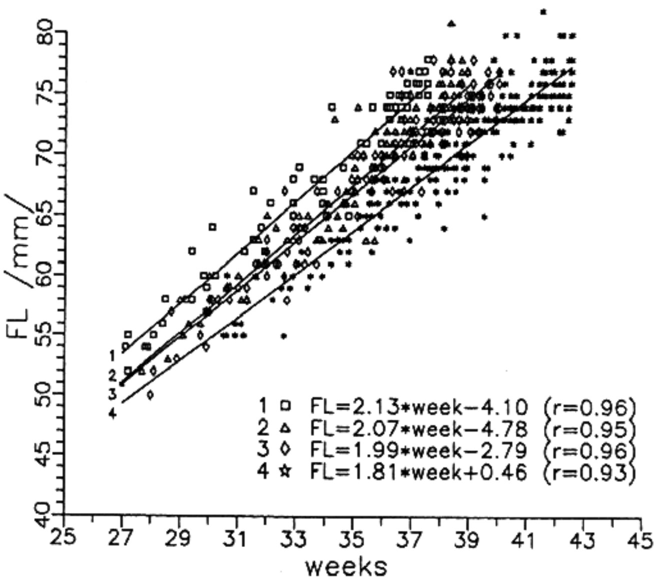

Fig. 11. Distribution of fetal length for fast (square sign), average at 39th week (triangle) or at 40th week (diamond) and slow fetal growth (star) for the calendar gestation weeks.

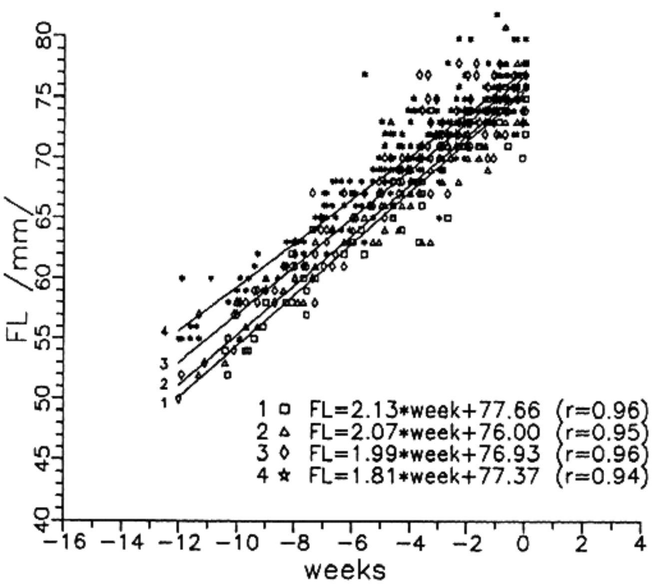

Fig. 12. Distribution of fetal length for fast (square sign), average at 39th week (triangle) or at 40th week (diamond) and slow fetal growth (star) for the biological gestation week.

average date of delivery ± 3 weeks with knowledge of the LMP date. The error lies not in the technologically superior equipment but rather in the application of programs and leads to increases in instrumental deliveries and their harmful effects on both mother and child.

It was Leonardo da Vinci who introduced for the first time the quantitative outlook in the growth of the fetus in utero till 19 months after birth[1,12]. Unfortunately, too many contemporary physicians seem to forget his statement: “Experience does not even err, it is only your judgment that errs in promising itself results which are not caused by your experiment” Leonardo da Vinci (c. 1510). Paraphrasing we can say: “Ultrasonograph does not even err, it is only its scales that err . . . ”

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