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Intrauterine growth retardation: ultrasonic diagnosis

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In 3258 pregnant mothers with ascertained gestational length, 3736 biparietal and transverse thoracic diameters were measured by a rapid screen ultrasound device. The data were processed by computer and the possibilities of detection and typing of intrauterine fetal retardation were examined. Serial measurements performed during pregnancy satisfactorily detected type I or the proportional type. The asymmetrical form, type II, can be distinguished by the Neyman-Pearson method. The decision curves applicable for each gestational week have been computed and are described. They can also be used for determination of the degree of intrauterine wasting.

Unsatisfactory development of the fetus has become a central problem of both obstetrics and paediatrics. Increased attention paid to "small for dates" is justified by their increased perinatal and infant mortality rates, their high incidence of malformations and their elevated risk for late, principally cerebral, complications [2, 9, 17]. Prevention and therapy of intrauterine growth retardation (IUR) have not yet been fully solved but early detection and the choice of the optimum time for delivery may help to achieve good results before irreversible changes have occurred.

The introduction of ultrasound (US) has revolutionized the diagnostics of intrauterine development of the fetus. The best known approach is measuring the biparietal diameter of the skull (Bip) and by weekly measurements performed in a sufficient number of cases a standard curve can be established. Comparison of the actual measurement with this curve allows the conclusion whether development of the fetus is normal or retarded [2, 3, 5, 8, 11, 13, 14, 15]. Two main types of retardation have been recognized [9, 12, 17], different in both aetiology and consequences [1, 9, 17]. Therefore, distinction of the two types is imperative (see Table I). If the growth rate of Bip declines from the second trimenon but the decline is gradual, the proportional type can be assumed. If the onset of the retardation in Bip increase falls to the third trimenon and skull development stops, this points to an asymmetrical retardation [9, 10, 13, 18].

In many cases of the disproportionate type malnutrition hardly or not at all affects skull development,

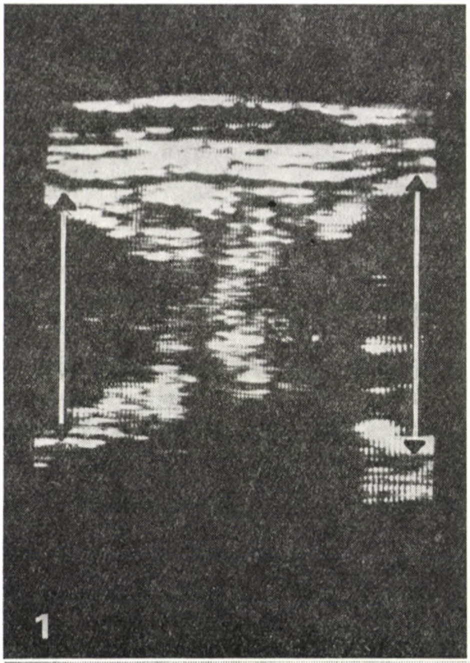
TABLE I

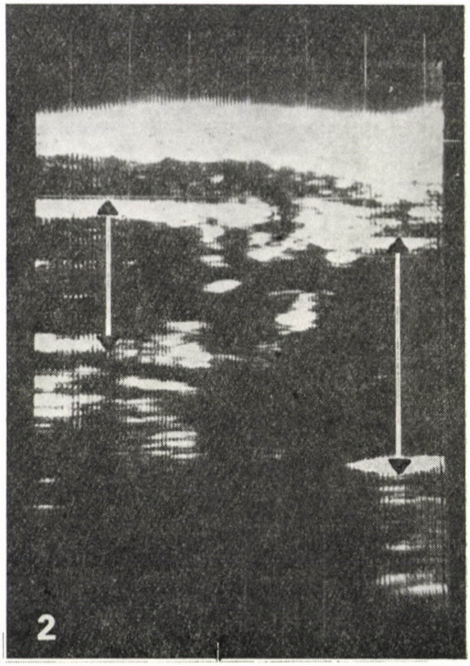
The main characteristics of IUR types
Either type occurred in 9.9% of all neonates in our material
(literature data: 8—12%)

	Type I Symmetrical	Type II Asymmetrical
Incidence within the retarded	14% in our series (literature: 10—30%)	86% in our series (literature: 70—90%)
Causes	physique, inheritance, social factors, chronic diseases, tobacco, etc.	placental insufficiency (gestosis, nephritis, hypertension, heart defect, postponed labour, diabetes, etc.)
Period of onset	from the beginning of the 2nd trimenon, during the period of cell proliferation.	during the 3rd trimenon, the period of cell hypertrophy
Consequences	Small, proportionate organs containing a reduced number of cells; persistence beyond the neonatal period. Good Apgar values and adaptation. High incidence of malformations and enzymopathies.	Normal number of cells of reduced size. Length and skull size hardly affected, wasting in other organs, especially in adipose tissue, disproportionate body. Intrauterine asphyxia, low Apgar values, pulmonary oedema and haemorrhage, hypoglycaemia, high perinatal and neonatal mortality and morbidity, late neurological sequelae.

the fetus appears to economize with the brain tissue, while other, less vital organs may cease to develop or, in extreme cases, may even lose weight [9, 17, 18]. It seems therefore logical that in addition to measuring the Bip, exact and synchronous measurements of other organs by ultrasound are necessary for a better approach of actual fetal development and distinction between the two main types of intrauterine retardation. Better estimates of the actual weight have been achieved [5, 7, 11, 16], by adding some other measurements to the previously used Bip. Most workers use quotients for the diagnosis of asymmetric intrauterine retardation; Bip/abdominal diameter [15], Bip/abdominal circumference [9], Bip/thorax area [18], Bip/transverse thorax diameter (Thq) [6], etc. A quotient exceeding a certain value can be regarded as an indicator of asymmetric retardation. E.g. during the 40th gestational week fetuses showing the proportionate type have a Bip/Thq value between 0.93 and 1.05 while a value above 1.05 points to disproportionate growth retardation (Figure 2).

In this study we have attempted to improve early detection and distinction of IUR by computer analysis of our serial data obtained in a large number of pregnancies.





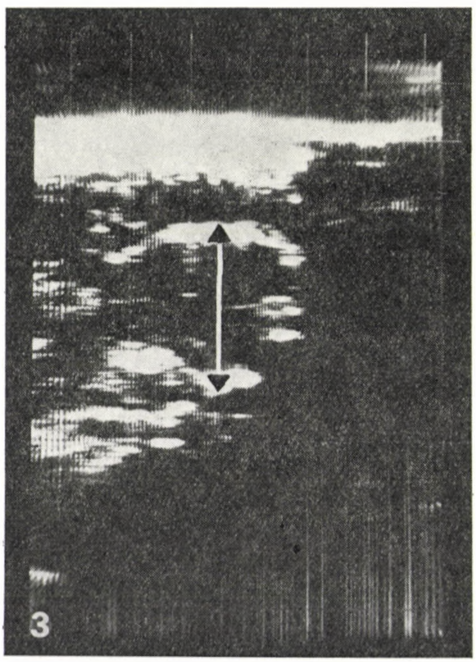


FIG. 1. Fetus of 34 weeks. Skull (right) and thorax (left), longitudinal sections. Bip: 88 mm, Thq: 84 mm. Physiological proportional development

FIG. 2. Fetus of 33 weeks. Skull (right) and thorax (left), longitudinal sections. Bip: 83 mm, Thq: 56 mm. Severe asymmetrical IUR

FIG. 3. Fetus of 33 weeks. Transverse section of thorax. Thq: 56 mm. Severe asymmetrical IUR

Material and Method

A total of 3736 US measurements were performed by the rapid screen device Vidoson 635-S from the 25th week of gestation. All consecutive patients fulfilling certain criteria and attending from 1 January, 1975, to 31 December, 1979, were involved in the study. In addition to measuring Bip, Thq was measured in the plane between the dome of the diaphragm and the apex of the heart using the method of Hansmann [5, 8] (Figures 1, 2 and 3). Data obtained in 3258 mothers who had had a regular bleeding cycle, the exact date of the last menstruation of whom was known, who had single pregnancy and gave birth to a live child were also included in the study. Retardation was diagnosed in all infants having a birth weight below the 10th percentile, as generally accepted [9, 13, 18]. This group was then subdivided on the basis of the ponderal index (PI)

$$PI = \frac{\text{body weight in g}}{(\text{body length in cm})^3} \times 100.$$

All neonates born during or before the 36th gestational week and having a PI value attaining or exceeding 2.0 and all infants born during or after the 37th week and having a PI value equal to or higher than 2.2 were regarded as belonging to the asymmetrical, disproportionate type of intrauterine growth retardation [4]. Since we have shown that the predictive value of Bip on weight can markedly be increased by measuring also Thq [11], we have attempted to find relationships between Bip and Thq values obtained at various gestational ages and the weight and proportions of the subsequently born infant.

Results

In the histograms of Bip-Thq values plotted against gestational age the areas of infants without retardation, of infants affected by symmetrical or asymmetrical retardation showed considerable overlapping. This is the result of the statistical character of biological events and in our case it means that even theoretically there is no method of decision perfectly discriminating the three types on the basis of measurements performed before birth since some retarded infants exhibit the same parameters as normal infants do.

In agreement with other workers [9, 13, 15, 18] we believe that serial US measurements are best for the early detection of type I, the symmetrical form of retardation. If the menstruation history is exactly known, Bip and Thq values corresponding to the same earlier gestational week indicate a proportionate retardation [5, 6, 11]. If the calculated term is uncertain, calculation of the weekly rates may be helpful, flattening of the Bip growth rate normally occurs during the 32nd or 33rd week of gestation (Fig. 4).

Histograms were composed from the Bip-Thq values obtained in non-retarded respectively asymmetrically retarded fetuses during the 32—42 weeks of gestation. Fig. 5. illustrates the results obtained for the 40th gestational week. It can be seen and be proved mathematically that the Bip/Thq value does not optimally discriminate the two groups because the lines constructed by connecting the points representing identical proportions (Lines A, B and C) cross the scatter areas of both non-retarded and asymmetrically retarded infants

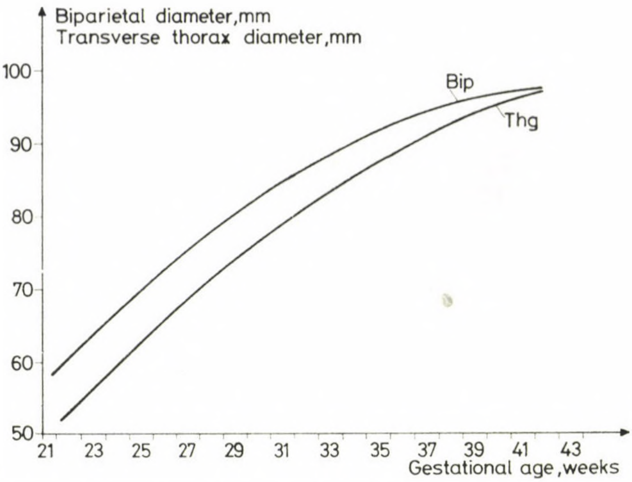


FIG. 4. Mean growth curve for Bip and Thq from the 22nd gestational week

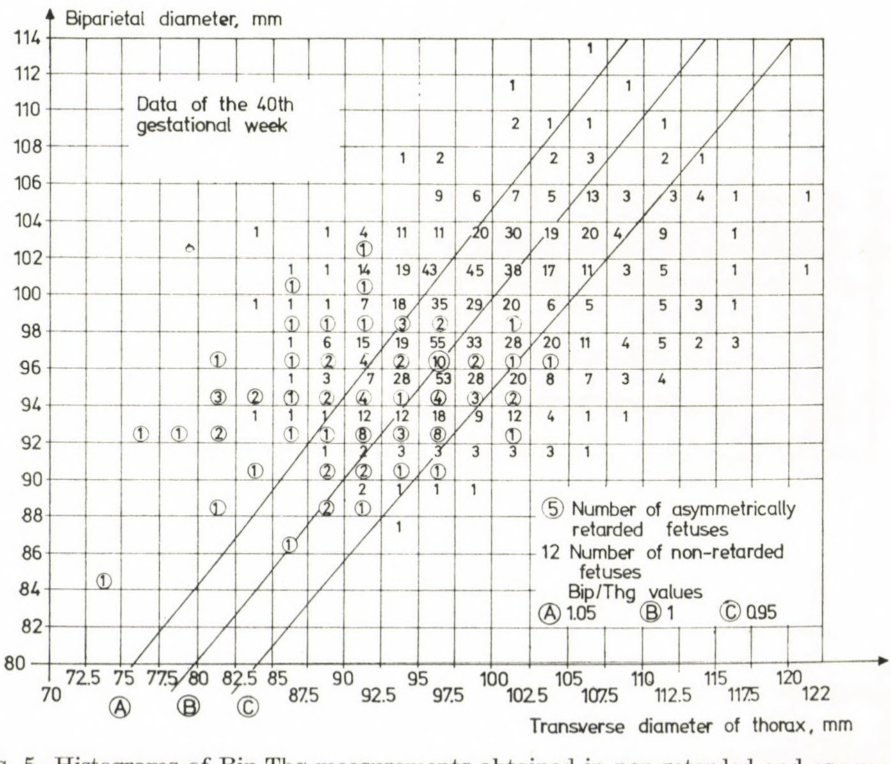


FIG. 5. Histograms of Bip-Thq measurements obtained in non-retarded and asymmetrically retarded fetuses in the 40th gestational week. A, B, C: lines representing identical Bip/Thq values

without separating them satisfactorily.

Optimum separation can be achieved by application of the mathematical method of Neyman-Pearson. By this method various optimal decision curves can be constructed fulfilling requirements arbitrarily fixed in advance; these curves separate the two groups, leaving the retarded values on the left and the normal ones on the right of the curve. Of course, the curves cannot perfectly separate the groups for the aforementioned reasons; quite obviously, any of them can be characterised by two values of error, the ratio of undetected asymmetrically retarded neonates to all cases showing this abnormality and the number of normal infants falsely classified as asymmetrically retarded ones to the total number of non-retarded neonates. The principal difference between the various decision curves consists in the capacity of detecting a certain percentage of asymmetrically retarded fetuses minimalizing at the same time the proportion of normal fetuses falsely diagnosed as retarded ones. Quite evidently, if we arbitrarily increase the percentage of retarded fetuses detected by the discrimination curve, the proportion of the spurious retarded cases will also increase; these latter cases have then to undergo

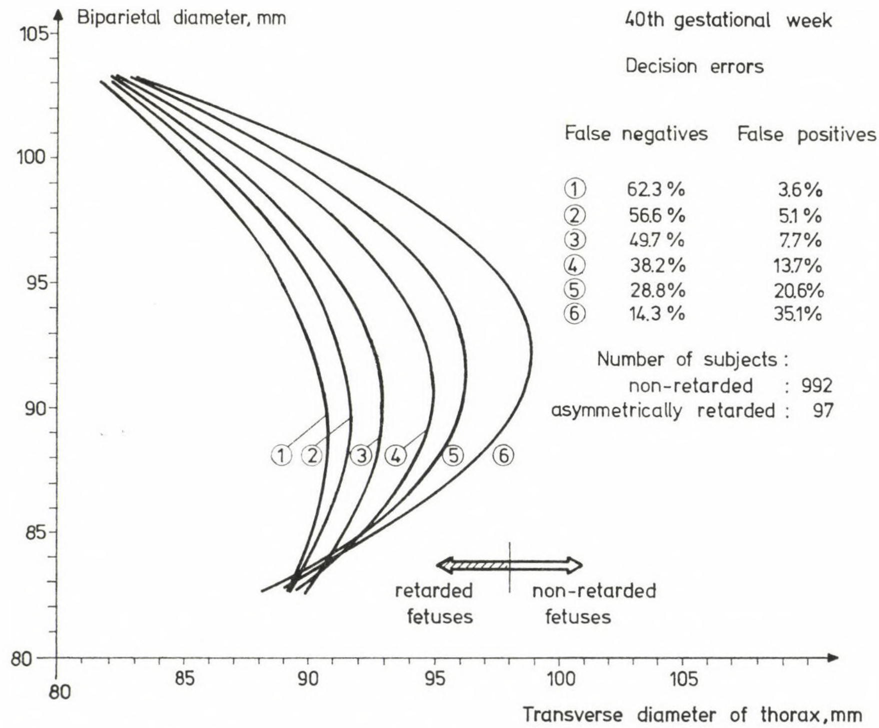


FIG. 6. Decision curves with various percentual error values for discrimination of non-retarded and asymmetrically retarded fetuses in the 40th gestational week

superfluous examination. It is just the clinician's task to decide how much additional work is tolerable as the price of better detection. Fig. 6 shows the various decision curves constructed for the 40th gestational week and the percentual risks for error are also indicated. The clinically acceptable risks have to be established according to facilities and other factors. It has however, to be stressed, that the differences between the various curves only influence decisions in ambiguous situations since values very far away from any curve, i.e. representing cases with extremely severe intrauterine malnutrition can be evaluated beyond doubt.

Discussion

Our weekly sets of decision curves are helpful in the early diagnosis of our suspicion for asymmetric retardation. A 50 respectively 80% safety for detection of type II malnutrition was fixed, this is related to an acceptably low risk of error of a false diagnosis of growth retardation among normal fetuses (Figs. 7 and 8). Since this type of retardation does not occur before the third trimenon and no sufficient number of data for the period before the 32nd gestational week are available, no curves were constructed for the period preceding the 32th week. In addition, such

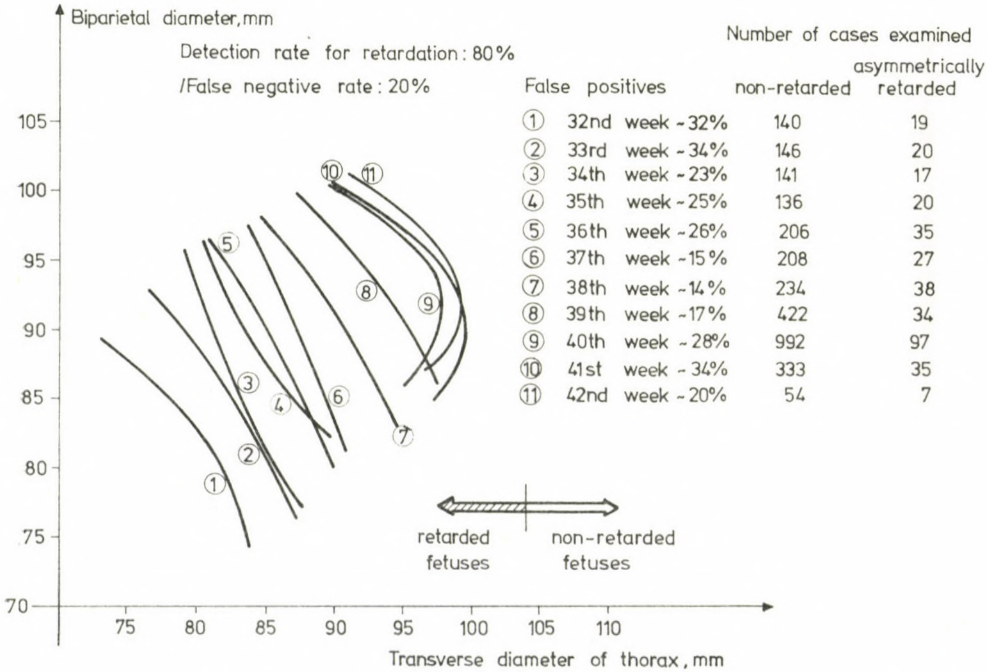


Fig. 7. Decision curves with a fixed 50% safety for detection of asymmetrical retardation and with different percentual error values in misclassifying normal fetuses, from the 32nd to the 42nd gestational week

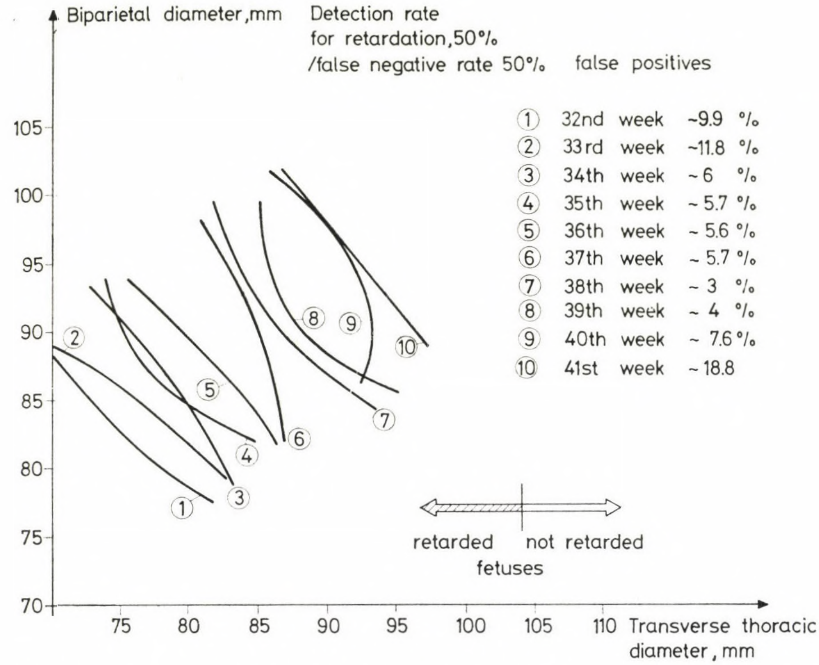


FIG. 8. Decision curves with a fixed 80% safety for detection of asymmetrical retardation and with different percentual error values in misclassifying normal fetuses, from the 32nd to the 42nd gestational week

curves would be rather impracticable considering the low viability of neonates born before this time. An exact menstrual history is also important but the decision curve of the week corresponding to the Bip value can be used in cases with uncertain menstrual history; in fact, in certain cases a single measurement may be sufficient for validation of the diagnosis of severe intrauterine retardation of the asymmetrical type. The validity can be further strengthened by serial measurements.

Our mathematical approach underlines the principle that a single examination or finding cannot alone lead to the diagnosis. No strict line can be drawn between the retarded and non-retarded during pregnancy and after birth. Let us mention that the critical values of the weight percentile (e.g. the 10th) or the ponderal index are also fully arbitrary. Careful observation, serial hormone determinations, loading tests, amnioscopy, etc., are all indispensable in the diagnosis of intrauterine malnutrition, transitory and mild cases included. Ultrasound is only one of these methods.

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