RADIOLOGIC ASSESSMENT OF BONE AGE IN LOW BIRTHWEIGHT INFANTS

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SUMMARY

106 infants with low birthweight and a well known gestational age were divided into four groups: preterm infants, small for gestational age (SGA) infants, appropriate for gestational age (AGA) infants and infants with Clifford syndrome.

With the 100 mm spot film technique X-rays of the right knee and ankle of the infants were taken and the size of the epiphyseal centers of the distal femur, the proximal tibia, the talus and the calcaneus was measured. The mean organ dose of the leg was only 2 mrad.

All epiphyseal centers examined showed an increase from the 33rd to the 42nd week of gestation, which is in good agreement to previous studies. There was no evidence of a statistical difference of epiphyseal size between the four examined groups of neonates of low birthweight. Thus, in the present material with very close mean birthweights of the four groups, we were unable to distinguish preterm born infants from SGA infants with this method alone.

This result suggests, that bone age is a more resistant criteria to fetal malnutrition than mass growth.

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Antenatal radiological assessment of « bone age » used to be a reliable parameter for fetal maturity ([14]) until the development of modern ultrasound and still is a valuable aid in modern obstetric care in certain cases ([5]). Recently we have succeeded in the correct estimation of the gestational age in 81 % of cases ([5]).

Postnatal radiological assessment of the scheletal maturity in the newborn ([4, 6, 10, 11, 13, 15]) is used besides the external and neurological criteria for the estimation of the gestational age, when it is unknown. Maternal anamnestical data concerning the duration of pregnancy are often unreliable. In such cases clinical estimations of maturity are necessary for pediatric therapy immediately after birth ([7]).

The birthweight and the relation of birthweight to gestational age are both relevant factors in assessing the immediate and future risks in newborn infants ([7, 12]). The perinatal mortality and morbidity of infants with low birthweight (below 2500 g) is different in preterm born babies and in so called « small for gestational age » (SGA)-infants ([1]). Therefore it is important to distinguish SGA-infants from preterm born infants ([7]). Having available a new radiological method, the 100 mm spot film technique, we thought it might be of interest to study this parameter in infants of low birthweight.

MATERIAL AND METHODS

106 newborns, whose birthweight was between 2000 and 2700 g were divided into four groups according to their gestational age and according to the intrauterine growth standard from Austria of Hohenauer (table 1). The upper limit of birthweight was set at 2700 g, to provide a larger group of less grossly SGA-cases. Only infants, whose mother could give a reliable menstrual history were included in this study. The gestational age was calculated in weeks from the first day of the last menstrual period of the mother until birth.

All X-rays were taken on the second or third post partum day. With a reproducible standard technique straight lateral pictures were taken of the right knee and ankle of the infant,

Table 1. — *Classification of infants according to gestational age and intrauterine growth standards from Austria* (Hohenauer 1973).

Preterm infant:
Gestational age less than 38 weeks.

Small for Gestational Age (SGA) infant:
Birthweight below 10th percentile of the intrauterine growth standards from Austria.

Appropriate for Gestational Age (AGA) infant:
Birthweight below the 10th percentile of the centile.

Infants with Clifford syndrome:
Secondary loss of weight due to subacute placental insufficiency, occurring in post term infants mostly, = intrauterine dystrophic infant, according to Kloos and Vogel, 1974 showing three stages.

who was covered with a lead apron. Also exposed was a scale with leadmarks of 1 cm intervals, which enabled to measure the real size of the epiphyseal centers on the X-ray. We use the 100 mm spot film camera with a roll film combined to a 9 inch caesium iodide image tube and a field-proven solid state power supply. Other technical data were: voltage 50 kv, focus 0,3 × 0,3 mm, film: Kodak PFC.

The advantage of the 100 mm spot film technique is the dose reduction to one tenth of the usual dose. We performed measurements of the X-ray dose with lithium-fluoride dosimeters in 10 infants. The mean organ dose of the leg was 1 mrad. This dose is practically negligible and certainly harmless for the infant ([15]).

Table 2. — *Number of investigated infants according to our classification.*

Measurement of epiphyseal centers of the knee: – distal femoral epiphysis and proximal tibial epiphysis.		*Measurement of epiphyseal centers of the knee and the ankle*: – distal femoral epiphysis, proximal tibial epiphysis, talus and calcaneus.
36	Preterm infants	22
37	Small for gestational age (SGA) infants	24
24	Appropriate for gestational age (AGA) infants	16
9	Clifford - Syndrome	2
106	*Total*	*64*

Figure 1 shows one X-ray as an example. The size of the epiphyseal centers of the distal femur, the proximal tibia, the talus and the calcaneus was assessed. The greatest diameter was measured, as previous investigators found it to be best correlated to gestational age ([4]). As the difference of the epiphyseal size of the right and the left body half is not significant, it is sufficient to measure the center on one side only ([4]). The results of male and female infants were combined, as the difference of epiphyseal size between boys and girls is negligible ([4, 14, 15]).

Table 2 shows the number of infants studied according to our classification.

RESULTS

Figure 2 shows the mean sizes and the standard deviations of the four epiphyseal centers of all investigated infants according to their gestational age. The distal femoral epiphysis (DFE) shows an increase of the mean diameter from the 33rd to the 42nd week of gestation from 3,8 mm to 5,14 mm. In the 40th week of gestation it was found 4,24 mm. V. Harnack found a mean of 5 mm ([6]), Finnström a mean of 4,37 mm.

The proximal tibia epiphysis (PTE) showed an increase from mean 1,8 mm to 2,42 mm. At term the mean size was 1,96 mm, in the series of v. Harnack a mean of 2,2 mm was found ([6]), Finnström found a mean size of 1,98 mm at this time ([4]).

The epiphyseal center of the calcaneus showed a range from 10 mm to 10,75 mm. It is the biggest of the four centers as its calcification begins already in the 24th week of gestation ([6]). At term we found a mean value of 9,33 mm, the comparable figure of v. Harnack was 10,5 mm (6), of Finnström 11 mm ([4]).

The epiphyseal center of the talus showed an increase of 7,2 mm to 8,5 mm. In the 40th week of gestation it was 7,83 mm, v. Harnack's mean was 7,4 mm ([6]), Finnström's mean value was 8,37 mm ([4]).

Only four neonates (3,7 %) between the 38th and 42nd week of gestation had no visible distal femoral epiphysis, whe-

Fig. 1. — Typical X-ray of the right knee and ankle showing the epiphyseal centers of the distal femur and the proximal tibia, the talus and the calcaneus

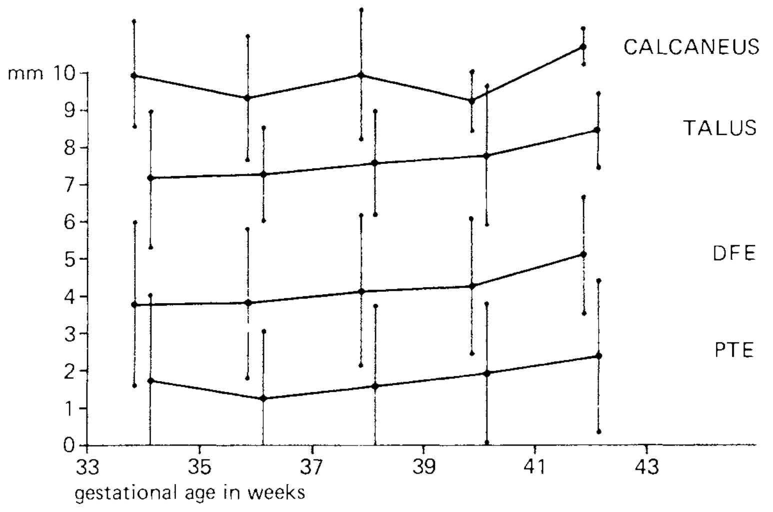

Fig. 2. — Mean sizes and standard deviations (mm) of the four epiphyseal centers from the 33rd to the 42nd week of gestation.

reas 34 infants (32 %) had no visible proximal tibial epiphysis. The centers of the talus and the calcaneus are always visible at the end of gestation, as the beginning of their ossification in the 24th respectively the 27th week of gestation ([6]).

Figure 3 shows the mean sizes of the four epiphyseal centers in preterm born infants, small for gestational age, and appropriate for gestational age infants and infants with Clifford syndrome.

The mean birth weights of the four groups were between 2322 g and 2587 g and did not differ significantly. Although in the group of preterms the mean size of all centers was somewhat lower than in the others, there was no statistical significance between the four groups to be proven.

Our results suggest, that there is no diminution of the size of epiphyseal centers in SGA infants, at least not in the less grossly ones, as in the present material.

It was impossible to distinguish preterm born infants from SGA-infants with this method alone.

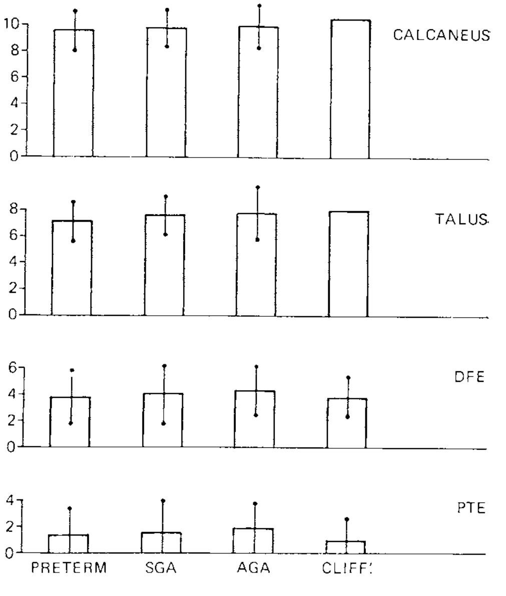

Fig. 3. — Mean sizes and standard deviations of the four epiphyseal centers in preterm born infants, small for gestational age (SGA) infants, appropriate for gestational age (AGA) infants and infants with Clifford syndrome: no significant differences.

Also the infants with Clifford syndrome ([2, 8]), compared to the other groups, did not show a significant difference of the epiphyseal size, which is not surprising, as the Clifford syndrome is appearing mostly in post term infants and is due to a short time subacute placental insufficiency only ([8]).

DISCUSSION

All our mean values are in quite good correlation to previous studies, although in v. Harnack's study a mean of the two measured epiphyseal diameters was assessed ([6]). The size of all centers was slightly smaller in our present study, which could be due to the low mean birthweight of our cases.

In the present material we were not able to show a significant delay in the ossification of epiphyseal centers in SGA infants as was stated by Scott and Usher ([16]), Finnström ([4]) and Philip ([13]). This could be due to the relatively close mean birthweight of our four groups.

According to v. Harnack and Coworkers ([6]) birthweight, length, head circum ference and size of bone centers seem to represent growth, rahter than maturation. In his material there was good correlation found between gestational age and the size of the epiphyseal centers in prematures, but less good in SGA infants.

These were regularly assessed as a lower gestational age. The length of gestation seemed to correlate much more with clinical and neurological parameters, than with the epiphyseal size.

Croall and Grech ([3]) found in 1970 an ossification delay sufficient to cause a high proportion of misleading underestimates of maturity only in grossly underweight fetuses, whose corrected birthweights were 200 g or more below the fifth percentile. In such cases, reliable X-ray confirmation of maturity can only be obtained when a lower femoral epiphyseal center is seen at 36 to 38 weeks. They stated, that ossification delay might be expected to be in proportion to the degree of fetal growth retardation, also judged by the correct birthweight. This would also give an explanation for our results.

Also Russell ([14]), who examined 3006 cases radiologically, pointed out, that the weight of the infant had no effect on the rate of radiological development; for him it seemed, that the fetus matures in the majority of cases at a rate equivalent to its chronological age, but a minority matures slowly or faster and this is not necessarily dangerous. In his comprehensive study radiological assessment of fetal maturity predicted the date of delivery more accurately, than the menstrual history.

Miller and Futrakul ([11]) found visible bone centers in 60 % of infants with a birthweight from 1000 to 2500 g, the incidence of respiratory distress syndrome (RDS) in its severest form was 4% in this group, compared to 20 % in the group without visible centers. No infant, who had visible centers, died as a result of RDS, compared to a fatality rate of 20 % in the group without visible centers.

Kloos and Vogel ([8]) and Kloos and Dunz ([9]) were the first, who performed a study of kyematopathologically analysed perinatal deaths. They found in 308 cases a delay of the appearance and the growth of the secondary fetal ossification in hypotrophic infants. This delay was less in a group of so called « disharmonic-hypotrophic » infants, in which the birthweight was below the 10th percentile of Lubchenco, but the length between the 10th and the 90 th percentile, than in a so called « harmonic-hypotrophic » group, in which the birthweight and the length were below the 10th percentile. Thus, disharmonic hypotrophy represents a lower degree of fetal disturbance, whereas harmonic hypotrophy is the expression of a severe and long-lasting fetal malnutrition, which is due to placental insufficiency. This may result in a premature birth, if there are not enough compensatory mechanisms.

The figures in this study are throughout lower than ours, as the mean of the two measured diameters was taken. For Kloos the secondary fetal ossification represents a process of differentiation, which is quantitatively less disturbed by malnutrition, than the mass growth. Although a birth weight below the 10th percentile will have an influence on the ossification, a large and general diminution of the size of epiphyseal centers was only found in severe cases of « harmonic hypotrophy ». Another important factor is also the coincidence with the critical growth periods of the bone centers, if the disturbance is temporal. Kloos concludes, that the evaluation of the secondary fetal ossification would considerably improve perinatal diagnostics.

In agreement with our present results also Senecal and Coworkers ([15]), who studied bone age in 994 babies pointed out, that bone age is a more resistant criteria to malnutrition, than weight and length.

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