Virchows Archiv A Pathol Anat (1988) 413:513–519

Virchows Archiv A
Pathological Anatomy and Histopathology

Routine perinatal postmortem radiography in a peripheral pathology laboratory

A.A. de la Fuente[1], G. Dornseiffen[2], G. van Noort[1], and R.N. Laurini[3]

[1] Pathologisch Streeklaboratorium, Edo Bergsmalaan 1, 7512 AD Enschede, The Netherlands
[2] Stichting Samenwerkende Ziekenhuizen Enschede, Radiological Department, Haaksbergerstraat 55, 7513 ER Enschede, The Netherlands
[3] Institut Universitaire de Pathologie, CH-1011 Lausanne, Switzerland

Summary. Routine postmortem radiography was done in 234 consecutive perinatal autopsies. Using ossification centre appearance and length of femoral shafts as variable it was a very useful and dependable method for estimating gestational age and intrauterine growth. In this way important conclusions can be drawn as to the reason for intrauterine growth deviations. Also many, sometimes diagnostic, abnormalities can be found.

Key words: Neonate – Radiology – Autopsy – Gestational age – Malformation

Introduction

In recent years, many publications have appeared on the subject of radiography in postmortem examination of fetuses and neonates. The method is reported to be useful in the assessment of maturation (Hodges 1937; Fagerberg and Roonemaa 1959; Murphy 1969; Russell and Rangecroft 1969; Croal and Grech 1970; Martin and Higginbottom 1971; Owen 1971; Russell et al. 1972; Foote 1978; Laurini 1986), assessment of growth deviation, in helping to establish pathology related to the cause of death and conditions otherwise undetectable or very difficult to find by autopsy alone (Foote 1978; Griscom and Driscoll 1980; Laurini 1986). It is valuable in comprehensive assessment of malformations, skeletal dysplasias and other skeletal processes, (van der Harten 1987) and can occasionally be used for additional studies with contrast medium. Last, but not least, it provides valuable documentation to be used in clinical conferences or for other purposes. Most of these publications have come from university centres.

For over two years we have used this method in a large pathology laboratory rendering general pathology services in a geographically defined region. It was found that postmortem radiography can give important additional information in perinatal pathology.

Offprint requests to: A.A. de la Fuente

Material and methods

During the observation period of 27 months autopsy was performed on 234 fetuses and neonates of gestational age 14 weeks or more. Fetuses of less than 28 weeks were, as a rule, brought to the laboratory. The radiographs were taken on a Faxitron, using Mamoray RP3 AGFA/Gevaert film. The other fetuses and neonates were autopsied in the hospitals in the region. Radiographs of these fetuses were kindly made by the radiology department of the hospital. In all cases one total body antero-posterior and one total body lateral exposure were made and when deemed necessary exposures of body parts were also taken.

Preliminary examination of the radiographs was done by the pathologist performing the autopsy, while a final evaluation, by the first two authors of this article, took place after all clinical, macroscopic, microscopic and other data were available. All visible abnormalities of skeleton and soft parts were recorded and skeletal age was estimated from the length of the femoral shaft, ossification centres in the foot, in the proximal tibia and distal femur. These were compared with the menstrual age and the gestational age estimated from crown-heel, crown-rump and footlength, (Streeter 1921; Larroche 1977). Any difference of 2 weeks or more between these variables were considered to be of significance and were tabulated.

The fetuses and neonates were divided into a macerated and a nonmacerated group. To make a distinction between retention and intrauterine growth retardation we took into consideration data such as maternal history, clinical data and other findings at autopsy. Such findings include echoscopic data, maternal hypertension, signs of pre-eclampsia, degree of maceration, signs of prolonged fetal infection, disturbance in microscopic appearance of costochondral junction, (Emery and Kalpaktsoglou 1967), degree of lipoid deposition in the fetal adrenal zone (Becker and Becker 1976), villitis in placenta, degree of diffuse placental villus fibrosis and other changes.

Results

In 133 cases the fetuses were macerated and in 101 no appreciable maceration was present. The weight and sex distributions are given in Tables 1 and 2.

In Table 3 overall results are presented by different gestational age groups for the macerated group. The results of morphometric (anthropometric) and radiological assessments of gestational age are compared with the duration of amenorrhoea. It can be seen that in as many as 67 cases there was a discrepancy between the period of amenorrhoea and the anthropometrically estimated gestational age of two weeks or more. In 67 cases (not necessarily the same ones) discrepancies were found between amenorrhoea and radiological maturation assessment. In 8 cases a difference of more than two weeks was noted between anthropometry and radiology. In the different gestational age groups between 16 weeks and 34 weeks a discrepancy was present in half or more of the cases, respectively 50%, 67% and 54%.

As has been stated, in many cases there was a difference of more than two weeks between amenorrhoea and estimated gestational age deduced from morphology and/or radiology. Obviously, when macerated fetuses are too small for gestational age there are two major possibilities: there is either intra uterine growth retardation (IUGR) or a prolonged retention: there might also be a combination of these two. The results are given in Table 4. In a total of 29 cases the major factor was thought to be IUGR. Retention was

Table 1. Weight (grams) and sex distribution

Macerated

Weight	M	F	?	Total
0– 499	42	34	1	77
500– 999	17	9		26
1000–1499	5	4		9
1500–1999	6	5		11
2000–2499	3	1		4
2500–2999	1	3		4
>3000	–	2		2
Total	74	58	1	133

Table 2. Weight (grams) and sex distribution

Nonmacerated

Weight	M	F	?	Total
0– 499	25	27	1	53
500– 999	11	6		17
1000–1499	5	1		6
1500–1999	3	2		5
2000–2499	1	3		4
2500–2999	3	4		7
>3000	5	4		9
Total	53	47	1	101

Table 3. Results in macerated group. Comparison of gestational age according to amenorrhoea, anthropometry and radiology; diagnostic findings. n = number of cases, R = range of discrepancy; AM = amenorrhoea in weeks; RAD = radiography; ANTHROP = anthropometry; ESS = findings essential for diagnosis; IMP = other radiological findings; TOT = total; M = male; F = female

Macerated

Weeks Amenorrh.	TOT	M	F	?	Discrepancy in weeks			Diagnosis	
					AM/anthrop Range (R)	AM/rad Range (R)	Anthrop/rad Range (R)	ESS	IMP
<16	10	8	2	–	$n3$ $R+5$ /-3	$n2$ $R+6$/ -3	– –	–	$n2$
16–22⁻	42	25	16	1	$n21$ $R-2$ /-6	$n21$ $R+2$/ -5	$n1$ $R+2$	–	$n4$
22–28⁻	36	17	19	–	$n24$ $R-2{,}5$/-8	$n24$ $R+3$/ -8	$n2$ $R+2$/-2	–	$n8$
28–34⁻	24	13	11	–	$n13$ $R+4$ /-7	$n13$ $R+4$/ -7	$n2$ $R+1$/-4	–	$n5$
34–40⁺	20	11	9	–	$n6$ $R-3$ /-5	$n7$ $R-3$/-10	$n3$ $R-2$/$+4$	–	–
Unknown	1	–	1	–	–	–	–	–	–
Total	133	74	58	1	$n67$	$n67$	$n8$	–	$n19$

Table 4. Reasons for difference between amenorrhoea and gestational age as estimated by anthropometry and/or radiology in macerated group. IUGR = intrauterine growth retardation

Amenorrhoea weeks	IUGR	Retention	IUGR + RET.	Not possib.	Too large	Total no fetuses
<16	–	2	–	–	1	10
16–22⁻	3	14	4	–	–	42
22–28⁻	10	6	6	–	2	36
28–34⁻	10	–	1	–	2	24
34–40⁺	6	–	1	–	–	20
Total	29	22	12	–	5	132 (+1)

Table 5. Diagnostic radiological findings in macerated group. Underlined are those items which were visible on the radiogram

Macerated

Weeks amenorrh.	Essential	Important or minor
<16 wk	–	1) *Skeletal asymmetry* 2) *Premature ossification centre calcanus*
16–22⁻	–	1) *Calcified meconium* 2) One of gemelli: *Abnormal facies, cyclops, 11 ribs, syndactyly* 3) *Anencephaly + spina bifida* 4) *Cervical rib*
22–28⁻	–	1) *Polydactyly postax.* + omphalocele, horseshoe kidney, abnormal genitalia 2) Turner: *hygroma cervicis* 3) *11 ribs* (4 cases) 4) *Cyclopia, polydactyly* 5) *Marked oedema* of trunc, teratoma
28–34⁻	–	1) *11 ribs* (2 cases) 2) *Microcephaly* (part of syndrome) 3) Turner: *hygroma cervicis* 4) *Amniotic band syndrome*

Table 6. Results in non-macerated group. Comparison of gestational age according to amenorrhoea, anthropometry and radiology; diagnostic findings. n: number of cases, R: range of discrepancy. AM = amenorrhoea in weeks; RAD = radiography; ANTHROP = anthropometry; ESS = findings essential for diagnosis; IMP = other radiological findings; TOT = total; M = male; F = female

Nonmacerated

Weeks Amenorrh.	TOT.	M	F	?	Discrepancy in weeks			Diagnosis	
					AM/anthrop Range (*R*)	AM/rad Range (*R*)	Anthrop/rad Range (*R*)	ESS	IMP
<16	15	10	4	1	*n*1 *R*+2	*n*2 *R*+2 /+3	–	–	–
16–22⁻	29	13	16	–	*n*1 *R*+2	*n*1 *R*+2	*n*1 *R*+2	*n*2	*n*11
22–28⁻	24	15	9	–	*n*5 *R*+1 /+3	*n*8 *R*+3 /−3	–	–	*n*9
28–34⁻	12	8	4	–	*n*3 *R*−2 /−6	*n*4 *R*−2,5/−5	4	*n*1	*n*4
34–40⁺	21	7	14	–	*n*4 *R*−2,5/−8	*n*4 *R*−3 /−4	*n*1 *R*−4	*n*2	*n*10
Total	101	53	47	1	*n*14	*n*19	*n*2	*n*5	*n*34

Table 7. Reasons for difference between amenorrhoea and gestational age as estimated by anthropometry and/or radiology in nonmacerated group. IUGR = intrauterine growth retardation

Amenorrhoea Weeks	IUGR	Malformation	Not possib.	Too large	Total no foetuses
<16	–	–	1	1	15
16–22⁻	–	–	–	–	29
22–28⁻	–	1	1	4	24
28–34⁻	3	–	–	–	12
34–40⁺	–	4	–	–	21
Total	3	5	2	5	101

Table 8. Diagnostic radiological findings in nonmacerated group. Underlined are those items which were visible on the radiogram

Nonmacerated

Weeks Amenorrh.	Essential	Important or minor
16–22⁻	1) Disloc C2** 2) Accardiacus* **Fig. 1a, b *Fig. 2	1) *Amniotic band malformation* 2) *Mult. malformation* (2/14 translocation) 3) *Gas in abdomen* (chorio-amnionitis) 4) *Anencephaly* (4 cases) 5) *Anencephaly* + spina bifida 6) *Premature calcification centre calcaneus* 7) *11 ribs* 8) *Cervical rib*
22–28⁻	–	1) *Malformation TH4 + OCC. fractures* 2) *Anencephaly + spina bifida. 11 ribs* 3) *Prune belly* 4) *11 ribs* 5) *Hydrops* + mult. cong. malformations 6) *Cervical rib* (2 cases) 7) *Premature calcification centre in calcaneus* 8) *Hydrops*
28–34⁻	Short rib Polydactyly Syndrome (Fig. 3)	1) *Acardiacus* (Fig. 2) 2) Trisomy 18 3) *Pneumothorax* 4) *Skeletal malformations* (Amniotic disruption)
34–40⁺	1) Fem. fract. (+ Poly-syndact.) 2) Pneumothorax	1) *Diaphr. hernia* (2 cases) 2) Meconium peritonitis: *mineral* 3) *Anencephaly* 4) *Cardiomegaly* 5) *Abnormal tibia* 6) Triploidy 7) Malformation *hydrocephalus* 8) *Hydrocephalus* 9) *Spina bifida*

deemed to be the major factor in 22 cases and a combination of the two factors in 12 cases. In the <16 weeks-group no IUGR was thought to have occurred among 10 cases, while 1 case was estimated as prolonged retention. In the 16–22⁻ weeks-group IUGR was thought to be present in 3 out of 42 cases, retention in 14 and a combination in 4. Of 36 fetuses in the 22–28⁻ weeks-group 10 were thought to be mainly growth-retarded, 6 were thought to have had prolonged retention. For the 28–34⁻ weeks-group these figures were 10, none and 1 out of 24 respectively, and finally in the 34–40⁺ weeks-group 6, none, and 1 out of 10 cases. In a total of 5 cases, measurements were too large for the duration of amenorrhoea.

In the last two columns the contribution of radiology to pathological diagnosis is listed and further elaborated in Table 5. In no case in this group

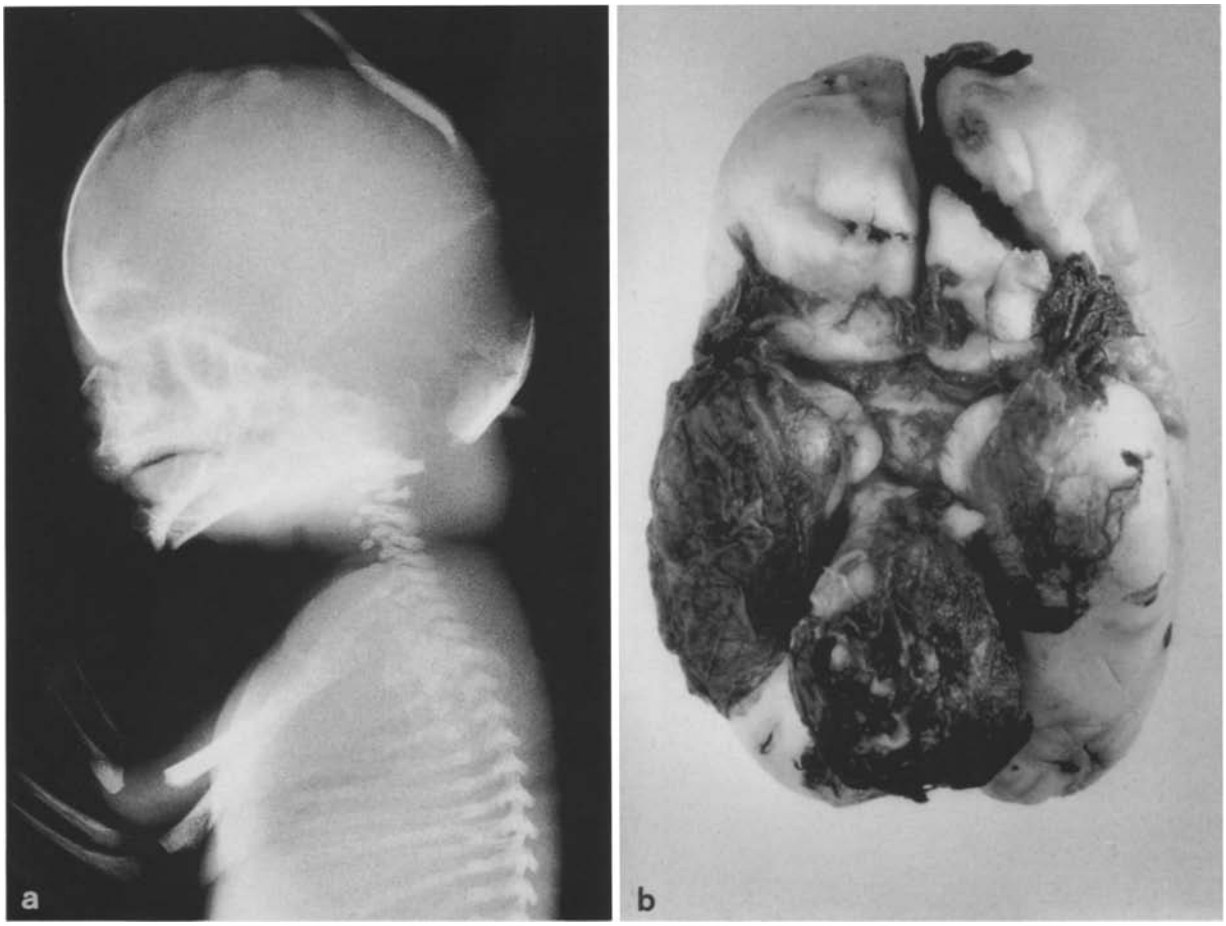

Fig. 1a. dislocation of C2. (**b**) extensive haemorrhage around cervical spinal cord with extension to posterior cranial fossa

was the radiograph absolutely essential. However, in 19 cases details of varying significance could be added to the pathological findings.

In the nonmacerated group, in the same way as for macerated fetuses, the results are tabulated for 101 cases in Table 6. In one case sex could not be stated. A difference in age estimation between amenorrhoea and anthropometrical measurements was present in only 14 cases, between amenorrhoea and radiography in 19 cases, and between anthropometry and radiography in 2 cases. For the different gestational age groups the numbers are small. Most cases of discrepancy occur in the higher gestational age groups (Table 7). For the group of $22–28^-$ weeks the figures are, respectively, 5, 8 and none out of 24 cases; for the group of $28–34^-$ weeks 3 (25%), 4 (33%) and none out of 12; and for the group of $34–40^+$ weeks 4 (20%), 4 (20%) and 1 (5%) out of 21. Negative discrepancies between amenorrhoea and anthropometry/radiology were presumably due to IUGR in 3 cases without, and in 5 cases with, malformations. In 2 cases there was considerable doubt whether the fetus was really small for dates or whether the discrepancy was due to miscalculation. Five fetuses showed measurements too large for the period of amenorrhoea. They could not be placed in either of the two categories. In 5 cases the radiograph was essential for the final diagnosis and in 34 cases it proved or substantiated major or minor abnormalities (Table 8).

Discussion

When performing autopsies on fetuses and neonates the pathologist is greatly concerned with pregnancy dating and with the assessment of growth deviations. Important information can thus be given to the obstetrician and together with other information, possible causes for growth deviation can be evaluated so that therapeutic or preventive measures can be taken in a next pregnancy. As is shown in the literature radiography is a reliable method for estimating duration of pregnancy.

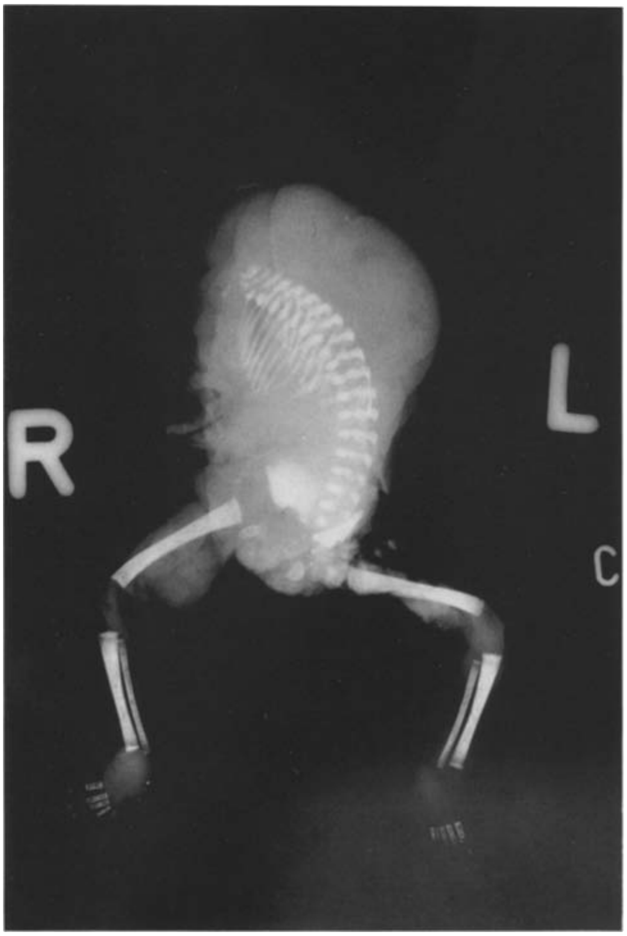

Fig. 2. Acardiacus. Note abnormal skeleton and oedema

Fig. 3. Short rib polydactyly syndrome

Measuring the length of the femoral diaphysis is an easy and reproduceable method, if precautions as to the correct projection are taken. Other measurements, as for instance the length of the humeral diaphysis, can also be taken, but the results of those other measurements run closely parallel to values obtained by measuring femoral length. It can be seen from the figures presented above (Tables 4 and 7) that, especially in macerated fetuses and neonates, there is often a discrepancy between amenorrhoea and anthropometrical and/or radiological assessment of gestational age. Together with other data, radiology can help to clarify whether this is due to prolonged retention, intra uterine growth retardation (IUGR), or both. Furthermore, one is often able to estimate whether the growth retardation is of the malnutrition type or of the symmetrical type (Wigglesworth 1984). From Table 4 it is evident that in the lower gestational age group of >16–22^- weeks the smallness of the fetus is mostly due to prolonged retention and that in only a minor proportion of cases could IUGR be assessed. Thus it is possible to calculate the approximate date of the intra uterine death. It then becomes possible to try and correlate the time of death with events during pregnancy. In the age group of 22–28^- weeks retention and IUGR seem to play almost an equal role, while with gestational age of 28 weeks and more IUGR emerges as the most frequent finding.

There were only 5 cases too large for dates and these were difficult to classify. In the case of <16 weeks gestation, miscalculation of dates seemed the most probable explanation. In some other cases this might have been the case as well. In 2 cases (22–28^- weeks) diabetes of the mother was suggested to the clinician.

In the nonmacerated group small-for-dates were relatively few in number, being present in only 10 out of 101 cases. Conspicuously, 5 cases in this group were associated with malformations. It can also be seen that IUGR was found in only 3 cases, all with gestational ages of more than 28 weeks, presumably falling into the category of asymmetrical (malnutrition) type of growth retardation (Wigglesworth 1984).

In the macerated group no radiological findings were absolutely essential for the final pathological anatomical diagnosis, but in 19 cases the radiogram either revealed or documented more or less important features ranging from abnormal number of ribs to soft tissue swelling and to skeletal malformations (Tables 3 and 5).

In the nonmacerated fetuses there were 5 cases where radiography was essential to the final pathological diagnosis. They are listed briefly in Table 8. In the case with the cervical dislocation (Fig. 1) this finding explained an extensive haemorrhage around the cervical spinal cord with some extension to the posterior cranial fossa. Skeletal dysplasias cannot be diagnosed correctly without radiography and this is illustrated in the case of short rib polydactyly syndrome (Fig. 3). In the acardiac monster (Fig. 2) the anomalous skeleton, the enormous oedema and the twin-twin placental circulation could be demonstrated and documented. The case with the femoral fracture could not be better documented and diagnosed than on the radiogram and this also holds true for the case of pneumothorax. Thirty-one cases showed major or minor abnormalities as can be seen in the table. In several instances the radiogram was a welcome addition to the morphological findings.

References

Becker MJ, Becker AE (1976) Fat distribution in the adrenal cortex as an indication of the mode of intrauterine death. Hum Pathol 7:495–504

O'Brien GD, Queenan JT (1981) Growth of the ultrasound fetal femur length during normal pregnancy. Am J Obstet Gynecol 141:833–837

O'Brien GD, Queenan JT (1982) Ultrasound fetal femur length in relation to intrauterine growth retardation. Am J Obstet Gynecol 144:35–39

O'Brien GD, Queenan JT, Campbell S (1981) Assessment of gestational age in the second trimester by real time ultrasound measurement of the femur length. Am J Obstet Gynecol 139:540–545

Croall J, Grech P (1970) Radiological maturity of the small-for-dates fetus. J Obstet Gynaecol Br Cwlth 77:802–807

Emery JL, Kalpaktsoglou PK (1967) The costochondral junction during later stages of intrauterine life, and abnormal growth patterns found in association with perinatal death. Arch Dis Child 42:1–13

Fagerberg S, Roonemaa J (1959) Radiological determination of foetal length by measurement of the lumbar spine. Acta Obst Gynec Scandinav 38:333–339

Foote GA, Wilson AJ, Stewart JH (1978) Perinatal post-mortem radiography-experience with 2500 cases. Br J Radiol 51:351–356

Griscom NT, Driscoll SG (1980) Radiography of stillborn fetuses and infants dying at birth. Am J Rad 134:485–489

Harten HJ van der (1987) The skeletal system. In: Keeling JW (ed) Fetal and neonatal pathology. Springer, London Berlin Heidelberg New York Paris Tokyo, pp 529–544

Hern WM (1984) Correlation of fetal age and measurements between 10 and 26 weeks of gestation. Obstet Gynecol 63:26–32

Hodges PC (1937) Roentgen pelvimetry and fetometry. Am J Roentgenol 37:644–662

Jeanty P, Rodesch F, Delbeke D, Dumont JE (1984) Estimation of gestational age from measurements of fetal long bones. J Ultrasound Med 3:75–79

Kuhns LR, Holt JF (1975) Measurement of thoracic spine length on chest radiographs of newborn infants. Radiology 116:395–397

Kuhns LR, Sherman MP, Poznanski AK (1972) Determination of neonatal maturation on the chest radiograph. Radiology 102:597–603

Larroche JC (1977) Developmental pathology of the neonate. Exerpta Medica, Amsterdam

Laurini RN (1986) Aspects of developmental pathology. Thesis Groningen Netherlands. Drukkerij van Denderen BV, Groningen

Martin RH, Higginbottom J (1971) A clinical and radiological assessment of fetal age. J Obstet Gynaec Br Cwlth 78:155–162

Murphy PJ (1969) The estimation of fetal maturity with retarded intrauterine growth. J Obstet Gync Br Cwlth 76:1070–1074

Owen RH (1971) The estimation of foetal maturity. Br J Radiol 44:531–534

Queenan JT, O'Brien GD, Campbell S (1980) Ultrasound measurement of fetal limb bones. Am J Obstet Gynecol 138:297–302

Russell JGB (1969) Radiological assessment of fetal maturity. J Obstet Gynaec Br Cwlth 76:208–219

Russell JGB, Rangecroft RG (1969) The effect of fetal and maternal factors' on radiological maturation of the fetus. J Obstet Gynaec Br Cwlth 76:497–502

Russell JGB, Mattison AE, Easson WT, Clark D, Sharpe T, Mc. Gough J (1972) Skeletal dimensions as an indication of foetal maturity. Br J Radiol 45:667–669

Shalev E, Feldman E, Weiner E, Zuckerman H (1985) Assessment of gestational age by ultrasound measurement of the femur length. Acta Obstet Gynecol Scand 64:71–74

Streeter GL (1921) Weight, sitting height, head size, foot length and menstrual age of the human embryo. Contrib Embryol Carnegie Inst 55:143–170

Warda AH, Deter RL, Rossavik IK, Carpenter RJ, Hadlock FP (1985) Fetal femur length: a critical reevaluation of the relationship to menstrual age. Obstet Gynecol 66:69–75

Wigglesworth JS (1984) Perinatal pathology (Major problems in pathology; v. 15) WB Saunders Company, Philadelphia, London, Toronto, Mexico City, Rio de Janeiro, Sydney, Tokyo

Williamson MR, Edwards DK (1980) Prediction of gestational age of infants from the abdominal radiograph. Pediatr Radiol 9:229–231

Received July 21 / Accepted August 12, 1988