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Sternal ossification in normal newborn infants

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Abstract. The lateral chest radiographs of 200 Nigerian newborn infants, whose gestational age was estimated by the Dubowitz examination, were analysed for the pattern of ossification of sternal segments. The length of each visible centre was also measured. The manubrium was ossified in all infants over 35 weeks. All infants 37 weeks and above demonstrated ossification of the first and second mesosternal segments. Ten infants had ossification of the xiphisternum. The average number of ossified segments seen in this study is more than previously reported amongst Caucasian infants. The length of each segment correlated better with birth weight than gestational age. Our findings indicate that any infant with two ossified sternal segments, including the manubrium, is at least 30 weeks and those with 3 and 4 segments 34 and 37 weeks gestation, respectively. There is no difference in the pattern of sternal ossification between the sexes.

The pattern of ossification and fusion of sternal segments has been of considerable interest, with particular reference to premature fusion of segments [2, 7], delayed ossification [9] in congenital heart disease and multiple manubrial centres in mongolism [2, 8]. Although reports have been made on various aspects of normal development of the human sternum [1, 12], none has related the pattern of ossification of centres to gestational age and birth weight in normal term and preterm newborn infants. We have related the pattern of sternal ossification and size of the centres to gestational age, as determined by physical and neurological examination [4, 5] amongst Nigerian newborn infants.

Materials and methods

We studied the lateral chest radiographs of 200 Nigerian singleton newborn infants, who were admitted to our newborn nursery mainly for respiratory distress of various types. All radiographs were obtained within 48 h of birth. Also in the first 2 days of life the gestational age of the infants was determined by a combination of maternal history and the Dubowitz [4] physical and neurological assessment. All infants with congenital heart disease or mongolism were excluded from the study. The presence or absence of the manubrial, mesosternal, and xiphoid ossification centres was recorded for each infant. In addition, the length of each visible ossification centre was measured using direct reading calipers with needle points to the nearest 0.1 mm.

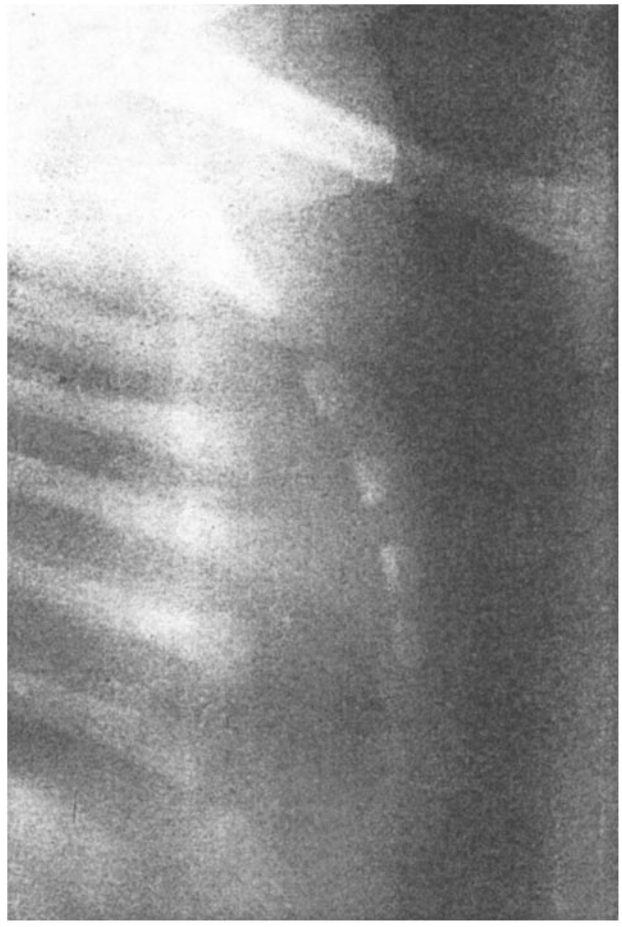

Fig. 1. Four mesosternal segments are clearly visible in addition to the manubrium in an infant of 40 weeks gestation

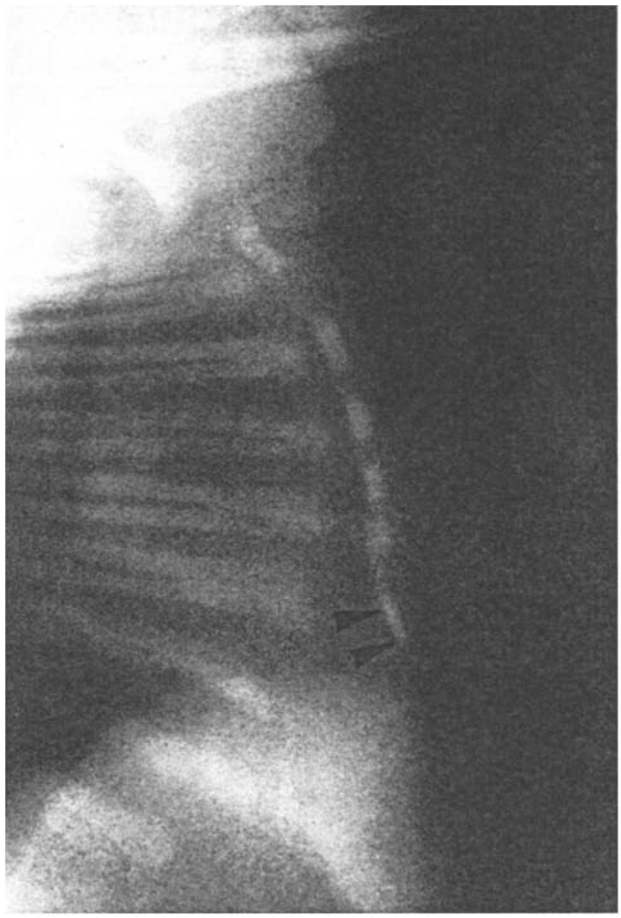

Fig. 2. The arrow heads show the xiphisternal ossification centre in a preterm infant

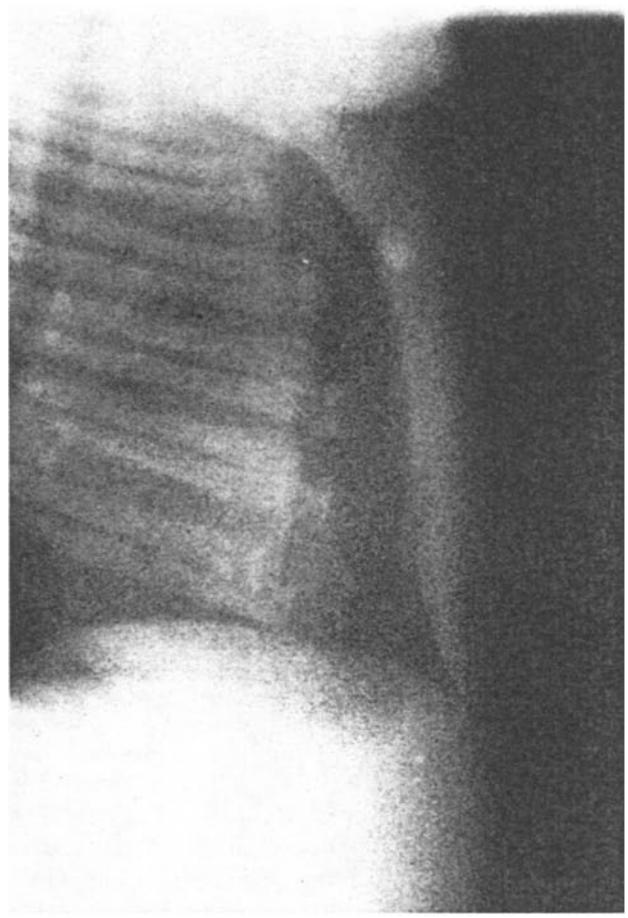

Fig. 3. Only the first mesosternal segment is ossified. Note absence of the manubrium

Results

There were 112 males and 88 females. The birth weights ranged from 1.0 to 4.6 kg and the gestational age 26 to 42 weeks. Since there was no significant difference between the pattern of ossification between the sexes, the results were pooled for both males and females. The percentage of ossified sternal centres at various gestational ages was detailed. All manubrial centres were ossified after 35 weeks and the earliest age at which this centre was visualised was 32 weeks. The first and second mesosternal segments were all visible at 37 weeks of gestation. On the other hand, 68% of the third mesosternal segments were present in infants over 36 weeks. At 38 weeks however, the centres were invariably present. Of the 12 (60%) neonates who showed ossification of the fourth mesosternal segment (Fig. 1), 8 were between 39 and 42 weeks gestation. Ossification of the xiphisternum was observed in 10 (5%) infants (Fig. 2) and ossification of this segment was not related to sex, gestational age or birth weight. Four infants had two manubrial ossification centres. Mesosternal ossification (in the absence of manubrial centre ossification) was seen in four cases (Fig. 3). The percentage of ossified sternal centres was related to birth weight. The manubrial and the first two mesosternal segments were invariably present in all infants over 2.5 kg, while 80% of infants showed an ossified third segment at this weight. Correlation coefficients between gestational age, birth weight and sternal segment length were considered. The birth weight correlated better with the sternal segment than gestational age by a factor of 2. Tables 1 and 2 give the mean lengths and standard deviations of each centre and the average number of ossified segment respectively.

Discussion

The results of this study indicate that sternal ossification in Nigerian newborn infants is more advanced than in Caucasian infants. In this regard, the average of 3.4 sternal segments per child reported by Kim

Table 1. Mean lengths and standard deviations of the sternal segments

Manubrium	Number	Mean length (mm)	Standard deviation
	168	6.9	2.9
1st Mesosternum	160	4.0	1.6
2nd Mesosternum	132	3.9	1.3
3rd Mesosternum	94	2.8	1.2

Table 2. Summary of the average number of visible ossification centres for various ranges of gestational age

Gestational age in weeks	Average number of centres
31 and under	1.94
32–35	2.38
36–39	3.66
40–42	4.20

and Gooding [9] amongst children between 1 and 2 years is much less than our figures of 3.66 in neonates between 36 and 39 weeks and 4.2 for infants above 40 weeks gestation. Similarly, whilst 100% of our infants, aged 35 weeks and above demonstrated manubrial and first mesosternal ossification, Paterson [2] obtained figures ranging from 52.5 to 99.2% in the same gestational age bracket amongst a presumed Caucasian population, whose gestational age was recorded only in months.

There is a striking similarity between the pattern of ossification of the manubrium and the first mesosternal segments, although the manubrium is significantly longer than the first mesosternal segment at all gestational ages.

Our findings indicate that any infant with visible manubrial and first mesosternal centres is at least 30 weeks, although in a few infants, these centres will appear before this time. Similarly, the appearance of 3 and 4 sternal segments including the manubrium suggests a gestational age of at least 34 and 37 weeks, respectively. The appearance of sternal segments on the lateral chest radiographs in the newborn affords an additional method of estimating maturity at birth.

Although several reports have stressed that the xiphisternal centre seldom ossifies before 3 years [6, 10], the 5% incidence of ossification observed in this series is similar to that of Paterson [12]. Xiphisternal ossification unlike the other segments is not related to gestational age and birth weight. Perhaps the development of this centre is sporadic and independent of the other sternal segments. Ogden [11] suggested that xiphoid ossification may be like calcification and ossification within the costochondral cartilage in the adult.

There is a low incidence of double manubrial centres in this series as compared with other reports. We feel that a double manubrial segment is a normal variant which is not necessarily more common amongst mongols, since as many as 20% of normal infants reported by Currarino et al. [3] had double manubrial centres.

The size of an ossification centre as found in the present study is a direct function of growth in size rather than maturity of the infant. However, we cannot offer any explanation for the more significant correlation between birth weight and size of ossification than was found for gestational age.

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