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The ossification of the costal element of the seventh cervical vertebra with particular reference to cervical ribs

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INTRODUCTION

Despite the large quantity of data available on the incidence of cervical ribs in the adult little attention has been paid to defining the natural history of this variant *in utero*. In this study sensitive radiographic techniques have been employed as a method of demonstrating the seventh cervical vertebra. We present the findings of radiography of 715 fetuses of varying gestational age.

METHODS

Medium speed fine grain industrial film (Kodak CX) was used with a D38 mobile unit. Exposure factors were 50 mA, 1·6 seconds, 65–85 kV and 107 cm FFD. Manual processing was used. AP and lateral views were taken in all cases with localised views of the cervical region if necessary. All stillbirths and perinatal deaths in Northwick Park Hospital between 1972 and 1988 were radiographed. Gestational age was assessed by maternal menstrual history and ultrasound findings, with standard ossification chart (Hartley, 1957) used in doubtful cases.

RESULTS

A total of 715 stillborn fetuses was X-rayed. Gestational age ranged from 14 weeks to 42 weeks. There were 403 males (56%) and 311 females (44%). In one case the sex

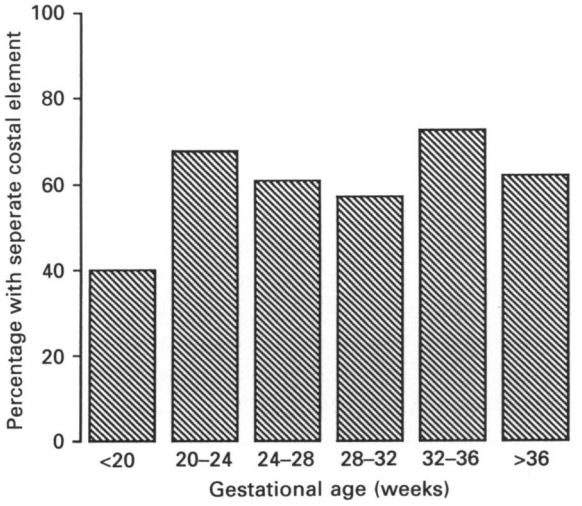

Fig. 1. Incidence of separate costal elements at different gestational stages.

could not be determined. Four hundred and fifty two (63%) had identifiable separate costal elements (Fig. 2*a*, *b*). The incidence at each gestational age is shown in Figure 1. Of the 452 cases, 73% were bilateral. Of the unilateral group 60% occurred on the right and 40% on the left. Skeletal abnormalities were found in 13% of fetuses with and 22% of fetuses without separated costal elements. Other rib anomalies were found in 16% of fetuses with and 13% of fetuses without separate costal elements. The commonest anomalies were 11 pairs of thoracic ribs in 45 cases (43%), 19 other fetuses (18%) had 12 ribs on one side and 11 on the other (12/11). There were 4 cases (4%) with a 13/12 configuration and 1 case each of a 13/13, 11/10 and 10/10 configuration. Differentiation between cases with 11/11 configuration and bilateral separate costal elements, and a 12/12 configuration was made by counting the number of cervical vertebrae occurring before the most cephalad rib-carrying vertebra.

DISCUSSION

One of the earliest records in the medical literature of variation in the number of ribs is found in Mikrocosmographia of 1651 where Helkiah Crooke records: "They are commonly both in men and in women on each side twelve, oftener more than fewer. For nature would rather there should be an abundance rather than want." The idea that the presence of 13 ribs represented an earlier evolutionary stage was suggested by Tyson in 1699 who found bilateral cervical ribs in a pygmy and Rosenberg, stimulated by the publication of Darwin's theories, in 1876 concluded that a decrease in the number of ribs from 13 to 12 was a manifestation of an ordered evolutionary process. Holl (1882), Paterson (1893), Bardeen (1905) and Dwight (1911) disagreed and concluded that variations were accidental and had no evolutionary significance.

During embryological development each body segment contains both a spinal nerve and mesoblastic tissue which will later form a rib or the costal element of a vertebra. In limbless animals such as the snake a rib will develop at each segment. The development of limbs necessitates a crowding together of a number of segments with their associated spinal nerves. It is therefore suggested that in the cervical and the lumbar regions the developing nerve takes precedence over the rib so that development of a rib at these levels is prevented.

Todd observed in 1911 that the costal element of the seventh cervical vertebra was normally present as a separate entity in the cervical region in the fetus. He suggested that it disappears after birth by becoming incorporated by synostosis into the transverse process of the associated vertebra. While the presence of a separate costal element of C7 during embryological development is well-recognised, neither the incidence *in utero* nor the changes occurring during gestation have, to our knowledge, been firmly established. These data confirm that a separate centre for the costal element can be identified in up to 70% of fetuses and commonly from as early as 14 weeks. This is somewhat earlier than had been previously thought. In 30% no such separate centre could be identified. Whether one would have developed at a later stage is impossible to say from this study. We did note, however, than fetuses without a separate costal element had a higher incidence of other skeletal abnormalities.

Rudimentary cervical ribs have been encountered during previous series of perinatal autopsies which have included radiography. De la Founte, Dornseiffen, van Noort & Laurini (1988) performed radiographs and autopsies on 234 fetuses of gestational age 14 weeks or more. Only 4 cases of separate costal elements were noted, but there are a number of reasons why they may have remained undetected by this group. Careful

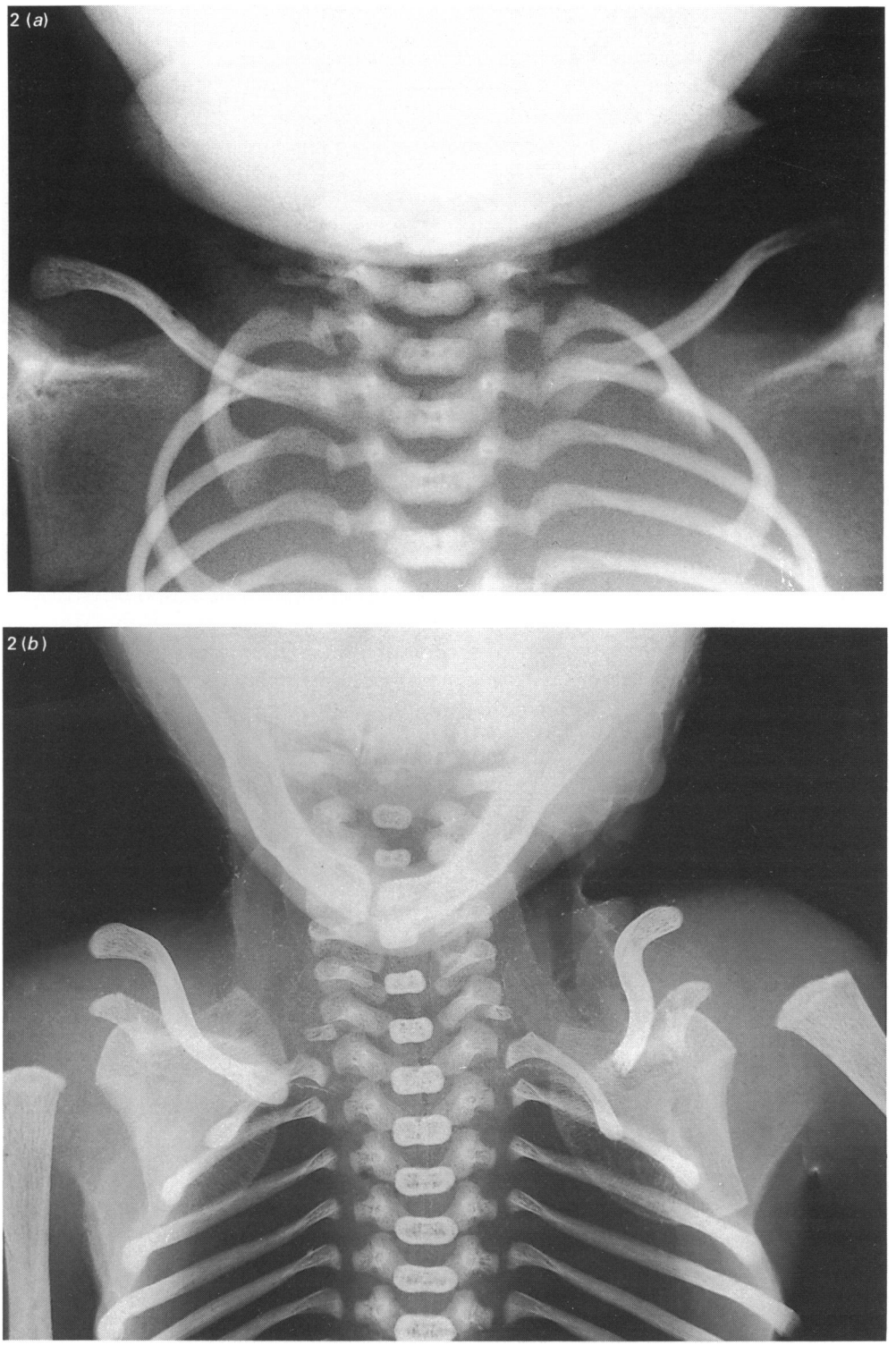

Fig. 2(*a–b*). Separate costal elements in a 35 weeks fetus (*a*) and a 24 weeks fetus (*b*). The latter specimen has been enhanced by pretreatment with silver nitrate.

radiographic technique, ensuring that the lower cervical region is clearly exposed, using the most sensitive film and careful examination of the radiograph is necessary as the tiny separate elements are easily missed (Fig. 2).

The incidence of cervical ribs in adults has been variously reported as between 0·03% and 0·5% on radiographic studies (Etter, 1944; Sycamore, 1944; White, Poppel & Adams, 1945) and up to 1% on postmortem studies. A number of reasons have been put forward as to why the costal element of C7 should become enlarged and persist into adult life as a cervical rib. Jones (1911) noted that when there is a large contribution to the brachial plexus from the second thoracic root, a rudimentary first rib results. Conversely he suggests that where there is a limited contribution from the first cervical root, cervical ribs are allowed to persist. Jones (1913) and others have found some support for this in dissecting room cases and the theory was advanced that prefixation of the brachial plexus (contributing roots from C4–C8 rather than C5–T1) allowed the 7th rib to remain and that postfixation (brachial plexus formed by C6–T2) resulted in a rudimentary first rib. In addition it has been suggested that the degree of prefixation will determine whether or not the patient will have symptoms and that only those with insufficient prefixation for the size of the cervical rib will present with symptoms of compression. Todd (1911) disagreed and dissected many cases which showed a normal configuration of the brachial plexus in the presence of cervical ribs. He concluded that the neural development alone is insufficient to account for the condition of the ribs.

While the reasons for the disappearance or fusion of separate costal elements and the time scale over which it occurs remain speculative as do the reasons for their occasional enlargement to form a true cervical rib, some interesting points can be made from this study. The incidence over a range of different gestational ages is similar (Fig. 1) confirming that the majority disappear (or become fused) postnatally. Furthermore, there would appear to be an unequal rate of disappearance between the sexes and sides. In the fetus we found an equal sex incidence with unilaterality more common on the right, while extensive studies of adults found cervical ribs to be more common in females (Raaf, 1955) and unilaterality more common on the left. It is difficult to suggest reasons why costal elements should disappear at a greater rate in males and on the right side. The greater prevalence of right-handedness might be important but it would be necessary to study the rate that the separate costal elements disappear postnatally before firm conclusions could be drawn. In neonates there can be few, if any, indications to undertake radiography merely to diagnose cervical ribs, and those radiographs taken for other purposes are rarely of sufficient clarity to enable an accurate incidence of cervical ribs to be determined. Finally there may be other factors involved; Thompson (1908), Wakely (1920–1) and Weber (1912–13) have all reported a familial occurrence of cervical ribs suggesting that generic factors may also play a role.

SUMMARY

During 16 years of study at Northwick Park Hospital 715 fetuses were radiographed to determine the incidence of skeletal malformations. A technique using low kV and industrial film provided higher resolution radiographs than would have been possible in live births because of dose considerations. Gestational age calculated from LMP and ultrasound findings ranged from less than 18 weeks to 42 weeks. A separate costal element of C7, the possible precursor of a cervical rib, could be identified in 63% of fetuses. Males outnumbered females 403:311 but there was no intersex difference in

the presence of such rudimentary cervical ribs with 63 and 64% respectively in each group. Of the 452 cases with separate costal elements, 73% were bilateral. Of the unilateral group 60% occurred on the right and 40% on the left. There was no significant difference in the incidence between the gestational age groups from 20 weeks onwards, confirming that the disappearance of the separate element occurs predominantly after birth. 394 cases (87%) of fetuses had an otherwise normal skeleton.

After this paper was submitted for publication our attention was drawn to the abstract of a paper presented by D. B. Meyer (*Anatomical Record* (1978) **190**, 481) entitled 'The appearance of "cervical ribs" during early human fetal development'. Meyer X-rayed 177 human fetuses of 49–150 mm and found an incidence of separate costal elements of approximately 33%, with 65% of them bilateral.

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