CONGENITAL SCOLIOSIS IN MONOZYGOTIC TWINS

GENETICALLY DETERMINED OR ACQUIRED IN UTERO?

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The term “congenital scoliosis” contributes little to our understanding of aetiology, for “congenital” simply means “to be born with” and is applicable to deformities present at birth whether these are genetically determined or acquired in utero.

The presentation of monozygotic twins, one of whom has congenital scoliosis (vertebral anomalies) while the other is normal, provides a rare opportunity to study the cause of this deformity. Three pairs of monozygotic twins, previously unreported, are presented with a review of the previous literature. These cases add weight to the argument that congenital scoliosis may be acquired in utero rather than being genetically determined.

Certain spinal anomalies contributing to congenital scoliosis are thought to be genetic in origin (Haffner 1936; Akbarnia and Moe 1978). James (1970) felt that a general genetic cause for this condition was unlikely, and Wynne-Davies (1973) suggested that, although multiple vertebral anomalies associated with neural tube defects such as spina bifida or anencephaly are genetically determined, single anomalies are sporadic and probably acquired in utero.

Embryological research has shown that abnormal vertebrae can be acquired in utero: a report from Montreal (Rivard et al. 1982) showed that, in mice embryos at an age equivalent to that of a six-week-old human embryo, hypobaric hypoxia can produce anomalies similar to those seen in congenital scoliosis. Other factors (chemical, thermal, nutritional, traumatic or infective) can be postulated as having the same influence.

In the three-week-old human embryo, mesenchymal cells gather dorsolateral to the notochord to form condensations called somites, up to 42 in number, from which the vertebral bodies, arches and ribs are derived. Seen under the microscope, somites have darker (and by inference denser) cranial halves and lighter, less dense caudal halves. At four to six weeks these halves separate and each cranial half fuses with the caudal half above it. The bodies of the vertebrae are formed by cells growing ventrally and medially around the notochord.

The intersegmental arteries, which originally are between the somites, therefore come to lie within the bodies of the vertebrae (Ehrenhaft 1943; Winter 1973; Zimbler and Belkin 1976). This normal embryological sequence could, however, be interrupted by external influences to produce anomalies (Winter, Moe and Eilers 1968; Nasca, Stelling and Steel 1975; MacEwen cited by Goldstein and Waugh 1973): these include failure of formation (partial failure produces a wedged vertebra while complete failure produces a hemivertebra); failure of segmentation (partial failure produces a unilateral unsegmented bar while complete failure produces block vertebrae); and combinations of the two. It is possible that most of these failures of formation or segmentation are secondary to abnormalities in the blood supply, or to failure of cartilage formation in the mesenchymal tissues.

Studies of twins where one has congenital scoliosis and the other is normal, or where both have different varieties of congenital scoliosis are rare, but valuable in this context as long as the twins can be shown to be identical, that is, monozygotic. Four such studies have previously been published (Table I) and three more pairs of monozygotic twins are presented in this report.

PATIENTS AND METHODS

Pair 1. Twin girls born in January 1966 presented at the age of 4 years 8 months when one twin was noted to be “lopsided” (Fig. 1). Examination of this twin revealed a right thoracic scoliosis with a patch of hair in the midline overlying the curve. Neurologically she was normal. Radiographs revealed developmentally abnormal vertebrae in the mid-thoracic spine (Figs 2 and 3). Subsequently an air myelogram revealed a diastematomyelia in the upper thoracic region and, since the curve was progressing, a Moe fusion was performed. Her sister’s spine was normal and remains so.

Pair 2. Twin boys were born in January 1966. When they were 15 years old, one presented with a back deformity which had embarrassed him to the extent that he no longer played games or went swimming. On examination there was a very rigid right thoracic scoliosis with marked rotation and a rib hump (Fig. 4). A myelogram revealed no evidence of a diastematomyelia. Radio-
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Pair 1: twin girls. Figure 1—The affected twin is on the left; note the patch of hair overlying the anomalous vertebrae. Figures 2 and 3—Anteroposterior radiographs of the affected twin show the anomalous vertebrae (Fig. 2); 28 months later (Fig. 3) the spinal curve is worse despite bracing.

Pair 2: twin boys. Figure 4—The affected twin is on the left. Figure 5—Radiograph of the affected twin shows anomalous vertebrae. Figure 6—Radiograph of the normal twin’s vertebral column; the extra rib is visible.

graphs confirmed that the scoliosis was due to vertebral anomalies (Figs 5 and 6). Each twin was found to have six lumbar vertebrae and an extra rib; both these features were thought to be genetic in origin. The mother’s radiographs were normal, but the father’s were unobtainable.

Pair 3. Twin girls were born in January 1979. At the age of three years one was found to have spinal curvature and radiographic examination revealed a congenital scoliosis at the level of T12 with vertebral anomalies (Fig. 7). Close follow-up has so far revealed no progression of the curve. The sister’s spine is normal (Fig. 8).
Vertebral anomalies

<table>
<thead>
<tr>
<th>Report</th>
<th>Sex (age)</th>
<th>Vertebral anomalies</th>
<th>Associated anomalies</th>
<th>Factors used to establish monozygosity</th>
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<tbody>
<tr>
<td>Haffner 1936</td>
<td>Female (22 years)</td>
<td>Hemivertebra on the left below L2</td>
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<tr>
<td>Peterson and Peterson 1967</td>
<td>Male (14 years)</td>
<td>Multiple hemivertebrae in the thoracic spine</td>
<td>Normal</td>
<td>Spina bifida occulta at S1 in both</td>
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<td>Hattaway 1977</td>
<td>Female (8 months)</td>
<td>Hemivertebra on the right at T5 and on the left at T9</td>
<td>Normal</td>
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<tr>
<td>Ogden and Southwick 1978</td>
<td>Triplets: 1 and 2, monochorionic and diamniotic; triplet 3, separate chorion and amnion</td>
<td>Hemivertebrae on the left at T8-T10</td>
<td>Hemivertebrae on the right T6-T9</td>
<td>Twin 1: ventricular septal defect</td>
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In these three pairs of twins, hair, eyes and skin were well matched. In Pair 1, the blood groups in 11 systems were identical so that the chance of monozygosity was 89%; in Pair 2 blood groups in 19 systems were identical, the chance of monozygosity being over 97%; and in Pair 3 blood groups were identical in 13 systems, the likelihood of monozygosity being over 90%. (Both cross-matching and calculations were done by Dr R. Sanger: Race and Sanger 1975.) Although it is impossible to prove conclusively that twins are monozygotic, the figures nonetheless show that it is very likely that the three pairs of twins are identical. In no pair of twins was there any family history of back deformity nor any evidence of illness or injury in the mother during the first trimester, particularly between the fifth and tenth weeks of pregnancy.

**DISCUSSION**

By definition monozygotic twins are endowed with identical genetic material. Dramatic differences between them at birth are therefore probably due to environmental factors. In the case reports previously published (Table 1) and in those described here, it is difficult to see how a genetic cause could so drastically affect one twin in utero and yet leave the other unscathed; it is surely more likely that one twin’s embryological spinal column was damaged by a faulty environment. The fault might have an hypoxic, chemical or nutritional basis, any of which may have compromised the segmental blood supply to produce the congenital vertebral anomalies.

When this hypothesis is applied to previously published case reports where both twins have congenital vertebral anomalies at different levels or of different types, it may be postulated that the same environmental fault has caused both. Environmental influences might affect the blood supply at different developmental stages; different sites in the embryonic spines could thus be affected to produce different anomalies or anomalies at different levels.

In conclusion, therefore, it seems likely that congenital scoliosis with vertebral anomalies can sometimes be acquired as the result of detrimental stimuli in utero and is not exclusively genetic in origin.

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**REFERENCES**


