Hypoplastic Left Heart Complex

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From the British Perinatal Mortality Survey, The National Birthday Trust Fund, London, S.W.1

Lev (1952) wrote, 'a group of congenitally malformed hearts are conveniently placed in the category of hypoplasia of the aortic tract complexes'. He considered that their basic feature was a hypoplasia of the left side and a hypertrophy of the right side of the heart. Noonan and Nadas (1958) expanded this concept and included in their series cases with aortic and mitral valve obstruction and cases with interruption and hypoplasia of the aortic arch, though not with uncomplicated infantile coarctation.

Previous studies of congenital heart disease (Carlsten, 1959; Mehriz, Hirsch, and Taussig, 1964; Lambert, Canent, and Hohn, 1966) have shown that lesions belonging to this complex are relatively common at birth though prolonged survival is unusual, so that the group ranks as the second or third most important category of congenital heart defects in stillbirths and neonatal deaths. Aetiological factors are unknown and information on parental age and gestational maturity is scanty. Fifty stillbirths and neonatal deaths in the British Perinatal Mortality Survey (Butler and Bonham, 1963) were found to have lesions that could be classified as part of the hypoplastic left heart complex. We give here an account of their birthweight, length of gestation, associated malformations, and parental age, and discuss the significance of our finding of high paternal ages in a substantial proportion.

Material and Methods

The Perinatal Mortality Survey has been described by Butler and Bonham (1963). Detailed questionnaires were completed for 98% of all births in England, Wales, and Scotland during one week in March 1958, and this population of 16,994 singletons and 412 twins is termed the 'main week population'. In order to obtain comparable data on a large number of deaths, questionnaires were completed for 94% of stillbirths and neonatal deaths occurring in the same areas during March, April, and May 1958. A total of 7822 stillbirths and neonatal deaths were ascertained, of which 705 were twins. Deaths among the main week population were included in this total. An estimate of the total number of births occurring in these three months is obtained by multiplying the main week population by a factor of 12 (Butler, 1965).

A total of 5300 stillbirths and neonatal deaths came to necropsy, and the 50 cases of the left heart complex in the present account were derived from this group. The questionnaire completed by the pathologists taking part in the Survey specifically asked about malformations of the valves of the heart, the condition of the endocardium, and any abnormalities of the chambers of the heart and great vessels.

The classification of the complex cardiac malformations was a major problem. In Table I each case has been arbitrarily assigned to a category, according to the cardiac lesion the authors considered the most important, so that the groups are mutually exclusive. For example, a case with a hypoplastic left heart and a septal defect would appear only once in the category of hypoplastic left hearts, and not again in that of septal defects. Further detailed descriptions of all congenital malformations of the heart in the Survey are in preparation.

Findings

Incidence. Table I lists the different types of congenital heart defect found at necropsy. Details are shown of the malformations classified as hypoplastic left heart complex, a group that accounted for 17% of the total heart lesions. Two of the 50 babies with this complex were twin births, both of a pair of girls, and in both instances the other twin survived the neonatal period.

Necropsy Findings. Cases included in the hypoplastic left heart complex had lesions that ranged from aortic and mitral valve atresia, together with left-sided endocardial fibroelastosis, to isolated hypoplasia of the aorta.

Table II shows associated malformations in the different types of this complex. Among the cases with aortic valve obstruction with or without mitral

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valve lesion nearly one-half had endocardial fibroelastosis. This association was only rarely noted in the other subgroups. Coarctation of the aorta was an additional defect in over 1 in 10 of all cases, most often in association with aortic valve lesions. Only 4 of 29 babies with aortic lesions had extracardiac malformations, in contrast to the remaining cases in which 12 out of 21 had extracardiac lesions.

**Birthweight and Gestation.** Table II also shows further details of each case, including birthweight and length of gestation calculated from the first day of the last menstrual period. In contrast to most other congenitally malformed babies, the majority of these were born at 40 weeks or later. When extracardiac malformations were present the gestation period tended to be shorter and the birthweight low.

**Sex.** There were 30 boys and 20 girls in the series. The male preponderance was most striking in those cases with aortic valve involvement, of which 20 out of 29 were boys. All four cases with interruption of the aortic arch were girls.

**Time of Death.** Of the 50 babies, 7 were stillborn, the remainder dying within four weeks.

**Maternal and Paternal Age.** The mean maternal and paternal ages of the cases in the complex (Groups A to E) were higher than in the main week population (Table III) (p < 0.01). This age effect was found in all the groups in Table III, except in those cases with interruption of the aorta (Group E) in which parental ages were below the mean for the population. After exclusion of Group E, the mean maternal age was 31.0 and the mean paternal age was 35.9 years, both significantly higher than in the control population (p < 0.01). The difference between the means, 4.9 years, was also significantly raised (p < 0.01), showing that paternal age was raised relatively more than maternal. The most striking age effect was in those cases with aortic valve involvement but no lesions other than those forming a part of the complex, Group A. In this subgroup alone the mean paternal age and mean difference between this and mean maternal age were significantly (p < 0.01) raised compared with the population.

Because of possible difficulties in distinguishing between hypoplasia and coarctation of the aorta, parental age was studied in cases where ‘coarctation’ was the major cardiovascular lesion. In this condition only maternal age was raised (mean 29.5 years) and paternal age (mean 30.1 years) did not differ from that in the population.

The groups of cases with aortic valve obstruction and other malformations (Group B), with mitral valve obstruction (Group C), and with left-sided hypoplasia without valve lesions (Group D) in general showed similar features to the cases in Group A, a raised mean paternal age and a high male-female sex ratio, but to a slightly lesser extent.

**Discussion**

From previous accounts and the present study, it is clear that the hypoplastic left heart complex is neither pathologically clear cut nor aetiologically homogeneous. Indeed one weak point of the classification suggested by Noonan and Nadas (1958) is the difficulty of distinguishing between 'hypoplasia' and 'coarctation' of the aorta, a difficulty discussed by Evans long ago (1933).

The study of parental ages in this complex may be one way of identifying homogeneous groups. In the present series, both maternal and paternal age, in the complex as a whole, were significantly higher than in the control population, and the excessive mean difference between the two ages suggested that paternal age was the factor of more importance (Penrose, 1955).

To our knowledge the only cases previously described, falling into the hypoplastic heart complex, where parental age was given, are the ten with aortic or mitral valve atresia described by Friedman, Murphy, and Ash (1951, 1955). The paternal ages
**Hypoplastic Left Heart Complex**

**Table II**

**HYPOLASTIC LEFT HEART COMPLEX:**
MALFORMATION, SEX, PARENTAL AGE, PARITY, BIRTHWEIGHT, AND LENGTH OF GESTATION

<table>
<thead>
<tr>
<th>Serial No.</th>
<th>Sex</th>
<th>Malformations</th>
<th>Maternal Age (yr.)</th>
<th>Paternal Age (yr.)</th>
<th>Parity</th>
<th>Birthweight (g.)</th>
<th>Gestation (days)</th>
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<td></td>
<td></td>
<td>AV</td>
<td>MV</td>
<td>EFE</td>
<td>Aorta</td>
<td>Other Cardiac</td>
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<td><strong>Group C—Mitral valve obstruction without aortic valve lesions</strong></td>
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<td><strong>Group E— Interruption of the aorta</strong></td>
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</tbody>
</table>

*Mother has congenital aortic stenosis.

### Notes:
- * AV: aortic valve; MV: mitral valve; B: bicuspid valve.
- EFE: + + = fibroelastosis; + = opaque.
- Aorta: H = hypoplasia; I = interruption; C = coarctation.
- Other cardiac: + = other.
- T = preceding serial number denotes twin.
- X = Not known.

where known were 35, 32, 38, 26, 38, 35, 29. Four out of the seven fathers were aged 35 or more. Moreover, Zoethout, Bonham Carter, and Carter (1964) gave details of parental ages in children presenting with aortic stenosis at The Hospital for Sick Children in London, a proportion of which almost certainly represents survivors of our Groups A and B in their mildest form. The mean maternal age in...
TABLE III  
GROUPS OF HYPOPLASTIC LEFT HEART COMPLEX: MEAN MATERNAL AND PATERNAL AGE AND MEAN DIFFERENCE

<table>
<thead>
<tr>
<th>Group</th>
<th>Malformations</th>
<th>Number (with known parental ages)</th>
<th>Mean Maternal Age (yr.)</th>
<th>Mean Paternal Age (yr.)</th>
<th>Mean Difference (yr.)</th>
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<tbody>
<tr>
<td>A</td>
<td>Aortic valve obstruction with no lesions other than mitral valve obstruction and endocardial fibroelastosis</td>
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<td>31.5</td>
<td>37.9</td>
<td>6.4</td>
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<td>B</td>
<td>Aortic valve obstruction with additional cardiac or extracardiac lesions</td>
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<td>29.8</td>
<td>33.7</td>
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<td>C</td>
<td>Mitral valve obstruction without aortic valve lesions</td>
<td>6</td>
<td>29.5</td>
<td>34.0</td>
<td>4.5</td>
</tr>
<tr>
<td>D</td>
<td>Left-sided hypoplasia without valve obstruction</td>
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<td>32.9</td>
<td>37.7</td>
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<td>E</td>
<td>Interruption of aortic arch</td>
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<td>A-E</td>
<td>All Main week population</td>
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<td>27.5</td>
<td>30.5</td>
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* Mongol excluded.

TABLE IV  
SYNDROMES WITH RAISED PATERNAL AGE  
(ADAPTED FROM BLANK, 1960)

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<tr>
<th>Syndrome</th>
<th>No. of Cases</th>
<th>Mean Paternal Age (yr.)</th>
<th>Mean Maternal Age (yr.)</th>
<th>Mean Difference (yr.)</th>
<th>Source</th>
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<td>Achondroplasia</td>
<td>97</td>
<td>38.7</td>
<td>32.1</td>
<td>6.6</td>
<td>March (quoted by Krouth &amp; Penrose, 1955)</td>
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<tr>
<td>Marfan's syndrome (sporadic cases)</td>
<td>37</td>
<td>40.2</td>
<td>33.3</td>
<td>6.9</td>
<td>Stevenson (1957)</td>
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<td>Apert's syndrome</td>
<td>37</td>
<td>36.9</td>
<td>31.8</td>
<td>5.1</td>
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<td>Group A</td>
<td>14</td>
<td>37.9</td>
<td>31.5</td>
<td>6.4</td>
<td>Present series</td>
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</table>

their series was 28.4 years, compared with 28.3 years in a control population. The mean paternal age (for which there was no control) was 32.3 years, and the average difference between this and maternal age was 3.9 years.

There are some grounds for believing this to be excessive. First this is a larger mean difference than 3-0 years found among the control births in the Perinatal Mortality Survey. Secondly, though there are no population data on paternal age at this time, data published on ages of all bridegrooms and brides (Registrar General, 1966) show that in the 12 years preceding 1964 the biggest mean difference between age of husband and wife in any one year was 3.1 years. Thirdly, 15% of fathers in the aortic stenosis series of Zoethout et al. (1964) had been aged 40 years or more, compared with 9.5% in the Survey mothers control population, a difference which seems unduly large even allowing for the fact that the Survey mothers were slightly younger than the controls used by Zoethout et al. (27.5 years compared with 28.3 years). While these findings clearly cannot be interpreted as confirming a paternal age effect in neonatal deaths with aortic valve obstruction they would be compatible with such a thesis.

Within the group of hypoplastic left hearts described in the present account it was clear that the paternal age effect was maximal in the cases with aortic valve involvement and without malformations other than those forming part of the complex, our Group A. In contrast, there seemed to be no age effect in the group where interruption of the aorta was the major defect. Since Gasul, Arcilla, and Lev (1966) consider that interruption of the aorta is the most severe form of preductal coarctation, it is interesting that in the present series no undue rise in mean paternal age was found in the cases where 'coarctation' of the aorta was the major cardiovascular defect. This finding is supported by Campbell's (1965) report, that while the mean paternal age was raised in all the groups with malformations of the heart, he did not think the increase was significant for the group with coarctation. Gasul and his colleagues also stated that it was possible to distinguish between 'hypoplasia' of the aorta, in which the ascending aorta is narrower than the aortic arch, and 'coarctation' in which the reverse relation occurs.

The distinction between interruption of the aorta and the remaining groups in the complex was also supported by the sex distribution. When our cases with aortic interruption were added to those described by Noonan and Nadas (1958), 9 out of the 10 were female. This was in contrast to all the other groups in the complex where there was a male preponderance, as in the series collected by Noonan and Nadas, and in other reported groups of aortic and mitral stenosis.

Raised paternal age has been described in some cases of Down's syndrome with a G/21 structural anomaly (Penrose, 1962) and in some patients with XO/X isochromosome for the long arm of the X (Polani, 1965). It has also been demonstrated in three non-chromosomal syndromes: achondroplasia, Marfan's syndrome, and acrocephaly-syndactyly (Apert's syndrome). Table IV shows that the increase in father's age in our Group A is of the same order as that described for these last conditions. The relevance of this finding lies in the
Hypoplastic Left Heart Complex

Summary

There were 50 cases falling into the category of hypoplastic left heart complex, either stillborn or dying during the neonatal period, which were included in the British Perinatal Mortality Survey.

It is considered that this complex is a heterogeneous group with one subgroup, interruption of the aorta, contrasting sharply with the others in sex and parental age distribution. In this sample, a feature of the remaining cases, particularly those with aortic valve obstruction uncomplicated by other types of cardiac or extracardiac malformation, was a high mean parental age. The relevance of such a finding is briefly discussed.

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