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CONGENITAL CARDIAC MALFORMATION IN THE NEWBORN PERIOD
FREQUENCY IN A CHILDREN'S HOSPITAL*

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AN APPROXIMATION of the incidence of congenital cardiac malformations in the population has been reached by different workers in a variety of ways.[1-4] A prospective study conducted by Richards and colleagues[2] found a figure of about seven congenital cardiac malformations per 1000 live births. Because of admitted sources of error inherent in any study of such large numbers of infants over a short period of one year, this figure was regarded by the authors as "almost certainly low". It has been suggested that between 15% and 30% of infants born with cardiac malformation die in the first month of life.[2-4] Regardless of the accuracy of this estimate, the fact is established that a substantial number of infants with congenital heart disease die in the neonatal period.

While the problem of determining an accurate incidence of unspecified congenital cardiac malformation is great, the difficulty of arriving at precise information on the frequency of the different defects in affected infants is greater. For varying reasons the frequency of the different malformations has differed greatly in several reports. The present study does not pretend to solve this dilemma. In expressing the recent experience of congenital heart disease in the first 28 days of life from a children's hospital with a large referral population, we approach the problem in a manner different from most previous communications.

CASE MATERIAL AND METHODS

Records were examined of all infants under the age of 29 days referred to the cardiac service of the Hospital for Sick Children, Toronto, between 1953 and 1957, together with all autopsies within the same age group where congenital cardiac malformation was found in the same five-year period. A total of 264 such infants was divided into two main groups.

(a) Infants dying with cardiac malformations established by post-mortem examinations:
- Operative deaths 24
- Non-surgical deaths 106

(b) Infants assessed in, but surviving, the newborn period
- Pseudo-cardiopathy[5], i.e. patients referred with possible heart disease in whom no cardiac malformation was found 53
- True congenital cardiac malformation 81

RESULTS

The Fatal Group

The 24 patients who died at or shortly after operation during the first month of life were separated for the reason that while in almost every instance death might have been expected without surgical treatment, a number could have survived 28 days. The chief proportion had transposition of the great vessels (seven patients), preductal coarctation of the aorta (six patients) and pulmonary atresia with normal aortic root (four patients).

The frequency of the major anatomical defect at autopsy in 106 patients who died in the neonatal period is shown in Table I. Malformations above

TABLE I.—THE FREQUENCY OF DIFFERENT CARDIAC MALFORMATIONS AT AUTOPSY IN 106 NEWBORN INFANTS BETWEEN 1953 AND 1957

	Per cent
Aortic atresia or stenosis	23
Coarctation of the aorta	13
Transposition of the great vessels	10
Pulmonary atresia or stenosis	8
Ventricular septal defect	7
Atrioventricularis communis	5
Tetralogy of Fallot	5
Complicated dextrocardia or levocardia	5
Mitral atresia or stenosis	4
Complete anomalous pulmonary venous drainage	4
Single ventricle	3
Persistent truncus arteriosus	3
Endocardial fibroelastosis	2
Ebstein's disease	2
Atrial septal defect	2
Patent ductus arteriosus	2
Tricuspid atresia	2
Total	100

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the black bar constitute together about 75% of the total number. Over one-third of the deaths were associated directly or indirectly with aortic lesions and more than half of the deaths were in infants with one of four malformations. Approximately two-thirds of the deaths were in the first week of life. Eight per cent were dead on arrival at the Admitting Department while 12% were not referred to the cardiac service, chiefly being examples of preductal coarctation of the aorta. In 4% of the total, heart disease was unsuspected before autopsy, and again these were chiefly aortic lesions or a ventricular septal defect. A single case of transposition of the great vessels was discovered at autopsy.

About one-quarter of the babies who died were premature, and one-fifth died from causes other than their cardiac malformation. The etiological agent in these cases was infection, prematurity or other gross malformations. Forty-four per cent of the group developed congestive heart failure before death. Fourteen per cent, i.e. 20% of those available, were investigated by accessory methods of study, such as cardiac catheterization or angiocardiography.

The Surviving Group

Of 149 infants seen by us with signs of heart disease in the first month of life who survived that period, 81 had true cardiac malformations and 53 pseudocardiopathy. A further 15 were seen and diagnosed as having heart disease, but since their fate after discharge was not known, they were excluded from the study. Of this latter number, ventricular septal defect, transposition of the great vessels and atrioventricularis communis were present in about equal numbers.

TABLE II.—DIAGNOSIS IN 53 NEWBORN INFANTS WITH PSEUDO-CARDIOPATHY, I.E. PATIENTS PRESENTING WITH SIGNS SUGGESTING HEART DISEASE IN WHOM NO CARDIAC MALFORMATION WAS FOUND

	Percentage
Respiratory distress syndrome	16
Innocent murmurs	15
Disappearing ventricular septal defect	12
Disorders of heart rate	6
Positional cardiac abnormalities	2
Extrathoracic AV fistula	1
Systemic hypertension, undetermined	1
Total	53

The pseudocardiopathies constitute a group the size and content of which vary in different institutions, but in our instance, in this five-year period, 53 patients had the diagnoses given in Table II. During the time of the study, cases of respiratory distress were largely confined to the mature babies with cyanosis or babies in whom frank congestive heart failure was present or suspected. The innocent murmurs were chiefly of hæmic origin in infants with blood incompatibility disorders. Those infants with so-called disappearing ventricular septal defect presented with a characteristic murmur but no other abnormalities. The murmur disappeared between six weeks and two years later. Evidence now suggests that this syndrome is due to a minute defect in the muscular septum, but these patients are not included as ventricular septal defects for the purposes of this study because complete proof of this assumption is still lacking. Supraventricular tachycardia or congenital heart block accounted for the cases with disordered heart rate, and dextrocardia for those positional anomalies of the heart without heart disease.

TABLE III.—THE FREQUENCY OF DIFFERENT CARDIAC MALFORMATIONS IN 81 INFANTS EXAMINED DURING AND SURVIVING THE NEWBORN PERIOD

	Percentage
Ventricular septal defect	20
Tetralogy of Fallot	16
Transposition of the great vessels	16
Pulmonary stenosis or atresia	13
Coarctation of the aorta	11
Complicated dextro- or levocardia	5
Single ventricle	4
Atrioventricularis communis	4
Ebstein's disease	2
Patent ductus arteriosus	2
Tricuspid atresia	2
Persistent truncus arteriosus	2
Mitral stenosis	2
Aortic stenosis	Less than 2
Total	100

Eighty-one infants remain who were seen in the newborn period and found to have true malformation of the heart (Table III). The malformations above the black bar constitute together about 75% of the total number. The malformation which headed the list in the fatal group is now the least common. Ventricular septal defect and tetralogy of Fallot assume a position of greater importance, while transposition of great vessels, pulmonary stenosis and coarctation of the aorta hold their previous positions. It will be noted that over half of the infants in this group were suffering from one of four malformations, namely, ventricular septal defect, tetralogy of Fallot, transposition of the great vessels or pulmonary stenosis. Sixteen per cent of the infants in this group were premature, and 25% developed congestive failure during the period of follow-up. In the same period, of the 81 infants, 31 died, 60% in the first six months and 90% by the end of the first year. Three-quarters of the babies were investigated by cardiac catheterization or angiocardiography, and the majority (73%) were so studied during the first month of life. Surgical treatment was undertaken in 20 of the 81 patients. Not all were treated in the first month and only half were operated upon under six months of age. There were five deaths, including one patient who died 21 months after operation. The 15 survivors included seven cases of coarctation of the aorta,

two of pulmonary stenosis, two of ventricular septal defect, two of tricuspid atresia, one of tetralogy of Fallot and one of patent ductus arteriosus.

DISCUSSION

Observations previously reported on the type of congenital cardiac malformation in newborn infants have shown considerable differences in frequency. The difficulty of obtaining accurate information from the various methods of study has been well appreciated by the several authors. Theoretically the ideal method is prospective analysis from a nursery population, but in one institution the chances of obtaining a large enough sample in the lifetime of one group of observers is remote. Smaller numbers followed for shorter periods end in figures of dubious value. Retrospective observations of frequency based on infants undergoing autopsy in a maternity institution over a very long period of time suffer the double handicap of documentation by examiners of differing experience or interest in congenital cardiac malformation as well as excluding infants dying after being sent home or transferred to a specialized unit elsewhere because of cardiorespiratory distress. At the other extreme, the information from children's hospitals tends to overemphasize the fatal malformations which are referred early. It does not necessarily reflect the true incidence of different malformations unless the institution receives all infants in the area in cardio-respiratory distress and unless the actual mortality figures correspond with the predicted figure from the number of live births in that area. The particular interests of the cardiac unit have a considerable bearing on the number of early referrals of infants with signs of heart disease but in no distress. Calculations based on live births and neonatal deaths in the city of Toronto during the period of the present study suggest that barely 50% of the estimated number of newborn infants dying with congenital cardiac defects were examined in the Hospital for Sick Children. Further, only one infant in every six born with heart defect was actually assessed in the first month of life in the same period of time.

The chief interest in congenital malformation in the newborn period lies in those patients in whom the malformation in the natural course of events leads to death during this period. Of this particular segment, experiences from Boston,[6] Scandinavia[7] and the present series show that of those malformations responsible for two-thirds of all fatalities in the newborn period, transposition of the great vessels and ventricular septal defect occupy a prominent place, the list being completed by coarctation of the aorta, aortic atresia, pulmonary stenosis and tetralogy of Fallot. The variation occurs in the order of precedence. The only really uniform proportion in these three studies lies in the frequency of coarctation of the aorta, which occurs in between 11 and 13%. In contrast, no cases of aortic atresia were noted in the Boston series, and only 9% were noted in the Scandinavian study. In the present report it was the leading fatal malformation, accounting for almost one-quarter of the total deaths. Over the five-year period of the Toronto study there was an average of five to six per year, and since the study was closed, although the numbers with aortic atresia are a little higher each year, the proportion of the total deaths from cardiac malformation in the neonatal period has remained about the same. For example, in 1958, aortic atresia was found in 10 of 30 autopsies in newborn infants with cardiac malformation while in 1959 the corresponding numbers were 8 and 38. Although one-third of the patients at autopsy are from outside metropolitan Toronto, the revised frequency figures for the city area alone do not show any important change in the percentage of the leading malformations.

Of the conditions in infants who have signs of cardiac malformation but who survive the newborn period, ventricular septal defect appears to be the most frequent. The proportion of cases of this lesion would be even higher (32% instead of 20%) if those patients with the characteristic disappearing murmur had been included rather than placed in the group of pseudocardiopathies. There is mounting evidence that spontaneous closure of small defects of the muscular ventricular septum is responsible for the clinical picture of disappearing murmurs of this type.[8] Tetralogy of Fallot, as well, is found in an increasing proportion of the surviving patients, while pulmonary stenosis and coarctation of the aorta remain at about the same relative frequency.

Despite some variations in the frequency figures of congenital heart malformation at all ages in large hospital experiences,[9-14] a composite suggests that ventricular septal defect and patent ductus arteriosus are the most common defects, followed by atrial septal defect, tetralogy of Fallot, pulmonary stenosis and coarctation of the aorta. These six malformations account for about 75% of affected individuals.

The surviving group of newborn patients reported here represents, in a sense, a transition between the very different incidence of fatal malformations in the neonatal period and those in older patients. The survivors include a high proportion (60%) with ventricular septal defect, tetralogy of Fallot, pulmonary stenosis and coarctation of the aorta, but differ principally in having a high incidence of transposition of the great vessels and a low incidence of patent ductus arteriosus and atrial septal defect. It is interesting that in newborn infants the ductus arteriosus, while an important temporary component of the respiratory distress syndrome and a secondary malformation in a wide variety of other cardiac malformations, is not usually a serious problem as an isolated lesion. The same is true of isolated atrial septal defects.

The ultimate aim of a study of this sort is to attempt to show which major malformations are contributing to the high mortality of congenital cardiac disease in very early life as well as to indicate the differing presentation of less severe malformations in this period. It would be unrealistic to suggest that the results of this study are valid for all areas and institutions or even to claim that they are more than an approximation of the true incidence. The figures do, however, suggest that a relatively limited number of regularly recurring malformations accounts for the main problems in this age group in hospital practice. They form a basis upon which attempts by family physicians, cardiologists and surgical teams can be made to improve the present discouraging situation.

SUMMARY

Of 211 infants with congenital heart malformation who were examined during the first month of life in a children's hospital over a five-year period, 130 died during the first month and 81 survived beyond 28 days.

An additional group of 53 patients with signs initially suggesting heart disease were found on further study to have no cardiac malformation. The majority of fatalities were accounted for by aortic atresia, coarctation of the aorta, transposition of the great vessels and pulmonary atresia or stenosis with normal aortic root, in that order.

The commonest lesions in the surviving patients were ventricular septal defect, tetralogy of Fallot and transposition of the great vessels.

It is suggested that the majority of patients with heart disease presenting in the newborn period are accounted for by a relatively small number of malformations.

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RÉSUMÉ

Pendant cinq ans à l'hôpital des enfants malades de Toronto, on a examiné, au cours de leur premier mois de vie, 211 nourrissons porteurs de malformation congénitale du cœur. De ce nombre, 130 moururent avant d'atteindre la cinquième semaine et 81 survécurent au-delà de 28 jours. Après une observation plus poussée, un autre groupe de 53 enfants chez qui on avait soupçonné la présence de cardiopathie s'en avérèrent indemnes. La plupart des mortalités relevèrent des causes suivantes, en ordre d'importance: l'atrésie aortique, la coarctation de l'aorte, la transposition des gros vaisseaux avec atrésie pulmonaire ou la sténose pulmonaire avec une souche aortique normale. Chez les survivants les lésions les plus fréquentes furent les défauts de la cloison ventriculaire, la tétralogie de Fallot et la transposition—des gros vaisseaux. Il ressort de cette étude que la majorité des affections cardiaques du nouveau-né ne tiendrait qu'à un nombre relativement restreint de malformations.

DES PROTEINURIES

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I. L'ALBUMINURIE LORDOTIQUE PHYSIOLOGIQUE

NOUS AVONS observé 130 sujets sains, tous de sexe masculin, âgés de 7 à 22 ans, non porteurs d'albuminurie permanente. L'épreuve d'orthostatisme simple a permis de découvrir, parmi ces 130 sujets, six cas d'albuminurie orthostatique.

Chez les 124 autres garçons, nous avons pratiqué, après miction et absorption de 150 à 200 c.c. d'eau, l'épreuve d'hyperlordose orthostatique d'une demi-heure. A la fin de l'épreuve, le sujet urine. L'albuminurie, lorsqu'elle est découverte, est évaluée en milligrammes par minute. Seules sont naturellement retenues les albuminuries pathologiques, c'est-à-dire supérieures à 0.12 mg. par minute.

Sur les 124 sujets, la lordose orthostatique a fait apparaître l'albuminurie dans 58 cas (soit 46.7%) à des taux variant de 0.20 à 40 grammes par litre, la plupart des résultats se situant entre 2 et 10 g./l. (soit 23 cas), des taux supérieurs à 10 g. étant notés dans 10 cas. Evaluée en mg./min., cette albuminurie lordotique se situe entre 0.20 mg./min. et 1.0 mg./min. dans 22 cas, entre 1 et 5 mg./min. dans 27 cas et est supérieure à 5 mg./min. dans 9 cas (5 mg./min. représentent théoriquement une perte de 7.20 g./24 h.). La protéinurie est donc importante dans plus de la moitié des cas. L'analyse électrophorétique montre que cette protéinurie est mixte: 70 à 80% d'albumine, une faible proportion d'a_1 et β globulines, des traces d'a_2 et γ globulines.

L'étude de la répartition des cas d'albuminurie lordotique en fonction de l'âge montre une augmentation progressive du pourcentage des sujets albu-

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