Endocardial Fibroelastosis

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Although a number of reviews of endocardial fibroelastosis have been published in recent years (Hill and Reilly, 1951; Adams and Katz, 1952; Blumberg and Lyon, 1952; Dennis *et al.*, 1953; Lambert *et al.*, 1953; Halliday, 1954) there is still much doubt about the nature, the incidence, and the course of this disease. Different diagnostic criteria adopted by various authors make comparisons difficult, and most of the published reports are based on selected groups of cases. During the 15-year period from 1946 to 1962 72 cases of endocardial fibroelastosis have been recognized after death in the South-Eastern Region of Scotland, and these are analysed here against the background of all cases of congenital heart disease seen at necropsy over the same period. Throughout this period the majority of post-mortem examinations on children under 12 years of age, including newborn and stillborn infants, have been carried out by the regional paediatric pathology service. The necropsy rate has been high, of the order of 85 to 95%. This regionalization of paediatric pathology services and high necropsy rate permit a fairly comprehensive appreciation both of the particular problem of endocardial fibroelastosis and of the wider one of all forms of congenital heart disease.

Incidence

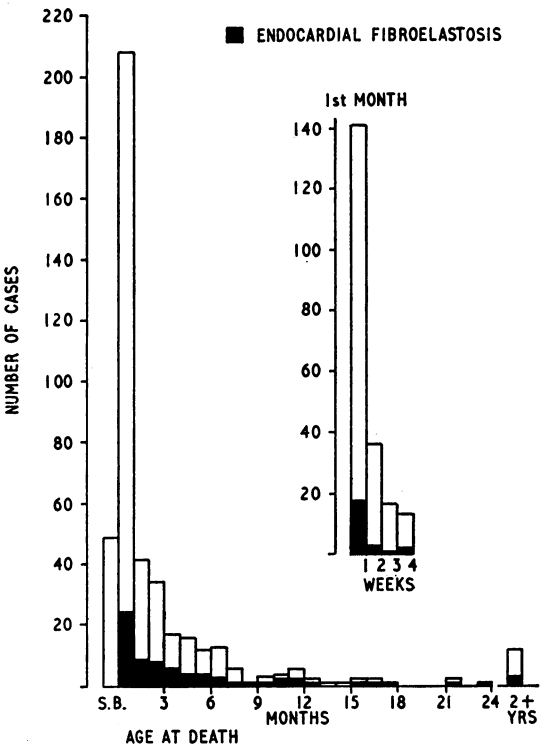
In the period under review 8,595 consecutive post-mortem examinations were carried out, including stillbirths. The incidence of congenital heart disease and of endocardial fibroelastosis among these is shown in Table I.

TABLE I.—*Necropsies, 1948–62, With Incidence of Congenital Heart Disease and Endocardial Fibroelastosis*

Necropsies		Remarks
Total necropsies	8,595	
Live-born	4,759 (55%)	
Stillborn	3,836 (45%)	
Total cases of congenital heart disease	433	5% of all necropsies
Live-born	383 (88·5%)	8% of all live-born necropsies
Stillborn	50 (11·5%)	1·3% of all stillbirth necropsies
Total cases of endocardial fibroelastosis	72	17% of all C.H.D. necropsies
Live-born	72	19% of all live-born C.H.D. necropsies
Stillborn	0	
Uncomplicated endocardial fibroelastosis	16 (22%)	4% of all live-born necropsies
Complicated endocardial fibroelastosis	56 (78%)	15% of all live-born C.H.D. necropsies

Keith *et al.* (1958) found the overall incidence of endocardial fibroelastosis in congenital heart disease to be 4%, considerably lower than our incidence of 17%. On the other hand, Andersen and Kelly (1956) found endocardial fibroelastosis in "the majority" of 237 cases of congenital heart disease. Halliday (1954) found that 7 (23%) out of 30 cases of endocardial fibroelastosis were uncomplicated by any other cardiovascular anomaly, an incidence for uncomplicated endocardial fibroelastosis similar to that which we have found (22%).

Age Incidence.—The Chart shows the age distribution of the 433 cases of congenital heart disease coming to post-mortem examination and of the 72 cases of endocardial fibroelastosis. Of all cases of congenital heart disease 11.5% were stillborn.



Age of patients at death in 433 cases of congenital heart disease (0–12 years), including 72 cases of endocardial fibroelastosis.

Of the 383 live-born infants and children with congenital heart disease, 54% of deaths occurred in the first month of life, 37% in the first week of life. Less than 2% occurred after the age of 3½ years. Endocardial fibroelastosis mortality rates according to age, for all cases, and in the complicated and uncomplicated groups are shown in Table II. Our figures agree with those given by Willis (1958), who reported that a quarter of all children with endocardial fibroelastosis die in the first week of life, half in the first four months, three-quarters in the first six months, and four-fifths in the first year.

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TABLE II.—*Percentage Mortality by Age in Endocardial Fibroelastosis*

Up to	All Cases	Uncomplicated	Complicated
1 week	24	0	30
1 month	33	0	43
2 months	47	6	59
3 „	57	31	64
6 „	78	43	88
1 year	90	75	95
2 years	96	87	98
3 „	99	94	100
4 „	100	100	—

Morbid Anatomy

The pathological diagnosis of endocardial fibroelastosis was based essentially on naked-eye recognition of abnormally thick, white or grey, and opaque endocardium. Microscopical examination was carried out in 30 cases. In the microscopical diagnosis an increase in both fibrous and elastic elements of the endocardium was required. The distribution of endocardial fibroelastosis in respect of the side of the heart and the individual chambers affected is set out in Table III for the whole group of 72 patients and contrasted with the findings of Blumberg and Lyon (1952), Dennis *et al.* (1953), and Lambert *et al.* (1953).

TABLE III.—*Distribution of Endocardial Fibroelastosis* (%)

	Present Series	Dennis *et al.* (1953)	Blumberg and Lyon (1952)	Lambert *et al.* (1953)
Left side of heart	89	—	100	—
Right „ „ „	38	—	28	—
Left side alone	63	82	—	—
Right „ „	11	2	—	—
Chambers:				
Left ventricle	86	98	96	70
Right „	38	—	24	50
Left atrium	21	—	88	43
Right „	4	—	12	36

Among all of the patients with endocardial fibroelastosis, enlargement as determined by post-mortem inspection of the heart occurred in the left ventricle in 58%, in the right ventricle in 60%, in the left atrium in 8%, and in the right atrium in 21%. In uncomplicated endocardial fibroelastosis enlargement of the left ventricle occurred more than twice as often (62%) as enlargement of the right ventricle (25%).

Enlargement was present in 60% of 107 chambers affected by endocardial fibroelastosis and in 24% of the 181 chambers not affected. In the 16 cases with no associated cardiovascular anomaly enlargement of the chamber affected by endocardial fibroelastosis was seen in 58% of instances while enlargement without endocardial fibroelastosis was seen only once in one chamber (3%). Thus endocardial fibroelastosis is often associated with enlargement of the chamber in which it occurs.

On the other hand, endocardial fibroelastosis may occur in a ventricle which is smaller than normal. This is particularly seen in the left ventricle. Edwards (1959) has classified endocardial fibroelastosis as either the dilated type, with dilated left ventricle and enlarged heart, or the contracted type, with small contracted left ventricle and dilated hypertrophied right ventricle. An abnormally small left ventricle was present in 15 of the 72 cases, and in all of these cases endocardial fibroelastosis was present in the small ventricle. These small left ventricles were usually associated with aortic atresia or stenosis. Endocardial fibroelastosis was present in one of three small right ventricles.

Endocardial fibroelastosis occurs more often in association with congenital cardiovascular anomalies than in an uncomplicated form—56 : 16 in our series. The types of associated cardiovascular lesion which occurred in the complicated cases are shown in Table IV. Thirteen had one accompanying lesion, eighteen had two, nine had three, six had four, seven had five, two had six, and one had seven. Valvular lesions occurred in 36% of the 72 cases of endocardial fibroelastosis. This compares with incidences of 34% and 51% reported by Lambert *et al.* (1953) and Dennis *et al.* (1953). Obstructive lesions of the aortic valve occurred in 25% of cases; obstructive aortic-valve lesions and coarctation or hypoplasia of the aorta occurring alone or together accounted for 40% of cases. Abnormalities of the mitral valve were seen in 11% of cases, of the pulmonary valve in 9%, and of the tricuspid valve in 4%.

TABLE IV.—*Incidence of Various Cardiac Anomalies in Cases of Congenital Heart Disease With and Without Endocardial Fibroelastosis*

Cardiovascular Anomaly	Percentage Frequency Among: Cases of E.F.E. (72)	Percentage Frequency Among: Cases of Congenital Heart Disease without E.F.E. (361)	P Value
Increased Association with Endocardial Fibroelastosis			
Small left ventricle	22·2	0·8	0·00001
Coarctation and hypoplasia of aorta	29·2	9·7	0·0001
Mitral stenosis	11·1	0·8	0·01
Aortic „	13·9	2·5	0·01
Patent ductus arteriosus	47·2	32·5	0·02
Aortic atresia	11·1	2·5	0·025
Decreased Association with Endocardial Fibroelastosis			
Ventricular septal defect	18·1	54·9	< 0·00001
Dextraposition of aorta	2·8	14·4	0·00001
Atrial septal defect	2·8	11·1	0·0003
Mitral atresia	—	3·6	0·0003
Tetralogy of Fallot	—	2·8	0·001
Persistent ostium primum	—	2·5	0·003
Transposition of great vessels	7·0	16·6	0·01
Atrio-ventriculare communis	—	1·9	0·01
Abnormal pulmonary trunk	—	1·9	0·01
Right aortic arch	—	1·7	0·01
Eisenmenger's complex	—	1·7	0·01
Absent aortic arch	—	1·4	0·02
Tricuspid atresia	1·4	5·3	0·03
Dextrocardia	—	1·1	0·04
Ebstein's anomaly	—	1·1	0·04
Abnormal superior vena cava	—	1·1	0·04
Persistent truncus arteriosus	4·2	9·7	0·05
Neither Increased Nor Decreased Association with Endocardial Fibroelastosis			
Abnormal course of great vessels	—	0·8	0·09
Single ventricle	2·8	5·8	0·15
Patent foramen ovale	12·5	18·3	0·19
Pulmonary stenosis	4·2	7·0	0·30
„ atresia	4·2	7·0	0·30
Double aortic arch	—	0·3	0·32
Anterior position of aorta	—	0·3	0·32
Tricuspid stenosis	2·8	1·4	0·49
Abnormal coronary arteries	2·8	1·7	0·59
Small right ventricle	2·8	1·7	0·59
Left superior vena cava	1·4	1·1	0·84

Other investigators have found abnormalities of the aortic valve and of the aorta to be most commonly associated with endocardial fibroelastosis. Halliday (1954) found these to be present in 43% of cases, Blumberg and Lyon (1952) in 36%, Dennis *et al.* (1953) in 38%. Dennis *et al.* recorded stenosis and cusp abnormalities of the mitral valve in 35% of cases, and Blumberg and Lyon in 24%. Most of the literature agrees that abnormalities of the pulmonary and tricuspid valves are not common in endocardial fibroelastosis, although Halliday found these valves to be abnormal in 17% and 30% of instances respectively.

Table IV set out the incidence of the various associated congenital cardiovascular abnormalities in the 72 cases of endocardial fibroelastosis and contrasts them with the incidence of these anomalies in the 361 cases of congenital heart disease in which no endocardial fibroelastosis was present. It will be seen that endocardial fibroelastosis showed an increased association with certain congenital anomalies, and a diminished association with others. The increased and diminished associations shown are statistically significant. In a third group there was neither increased nor decreased association.

Aetiology

No examples of endocardial fibroelastosis were seen in stillborn infants, but the condition was present in one infant who lived for less than 30 minutes. Death occurred in 15% of

patients within the first three days of life and 24% within the first week. In view of the short period of survival of these patients it is inconceivable that in some of them at least endocardial fibroelastosis did not occur in foetal life. Dennis *et al.* (1953) reported two cases in stillbirth, out of 149 cases. Thus endocardial fibroelastosis can occur antenatally, but does so very much less commonly than in post-natal life. Where, in our series, only one chamber was affected the average age at death was 120 days ; where two were affected it was 206 days ; where three were affected it was 300 days. Thus the longer the infant survives the more extensive is the endocardial fibroelastosis, suggesting that it is secondary to the associated congenital cardiac lesions or to some other factor, and not primary. This is in keeping with the views of Andersen and Kelly (1956) and against the concept of foetal endocarditis or a primary anomaly.

Table IV shows that endocardial fibroelastosis occurred with increased frequency in conjunction with a small left ventricle, aortic stenosis and atresia, coarctation and hypoplasia of the aorta, mitral stenosis, and patent ductus arteriosus. Thus obstructive lesions of the left side of the heart were a common factor. On the other hand, endocardial fibroelastosis occurred with diminished frequency in the presence of ventricular septal defect, dextraposition of the aorta, atrial septal defect, mitral atresia, the tetralogy of Fallot, persistent ostium primum, transposition of the great vessels, atrioventriculare communis, abnormal pulmonary trunk, right aortic arch, Eisenmenger's complex, absent aortic arch, tricuspid atresia, dextrocardia, Ebstein's anomaly, abnormal superior vena cava, and persistent truncus arteriosus. The common factor in this second group appeared to be that these lesions cause or are related to intracardiac shunts. Such shunts would appear to exercise a preventive effect against the development of endocardial fibroelastosis.

Andersen and Kelly (1956) examined the relationship of the distribution of endocardial fibroelastosis to the valve affected and concluded that endocardial fibroelastosis tended to occur in the chamber proximal to an obstructed valve. We have found this to be true for the aortic valve and for obstructive lesions of the aorta, but not at all consistent for the other valves. Obstruction *per se* did not appear, therefore, to play a uniform causative part in endocardial fibroelastosis. Stagnation of blood within a chamber may have done so, however. The small left ventricle which was so consistently complicated by endocardial fibroelastosis and which must usually have been associated with negligible blood-flow through the aortic valve suggests the likelihood of stagnation of blood in the ventricle. As a corollary many of the shunt lesions with which endocardial fibroelastosis showed a decreased association would cause an increased blood-flow within the heart. Thus increased blood-flow may reduce the likelihood of endocardial fibroelastosis, diminished blood-flow increases it.

The general effect of increased blood-flow through the heart has to be differentiated from the local effect of abnormal streams of blood. We have observed that where an abnormal jet of blood impinges on a localized area of the endocardium, endocardial fibroelastosis may develop. This has been seen, for instance, in association with a jet of blood through a ventricular septal defect, the endocardium in relation to the edge of the defect and the area of the wall of the right ventricle against which the jet impinges being involved. Others have observed this phenomenon (Andersen and Kelly, 1956). This would appear to be a local reaction to the traumatic effect of the blood. Thus trauma may be another factor in the development of endocardial fibroelastosis which may in these circumstances play a protective part.

Johnson (1952) has suggested that endocardial fibroelastosis is related to hypoxia of the endocardium following premature closure of the foramen ovale during intrauterine life. This would explain the preponderance of left-sided involvement and the common association of a small left ventricle with endocardial fibroelastosis. Intrauterine closure of the foramen ovale would, however, be likely to be associated with the more frequent development of endocardial fibroelastosis prior to birth than appears to be the case. On the other hand, in nine of our cases the foramen ovale was still patent at death, so that primary closure appears unlikely to have been a factor. Johnson (1952), however, has described a functional obstruction of the foramen ovale related to abnormal structure but associated with anatomical patency. It is suggested that such an abnormality or a stenosis occurring *in utero* might so reduce blood-flow through the foramen as to have an effect similar to complete closure.

These theories do not explain very adequately cases of endocardial fibroelastosis in which there is no other recognizable cardiac anomaly, although in such cases it is possible, as suggested by Johnson (1952), that premature closure of the foramen ovale *in utero* or stenosis of that foramen might be an aetiological factor which would not be evident after birth.

Some evidence of hereditary and familial factors was obtained in our series in that four cases (including a brother and sister) were the offspring of three mothers who were sisters. These were uncomplicated cases. Two other cases with accompanying cardiac anomalies were identical twins. Rosahn (1955) described endocardial fibroelastosis occurring in two siblings and cited two comparable cases from the literature. He suggested a recessive inheritance. Andersen and Kelly (1956) reported two instances of the familial occurrence of endocardial fibroelastosis in two siblings and in twins.

Symptomatology and Course of the Disease

The symptoms and signs associated with endocardial fibroelastosis are well established—respiratory difficulty, attacks of dyspnoea, cough, anorexia and failure to gain weight, irritability, vomiting, malaise or weakness, intermittent cyanosis, congestive cardiac failure, precordial murmurs, tachycardia.

In symptomatology our cases conformed to the recognized pattern. Intermittent or persistent breathlessness was usually the first abnormal sign and was present in all cases. Cough, wheezing, and sweating were common accompaniments even in the absence of infection. Congestive heart failure at some stage was found in 45%. Tachycardia was detected in 32 (76%) of the 42 patients who had an electrocardiogram. Two who did not have tachycardia had complete heart-block. Blood-pressure findings proved diagnostic in eight out of nine cases of coarctation of the aorta where this investigation was made. In six of these eight cases the flush method was employed, in two the auscultatory method. In 24 (43%) out of the 56 patients with associated congenital cardiac anomalies cardiac murmurs were heard, but these were probably due to the associated lesion. In only 3 (19%) of the 16 cases with no associated cardiac anomalies were murmurs heard. In general the character and situation of the murmurs proved of little value in locating the anatomical defect in the heart. For example, patency of the ductus arteriosus was diagnosed only twice in the 34 cases in which this was present, ventricular septal defect only three times in the 13 cases in which it occurred, and mitral stenosis in only one of the eight cases with this lesion.

Dennis *et al.* (1953) divided their cases into three chronological age-groups according to the time of onset of symptoms, 0–6 weeks, 6 weeks–6 months, and over 6 months. In Table V the proportions of our cases in these groups, the average ages at onset of symptoms and hospitalization, and the average course are given. In the first group 36 (72%) had some disturbance

TABLE V

Age at Onset of Symptoms	Up to 6 Weeks (50 Cases)	6 Weeks–6 Months (18 Cases)	Over 6 Months (4 Cases)
Proportion of cases	70%	25%	5%
Average age at onset of symptoms	12 days	11½ weeks	11 months
„ „ „ first visit to hospital	7 weeks	17 „	16½ „
„ course	10 „	13 „	15 „

of breathing as the presenting symptom and 23 (46%) had difficulty in feeding. The day of onset of symptoms ranged from the day of birth to the 42nd day. The diagnosis of heart disease was usually made on the patient's admission to hospital, but was considered to be complicated in about a quarter of cases by possible effects of birth trauma and in a quarter by respiratory infection. A quarter showed evidence of congestive heart failure. The course of the disease ranged from death on the day of onset of symptoms to death two and a half years later. Ten of the 50 patients in this group died within a week of onset of symptoms, five within 48 hours, and two within 24 hours. Six lived for longer than six months. Many of these patients died suddenly either with an apparent respiratory infection or for no obvious reason.

The second group, in whom first symptoms developed between 6 weeks and 6 months, showed similar presenting symptoms, but a higher proportion were in congestive heart failure than in the earlier group. Six patients (33%) died within a week of admission to hospital, three of these on the day of admission. The course of the disease in this group ranged from 1 day to 19 months.

The third group, occurring at over 6 months of age, showed a range of first onset of symptoms of from 8 to 13 months. One of these cases was admitted to hospital with an attack of unconsciousness which ultimately proved to be one of a series of Stokes–Adams seizures—one because of failure to thrive, and two because of cardiac failure associated with respiratory infection. Three of these patients survived for over a year beyond the onset of symptoms ; one died after a week.

Taking all cases and comparing those with accompanying congenital heart disease with those without it, the average age at onset of symptoms was 1 month in the former and 4 months in the latter.

Dennis *et al.* (1953) found that about a quarter of their cases fell into the 0–6 weeks age-group. The majority of these cases were fulminating, running a course of minutes or hours, and were characterized by sudden onset of breathlessness and sudden death. Approximately half their cases fell into the 6 weeks to 6 months age-group. These ran an acute course averaging 15 days and were characterized by intermittent dyspnoea followed by gradual deterioration, with recurrent cough, wheeze, loss of appetite, and poor response to treatment. The remaining quarter of their patients—over 6 months old at onset—ran a chronic course of several months marked by loss of appetite and unsatisfactory weight gain, with terminal dyspnoea and cyanosis.

Our cases thus ran a longer course than did those of Dennis *et al.* (1953) and a much higher proportion occurred within the first six weeks of life. These differences may well have been due to the fact that their patients were selected whereas ours are an unselected group and thus are more likely to reflect the true pattern of endocardial fibroelastosis. Nor did we find a striking difference in the course of the disease according to whether its onset occurred in the first six weeks of life or from the sixth week to the sixth month. We did find that the few cases occurring after six months ran a much longer course.

Radiology

Radiological examination of the chest was carried out in 52 of the 72 patients with endocardial fibroelastosis, and in 48 (93%) of them obvious cardiomegaly was present.

As regards the radiological assessment of enlargement of individual chambers compared with electrocardiographic and post-mortem assessment there was reasonable correlation—of the order of 60%—in respect of each of the ventricles, but poor correlation—less than 30%—in respect of the atria.

Others have found radiological cardiomegaly to be the rule in endocardial fibroelastosis. Both Blumberg and Lyon (1952) and Dennis *et al.* (1953) found this in 94% of cases.

Electrocardiographic Examination

The electrocardiographic changes found in 43 patients in whom adequate electrocardiography was carried out have been the subject of a special study which will be reported elsewhere. The interpretation of the E.C.G. records was based on the normal values prepared by Ziegler (1951), and the diagnostic values for ventricular hypertrophy were those laid down by Keith *et al.* (1958) and for atrial enlargement those given by Dimond *et al.* (1955), Abildskov (1959), and Riseman (1960).

By these criteria enlargement of the right atrium was present in 37% of cases and of the left in 44%. Right ventricular hypertrophy was present in 83% of patients and left ventricular hypertrophy in 54%. These figures compare with those of Vlad *et al.* (1959) of 9% for right atrial enlargement, 44% for left atrial enlargement, 30% for right ventricular hypertrophy, and 70% for left ventricular hypertrophy. The considerable difference between these figures may, in part at least, be due to the small proportion of their cases which had associated cardiac anomalies other than valvular anomalies and the high proportion of ours which had.

As has been reported by others (Vlad *et al.*, 1955 ; Dimond *et al.*, 1955 ; Apley, 1961), large P waves, depression of the RS-T segment, and inverted T waves are not infrequently found in cases of endocardial fibroelastosis. In our cases large P waves were present in 53% of cases. Depression of the RS–T segment was seen commonly in leads aVF (16%), V1–3 (21%), and V6 (30%). T-wave inversion was often encountered in leads aVF (28%) and V6 (56%).

The various conduction defects in our patients with endocardial fibroelastosis were partial heart-block (one case), complete heart-block (two cases), right partial bundle-branch block (three cases), and bundle-branch block in one of the cases with complete heart-block.

Treatment

Three main forms of treatment have been employed in endocardial fibroelastosis. Antibiotics and oxygen for the respiratory infection which is such a common accompaniment may produce considerable symptomatic improvement. Digitalis is for the prevention or relief of heart failure. Treatment with digoxin was tried in 27 of the present series of cases. In 22 of these it was given when the patient was in congestive heart failure and continued until the patient died. In the remaining five cases digoxin was prescribed earlier in the hope that it would prevent a fatal outcome, but, despite continuance of treatment, these patients also died. The duration of treatment varied from 2 days to 14 months (average 7 weeks). Response to treatment was initially good in 10 of the 22 patients in congestive heart failure and in two of the five who had no congestive heart failure, although they probably had combined left ventricular failure and bronchitis. It would in these cases be difficult to distinguish the relative parts played by digoxin and by supportive treatment with oxygen and antibiotics. Ultimately all of these patients died, some in congestive heart failure, but we would conclude that digoxin and antibiotics did prolong their lives.

Discussion

A number of differences are evident between this series of cases and certain other series, particularly in respect of age incidence, course, and electrocardiographic findings. These differences are probably related to the method of collecting cases. The largest series, that of Dennis *et al.* (1953), consisting of 149 cases from the literature, contained a great many individually selected cases and might well not represent the true overall pattern of endocardial fibroelastosis as accurately as a series of consecutive cases from a whole region. Likewise consecutive

cases from one specialized hospital, for example a children's hospital, would not reflect the true overall picture if it excluded cases occurring in maternity hospitals. The differences noted in the E.C.G. results in the present series compared with other series can also be explained to some extent on the basis of case selection.

Failure to assess endocardial fibroelastosis against a background of congenital heart disease in general may also give rise to mistaken ideas. For instance, the occurrence of a ventricular septal defect in 13 (18%) of our cases of endocardial fibroelastosis might suggest some association until we realize how common this defect is in congenital heart disease unassociated with endocardial fibroelastosis (55%).

The wide variations in the reported incidence of endocardial fibroelastosis are not difficult to understand because clear-cut diagnosis is not always possible and the determination of lesser degrees of endocardial fibroelastosis on histological grounds is so much a matter of individual opinion. We have preferred to rely on naked-eye inspection as our main diagnostic criterion. We feel that there is no doubt about the diagnosis in the cases reported here. A few doubtful cases have been excluded.

The pathogenesis of endocardial fibroelastosis remains obscure. We cannot be certain whether the disease is primary or secondary, although on the evidence we have obtained we have suggested that the latter is more likely. No theory satisfactorily explains all the manifestations of this condition, which may indeed be a response that can be stimulated in a number of different ways. Whatever theories are advanced on aetiology they must take into account a number of factors: the occurrence of the disease with and without associated congenital structural abnormalities of the heart and great vessels ; its predilection for the left side of the heart ; its particular association with left-sided obstructive lesions ; its infrequency in stillbirths and its more extensive spread the longer the patient lives ; its association in a localized way with the impingement of abnormal streams of blood against the endocardium ; its increased association at times with enlargement of the chamber involved and at other times with smallness of the chamber involved, when that is the left ventricle ; its diminished occurrence when there is increased blood-flow through the heart and its increased occurrence with stagnation of blood in a chamber ; and the hereditary factor evident in some cases.

Nor can we assess the part which endocardial fibroelastosis plays in impairing cardiac function. On the face of it, it appears to do so in uncomplicated cases. On the other hand, many of the cardiac lesions with which it is associated are themselves fatal whether endocardial fibroelastosis is present or not. The fact that the longer the patient lives the more extensive is the endocardial fibroelastosis found to be, and that abnormal jets of blood impinging on the endocardium result in the development of endocardial fibroelastosis, might be adduced as arguments that endocardial fibroelastosis is a protective reaction improving cardiac function in the presence of the other adverse factors. If endocardial fibroelastosis had occurred as commonly in the stillborn infants as in the liveborn, nine cases would have been expected among our 50 stillbirths, but no case was found. Yet we know that the condition must exist in foetal life. The majority of such cases must therefore survive to post-natal life, and it could again be postulated that the endocardial fibroelastosis has a beneficial effect in prolonging their survival. Even in uncomplicated cases it may be that it is the function of the cardiac muscle which is primarily impaired and that the endocardial fibroelastosis reduces the effect of this impairment. These suggestions are little more than speculations.

Recognition of the clinical features exhibited by severe cases of endocardial fibroelastosis in which the diagnosis is ultimately proved on post-mortem examination might be expected to improve the diagnosis in mild cases which survive. There is a growing body of opinion that such surviving cases exist. Unfortunately, in these cases absolute diagnosis is impossible. There are no incontrovertible clinical signs and no specific laboratory tests. The picture, too, is often confused or dominated by the associated cardiovascular anomaly. A number of features will, however, make the diagnosis of endocardial fibroelastosis more likely. The nature of the associated cardiac lesion, if present, is one of these. In the presence of coarctation or hypoplasia of the aorta or aortic or mitral stenosis, particularly if any of these are accompanied by patent ductus arteriosus, endocardial fibroelastosis is commonly present. Cardiac failure is common in endocardial fibroelastosis. In the absence of murmurs and in the presence of cardiomegaly failure is likely to be related to the uncomplicated type of endocardial fibroelastosis. The electrocardiograph is probably of some value in diagnosis. Although the tracing will reflect any associated cardiac anomaly and will vary accordingly, there are certain features, particularly abnormally tall P waves and abnormalities in lead aVF and lead V6 in the form of depression of the RS–T segment and inversion of the T waves, which have some degree of specificity for endocardial fibroelastosis. From the negative aspect the absence of radiological cardiomegaly and the presence of a normal E.C.G. make the diagnosis of endocardial fibroelastosis unlikely.

Summary

During the 15-year period 1948–62 433 patients with congenital heart disease died or were stillborn and were examined after death by the regional pathology service. These represented 5% of all paediatric necropsies. Thirty-seven per cent. died within the first week of life and 54% within the first month.

Seventy-two (17%) cases of congenital heart disease were found to have endocardial fibroelastosis. Sixteen of these cases were uncomplicated by any other congenital cardiac anomaly and 56 had associated congenital cardiac lesions.

Of patients with uncomplicated endocardial fibroelastosis 31% died within three months, 75% within a year ; of complicated cases 64% were fatal within three months and 95% within a year.

Endocardial fibroelastosis was present in the left side of the heart in 89% of the cases and in the right side in 38%. The ventricles were involved more often than the atria. Enlargement of the chamber in which endocardial fibroelastosis occurred was a frequent occurrence ; so too was abnormal smallness of the left ventricle when endocardial fibroelastosis occurred in it along with aortic stenosis or atresia.

There was a significantly increased association between endocardial fibroelastosis and a small left ventricle, aortic stenosis and atresia, coarctation and hypoplasia of the aorta, mitral stenosis, and patent ductus arteriosus. There was a diminished association between endocardial fibroelastosis and a number of congenital cardiac anomalies where the common factor appeared to be that they caused or were associated with intracardiac shunts.

Evidence is put forward that endocardial fibroelastosis tends to be a secondary condition commonly associated with certain cardiac lesions. Obstructive lesions of the aortic valve and aorta particularly favour its occurrence. Stagnation of blood in a chamber and local trauma to the endocardium caused by abnormal jets of blood also favour its occurrence and increased blood-flow helps to prevent it. Hereditary and familial factors appear to be involved in its transmission.

The prominent symptoms and signs were those of respiratory embarrassment and cardiac failure. Cardiac failure developed in 45% of cases.

In 70% of cases the onset of symptoms occurred in the first six weeks of life, the average time of survival between onset of symptoms and death in these cases being 10 weeks. In 25%, onset of symptoms occurred between 6 weeks and 6 months, the average survival time being 13 weeks. With onset of symptoms

after 6 months (5% of cases) the average survival time was 15 months. Treatment had some effect in prolonging the course of the disease.

On radiological examination 93% of cases showed cardiomegaly.

On electrocardiographic examination 40% of cases showed right atrial enlargement, 42% left atrial enlargement, 83% right ventricular enlargement, and 54% left ventricular enlargement.

Certain electrocardiographic changes—namely, enlargement of the P waves, RS–T depression, and T-wave inversion—are of some value in diagnosis.

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Vagotomy in the Treatment of Perforated Duodenal Ulcer

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The basic treatment for perforated duodenal ulcer has long been suture or its variant, the application of a live omental graft (Roscoe Graham, 1937). Conservative treatment for perforation (Taylor, 1957) has enjoyed only limited support despite good results in some hands; a major disadvantage is uncertainty regarding the detailed diagnosis in terms of the site of the ulcer and possible obstructive effects. Such limited treatment is life-saving in the majority of cases, although the results are less good in those patients with bleeding or pyloric stenosis; the case for adopting any more extensive operative procedure rests upon the 50% incidence of further disability in the ensuing years.

Emergency partial gastrectomy for perforation has generally been reserved in Britain for gastric ulcer and for those duodenal ulcers presenting with concomitant bleeding or pyloric stenosis as strong indications for definitive surgery. Despite several series with low mortality rates, partial gastrectomy has not found a larger place in the treatment of perforation, partly because it involves a rather extensive dissection in the presence of peritoneal contamination, and partly on account of its proportion of unfortunate sequelae both early and late (Muir, 1949; Wells, 1954; Stammers, 1955).

The introduction of vagotomy and a gastric-drainage procedure as elective treatment for duodenal ulceration (Beattie, 1950; Dragstedt, 1959; Burge and Clarke, 1959) offers a less drastic alternative in the treatment of perforated duodenal ulcer, and may justify some broadening of the indications for a definitive operation. In America Pierandozzi *et al.* (1957, 1960) and Harbrecht and Hamilton (1960) have reported their very satisfactory short-term results for selected series of duodenal perforations treated by vagotomy and pyloroplasty. We present the results of treatment of 61 perforated duodenal ulcers by vagotomy and a drainage procedure, together with follow-up studies at periods of 18 months to 4 years. The late results of a local series of duodenal perforations treated by simple suture are given for comparison.

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The Patients

The treatment of 177 patients with perforated duodenal ulcers presenting at the Leicester Royal Infirmary in 1959–63 is summarized in Table I. Sixty-one of these (52 males and 9 females) were treated by vagotomy and a drainage procedure. During this period 107 other patients with perforated duodenal ulcers were treated by simple suture. Conservative treatment for perforation was not employed, but four moribund or misdiagnosed patients were found at necropsy to have perforated duodenal ulcers. "Poor general condition" was regarded as a reason for, rather than against, surgery, so such bad-risk subjects are among those treated by simple suture.

TABLE I.—*Treatment of Perforated Duodenal Ulcers, Leicester Royal Infirmary* 1959-63

Method of Treatment	No. of Cases
Simple suture	107
Partial gastrectomy (Polya)	2
Vagotomy and antrectomy	1
Vagotomy and a drainage procedure	61
Pyloroplasty	1
Suture and gastroenterostomy	1
No operation	4

The patients were selected for vagotomy and a drainage procedure on account of a convincing history of peptic ulcer of two years or more (42 patients) or a previous perforation without other symptoms of ulcer (two patients), or, failing such a history, on the operative finding of an obviously chronic ulcer (16 patients). For one patient no such indication for a definitive operation was apparent, his history being only six months. Of the 42 patients with a "chronic" history, some