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Infective endocarditis in the grown-up congenital heart (GUCH) population

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Aims Infective endocarditis accounts for 4% of admissions to a specialized unit for grown-up congenital heart patients. This study defines lesions susceptible to infection, antecedent events, organisms, outcome and surgical treatment in a group of such patients.

Methods and results The grown-up congenital heart disease database was searched for all patients aged 13 years and above with adequate documentation of infective endocarditis retrospectively between 1983–1993 and thereafter between 1993–1996. There were 185 patients (214 episodes) divided into Group I: 128 patients unoperated or palliated and Group II: 57 patients after definitive repair and/or valve repair/replacement. In Group I, the commonest affected sites were ventricular septal defect in 31 (24%), left ventricular outflow tract in 22 (17%) and mitral valve in 17 (13%) and in Group II, left ventricular outflow tract in 20 (35%), repaired Fallot in 11 (19%), and atrioventricular defects in eight (14%). Infective endocarditis was not seen in secundum atrial septal defects before or after closure; in closed ventricular septal defects and ducts without left-sided valve abnormality; in isolated pulmonary stenosis; in unrepaired Ebstein; or after Fontan-type or Mustard operations. Surgery was performed in 39 patients: as an emergency in 17, and for failed medical therapy in 22. Only 87 (41%) of patients had a predisposing event: dental procedure or sepsis were the commonest events in Group I (33%) and cardiac surgery in Group II (50%). *Streptococci* species were found in 54% of Group I patients and in 45% of Group II. *Staphylococci aureus* was commoner in Group II (25%) compared to Group I (14%). Mean time from the onset of symptoms to diagnosis was 60 and 29 days in Groups I and II, respectively. Eight (4%) patients died as a result of septicaemia related to emergency or repeated surgery and *Staphylococcus aureus* infection. Recurrent attacks occurred in 21 (11%) patients.

Conclusion Reparative surgery does not prevent endocarditis except for closure of a ventricular septal defect and duct. Delay in diagnosis is serious since it contributes to mortality, although the overall mortality % is not high. Specific lesions are not affected so prophylaxis is probably unnecessary in those anomalies.
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Key Words: Grown-up congenital heart disease, infective endocarditis.

Introduction

Infective endocarditis is a complication of valvular and congenital heart abnormalities[1,2]. With an increasing number of patients with complex congenital heart diseases surviving to adulthood, endocarditis is now observed with greater frequency in the grown-up congenital heart population. However, there is insufficient documented experience. This study aimed to identify lesions susceptible to infection and the outcome in this special group of patients. The patients were those treated in the unit dedicated to the care of grown-up congenital heart disease patients with a referral bias towards complex lesions.

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Material and methods

The grown-up congenital heart disease database established over 18 years ago, was interrogated to identify patients with congenital heart disease, aged 13 years and above with documented episodes of infective endocarditis. Up to 1993, data were collected from retrospective reviewing of patient notes, echocardiograms and necropsy reports, and thereafter to 1996 data were prospectively collected from diseased patients. Duke criteria[3] were used for the definition of diagnosis. A total 266 suspected episodes of infective endocarditis in 234 patients were analysed. One hundred and

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Table 1 Age and gender at time of each episode of infective endocarditis in 185 patients with congenital heart diseases

Age of patients (years)	Group I episodes (female)	Group II episodes (female)
13–20	71 (38)	17 (4)
21–30	47 (23)	19 (9)
31–40	21 (13)	14 (4)
>40	16 (4)	9 (3)
Total	155 (78)	59 (20)*

*Number of males was more than females in Group II compared to Group I ($P<0·05$).

seventy-seven episodes in 151 patients were classified as definite endocarditis, with 99 (56%) showing pathological evidence at operation and/or necropsy. There were 37 (14%) episodes in 34 patients of possible infective endocarditis. Forty-nine patients with 52 (20%) episodes had to be rejected from the study because of transient septicaemia as well as rheumatic heart disease.

One hundred and eighty-five patients (214 episodes of infective endocarditis) thus formed the study group. Patients were divided into two groups according to whether or not definitive repair surgery had been performed on the main lesion. Group I (unoperated or palliated) included 128 patients (155 episodes), 25 of whom had palliative procedures, including systemic to pulmonary artery shunts or pulmonary artery banding. Group II consisted of 57 patients (59 episodes) who had had definitive repair including aortic, pulmonary, mitral and/or tricuspid valvotomy, repair or valve replacement. The following data were collected in each group: age, gender, basic anomaly, antecedent event, organisms, time between the onset of symptoms and diagnosis, surgical treatment and mortality in relation to infective endocarditis.

Statistics

The incidence of infective endocarditis in the two groups was compared using the Chi-squared test. The *P* value less than 0·05 was considered significant.

Results

Patients' age and gender are shown (Table 1); 111/185 were male, seven patients (3·8%) had had a previous episode of infective endocarditis at age 6–11 years.

Cardiac lesions

Basic cardiac lesions in the two groups are shown in Table 2. Left ventricular outflow tract lesions were the most commonly seen, occurring in 42 patients (45 episodes). In the majority, the involved site was the abnormal aortic valve, including 10 patients with a fixed subaortic stenosis (six in Group I and four in Group II) but none had a supra-aortic stenosis. Of the 20 patients in Group II, eight had an aortic homograft replacement, seven an aortic valvotomy, three a mechanical valve and two a pulmonary autograft, one of whom had infective endocarditis on the fascia lata pulmonary valve. Fifty-six episodes of infective endocarditis occurred in 47 cyanosed patients. Their basic diagnosis was Fallot in 12, pulmonary atresia with ventricular septal defect in

Table 2 Basic cardiac abnormalities in 185 patients (214) episodes of infective endocarditis

Lesions	Group I (episodes)	Group II (episodes)
Left ventricular outflow tract	22 (24)	20 (21)*
Ventricular septal defect	31 (37)	6 (6)*
Fallot (shunt 6, valvotomy 1)	12 (13)	11 (11)
Corrected transposition	11 (18)	2 (2)
Mitral valve prolapse	17 (18)	(1)†
Pulmonary atresia (shunt 7)	10 (13)	2 (2)
One ventricle (shunt 7, PA banding 1)	12 (15)	—
Classic transposition (shunt 2)	5 (9)	3 (3)
Atrioventricular defect	2 (2)	8 (8)
Coarctation	1 (1)	3 (3)
Common trunk	2 (2)	1 (1)
Infundibular pulmonary stenosis	2 (2)	—
Duct	1 (1)	—
Ebstein	—	1 (1)‡
Total	128 (155)	57 (59)

†Same patient in Group I had recurrent infective endocarditis after radical repair.
‡Replaced tricuspid valve.
*$P<0·05$.

Table 3 Pre-disposing events recorded in 87 episodes of infective endocarditis*

Pre-disposing events	Group I	Group II
Dental instrumentation	33	9
Open heart surgery	—	15
Skin infection	8	2
Cardiac catheterization	2	1 (stent)
Others†	14	3
Total	57	30

*In 127 episodes no definite pre-disposing event recorded.
†Others including post transoesophageal echocardiography, intrauterine device placing, and unusual occupations.

10, a single ventricle in 12, transposition of the great arteries in five, atrioventricular defect with pulmonary stenosis in two, common trunk in two and Eisenmenger ventricular septal defect in four. Systemic to pulmonary artery shunts (palliative procedure) were present in 22 of the 47 patients.

Predisposing events

An event likely to have caused infective endocarditis was identified in 87/214 episodes (Table 3). Previous dental treatment was the most common event in 42/87 patients, 17 of whom had undergone antibiotic prophylaxis. In Group II, 15 episodes were related to recent open heart surgery due to prolonged ICU stay and infection on an implanted homograft; one patient had 7 years of ill health after implantation of an aortic homograft and another had complex pulmonary atresia which needed repair by aortic homograft. Three patients had infective endocarditis related to cardiac catheterization: one had ballooning and stenting of a left pulmonary artery, presented as pulmonary emboli, the second with transposition of the great arteries presented with haemoptysis 2 weeks later, and the third with Fallot developed hemiparalysis at the end of procedure. Instances of infective endocarditis occurred in relation to intrauterine device placement, therapeutic abortion, and prolonged transoesophageal echocardiography, although only in a small number. Special occupations or environment were the cause of infection with strange organisms such as *Actinomycetemcomitans* in a sewer worker and a woman with *Aspergillus* infection in an aortic jet lesion who lived beneath a chronic leaking ceiling.

Organisms

Blood culture reports were available in 147 episodes; 134 were positive (Table 4). *Candida* infection was seen once on a replaced right-sided homograft after a long period in the ICU, during which time the patient received massive antibiotic therapy including treatment for methicillin resistant *Staphylococeus aureas* infection. Blood cultures were reported negative in 10 episodes in Group I and in three in Group II. Blood culture results were not filed in the patients notes in 67 episodes, but in 22 of these there was obvious evidence of infective endocarditis at operation and/or necropsy. A further 12 episodes fulfilled the criteria for clinically definite infective endocarditis with echocardiographic evidence of vegetations, abscess and/or destroyed valves. The other 33 episodes were diagnosed as possible infective endocarditis. It is suspected that many of these blood cultures were truly negative, making the true incidence of negative blood cultures in this grown-up congenital heart disease population greater than 9%. Scrutiny of patients and laboratory test suggests it was 20–23%.

Echocardiography and site of infection

The site of infection (vegetation, abscess and destroyed heart structure) was identified in 122 episodes of

Table 4 Reports of micro-organisms isolated from blood in 134 episodes*

Microorganisms	Group I No (%)	Group II No (%)	Total No (%)
Viridans streptococci	52 (61)	23 (47)	75 (56)
Staphylococcus aureus	13 (15)	13 (27)	26 (20)
Haemolytic streptococci	12 (14)	1 (2)	13 (10)
Coagulase-negative *Staphylococci*	5 (6)	3 (6)	8 (6)
Pseudomonas aeruginosa	—	4 (8)	4 (3)
Enterococci	2 (2)	—	2 (1)
Fungi	1 (1)	1 (2)	2 (1)
Coxiella burneti	1 (1)	1 (2)	2 (1)
Citrobacter	—	1 (2)	1 (1)
Actinomycetemcomitants	—	1 (2)	1 (1)
Total	86 (100)	48 (100)	134 (100)

*There were 13 episodes (10 in Group I, three in Group II). Where blood cultures were recorded as negative and in 67 episodes (59 in Group I, eight in Group II) the microorganisms were not recorded in the notes.

infective endocarditis. Transthoracic echocardiography identified 55 of the 104 scanned patients with vegetations, three with aortic root abscess and three with destruction of the aortic valve. In 43 patients there was no obvious infection site. In 32 patients studied with transoesophageal echocardiography, 13 were found to have vegetations and abscesses, six root abscesses, three destroyed valves and in 10 nothing was found to suggest infection. Eight patients with no signs of infection on transthoracic echocardiography, had obvious vegetations and/or abscess on transoesophageal echocardiography.

Delay in diagnosis

The mean time lag between onset of symptoms and clinical diagnosis of infective endocarditis was 60 and 29 days in the two groups, respectively. In 27 episodes (23 in Group I and four in Group II) the delay in diagnosis exceeded 2 months. In these, the basic diagnosis was ventricular septal defect in seven, pulmonary atresia in three, mitral valve prolapse in six, left ventricular outflow tract lesions in six, single ventricle in two, Fallot in two, and coarctation of aorta in one. The basic cardiac lesions in three patients with abnormal aortic valve and one with mitral valve prolapse were not diagnosed until they presented with heart failure and systemic emboli. In one patient with a ventricular septal defect and aortic regurgitation, infective endocarditis was not diagnosed until operation for aortic regurgitation, when perforation of a cusp was found with histological evidence of infection. Half the 27 episodes were due to *Viridans streptococci* infection, three *Haemolytic streptococci*, two with *Staphylococci aureus*, one *Staphylococci epidermidis* and eight with a negative blood culture. The negative blood culture group had had courses of antibiotics; two were misdiagnosed for arthritis, and one was delayed for 5 months until presenting with severe aortic regurgitation. In 13 patients with left-sided *Staphylococci aureus*, infective endocarditis affected the aortic valve in 10 and left atrioventricular valve in three; the mean diagnosis lag time was 13 days. In seven patients with the same organism but presenting with pulmonary emboli from infective endocarditis the diagnosis lag time was 42 days. In these seven patients, the site of infective endocarditis was on the pulmonary valve (2), the aorto-pulmonary collaterals (2), the pulmonary bifurcation site (1), the triscupid valve (1) and an open left Blalock–Taussig shunt after radial repair (1).

Recurrence

Recurrent attacks occurred in 21 (11%) patients, 19 of whom were in Group I. The site of infection was ventricular septal defect in six, congenital corrected transposition of the great arteries with ventricular septal defect and pulmonary stenosis in three, pulmonary atresia with ventricular septal defect in two, single ventricle in two, mitral valve prolapse in two, Fallot with aortic regurgitation in one, transposition of the great arteries with ventricular septal defect in one and two patients with congenital abnormal aortic valve. In Group II, only two patients had recurrent attacks; one with a Starr–Edwards aortic valve and the second with transposition of the great arteries on a right ventricular outflow tract valve (Hancock prosthesis).

Specific problems

Eisenmenger reaction

Six patients aged 21–47 years with Eisenmenger reaction had seven episodes of infective endocarditis, four with ventricular septal defect and two with truncus. In those with ventricular septal defect the vegetation was on the tricuspid valve in three and spreading to all valves in one (Fig. 1). The two patients with truncus had the infection on the truncal valve. Cerebral abscess occurred in three patients. Infection was treated by antibiotics in six patients; three were discharged with large vegetations presumed sterile with no recurrence after one year; the organisms in two were *Streptococci viridans* and unknown in three, negative blood culture in one. No death related to infective endocarditis occurred although three had transient cerebral 'events' in relation to intravenous 'neckline'.

Coarctation of aorta

Of the four patients aged 22–51 years with coarctation, one was unoperated and presented with severe coarctation and a large aneurysm distal to the site of coarctation. This could be seen on angiography after antibiotic therapy; at operation evidence of sepsis was found. The other three had repaired coarctation, one presenting with haemoptysis from a false aneurysm, and the other two with a positive blood culture for *Streptococci viridans*, but no aneurysm formation was found.

Tetralogy of Fallot

Tetralogy of Fallot was present in 12 patients in Group I: six had an aorta-to-pulmonary shunt, four with left and one with bilateral Blalock–Taussig shunt, and one with Waterston anastomosis. Infection was as suggested by recognition of vegetations on the tricuspid valve in one, the aortic valve in two and the Blalock–Taussig shunt in three. Only one patient with a closed pulmonary valvotomy and infundibular resection had two episodes of infective endocarditis at age 15 and 36 years on the right ventricular outflow tract. Two patients developed hemiplegia during an acute episode of infective endocarditis. Eleven Group II patients had 11 episodes. Infection attacked the aortic valve in three, the tricuspid valve in one with a residual ventricular septal defect, an open left Blalock–Taussig shunt in one and right ventricle to pulmonary artery homograft in one. The pulmonary valve was involved in two patients who

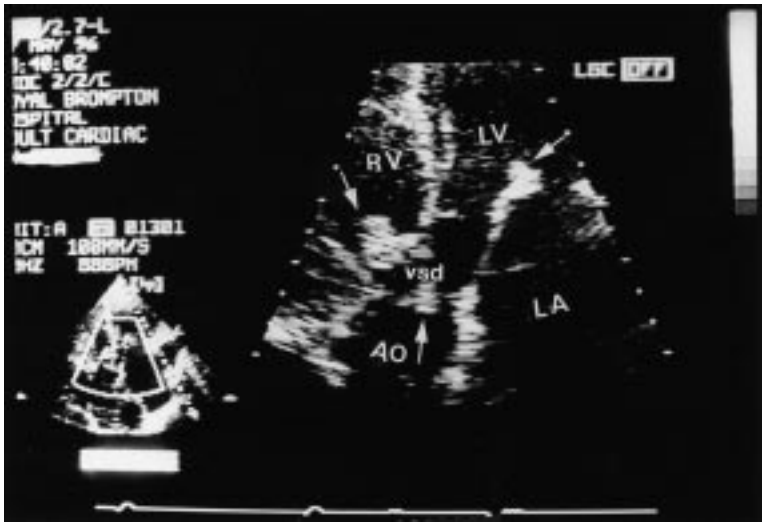

Figure 1 **2D echocardiogram. Apical five chamber view of a patient with Eisenmenger ventricular septal defect. Arrow indicates vegetation on mitral valve, aortic valve and tricuspid valve.**

had residual ventricular septal defect and infundibular stenosis. One patient had infection on a stented left pulmonary artery. The infection site was not identified in two patients. All patients were treated successfully with antibiotics. Three had surgical repair for a damaged aortic valve, pulmonary valve and aorta left ventricular fistula. One had ligation of an open shunt and another had a heart transplant for left ventricular failure from aortic regurgitation.

Corrected transposition

Thirteen patients aged 15–56 years had 20 episodes of infective endocarditis, 11 of whom were in Group I: infective endocarditis was on the left atrioventricular valve in two, the pulmonary valve in one, the jet lesion on a pulmonary bifurcation in one, and on the right atrioventricular valve in a patient with an infected pacemaker wire; in the remaining six the site of infection was unknown. Two patients in Group II had infection, one on a native and another on a previously replaced pericardial left atrioventricular valve.

Single ventricle heart

Twelve patients, two with tricuspid atresia and 10 with double inlet ventricle aged 13–40 years had 15 episodes. Eight patients had had palliative surgery, shunts in seven and pulmonary artery banding in one. The identified site of infection was the aortic valve in three, the pulmonary valve in one and the atrioventricular valve in three patients; all were treated successfully with antibiotics. Three were discharged with vegetations (two on the atrioventricular valve and one on pulmonary valve) and all progressed well with no evidence of further infection.

Right ventricle to pulmonary artery valved conduits

Five patients had six episodes of infective endocarditis on a right-side valved conduit which was a homograft in four, a Hancock in one and a fascia lata valve in one. Four patients had infection on the right ventricle to pulmonary artery homograft valves; one of them had acquired the infection at the time of implantation and another in the ICU. Both were treated successfully with antibiotics and anti-fungal therapy. Two late infections developed: one patient had *Coxiella burneti* and died from chronic heart failure and another had recurrent *Staphylococcus aureus* infection on a Hancock prosthesis and later a replaced homograft. He underwent emergency surgery for obstruction by vegetation and died at the time of reoperation. Another patient with a fascia lata pulmonary valve as part of the pulmonary autograft operation, had the infection controlled with antibiotics and the valve was replaced 5 years later.

Surgery during infective endocarditis

An operation was performed during infective endocarditis in 39 patients. In 17 (eight in Group I, nine in Group II) it was performed as an emergency within 2 weeks of admission: for sepsis in three, recurrent emboli in six and acute haemodynamic failure in eight patients. The organisms cultured were *Staphylococci aureus* in seven, *Viridans streptococci* in three, negative in two, *Pseudomonas aeruginosa* in one, *Staphylococci epidermidis* in one, *Haemolytic streptococci* in one and two with an unknown organism. The latter two patients had several pre-admission course of antibiotics. The sites of infection in these 17 patients were the aortic valve in 10, the mitral valve in four, the right ventricle to pulmonary artery homograft conduit in one, the tricuspid valve in one and in all four valves in a patient with a small ventricular septal defect whose infection was acquired at termination of pregnancy. There were two intraoperative deaths, one in the first post-operative week

Table 5 Outcome of 185 patients with endocarditis

Outcomes	Group I		Group II	
	No	%	No	%
Cured	106	83	50	88
Recurrent	19	15	2	3*
Death	3	2	5	9*
Total	128	100	57	100

*$P<0{\cdot}05$.

due to persistent sepsis and renal failure and another with ventricular septal defect who died at re-operation for tricuspid valve replacement one year later, because of uncontrolled *Staphylococci* infection.

Elective surgery was performed in 22 patients (14 in Group I and eight in Group II); before completion of an antibiotics course for persistent sepsis in five; recurrent embolic events in nine and haemodynamic deterioration in eight. Basic lesions were left ventricular outflow tract abnormality in nine, ventricular septal defect in six, mitral valve prolapse in three, Fallot in one, atrioventricular septal defect in one, pulmonary atresia in one and the last with congenitally corrected transposition of the great arteries. Eleven patients had *Streptococci*; three *Haemolytic streptococci*, two *Staphylococci aureus*, one *Aspergillus*, one negative and four unknown. No death occurred in this group.

Outcome

Patient outcomes are summarized in Table 5. Eight (4%) patients, three in Group I and five in Group II, died during acute infective endocarditis (Table 6. One patient died with *Staphylococcus aureus* endocarditis on the homograft aortic valve, four during emergency surgery and three of myocarditis, ruptured collateral and heart failure induced by mechanical aortic valve endocarditis.

Discussion

Most series of infective endocarditis included patients with both congenital and acquired heart disease[4–7]. Even though there were a few published reports concerning the incidence of infective endocarditis in the natural history of certain congenital heart diseases[8,9], it is difficult from the current literature to define the facts in relation to the grown-up congenital heart population.

In this study, the sites most frequently affected by endocarditis were left ventricular outflow tract lesions in the two patient groups, regardless of the presence or absence of previous surgery. Other cardiac lesions were

Table 6 Clinical data on the eight patients who died during endocarditis

Case no	Age (years)	Diagnosis	Previous surgery (age-years)	Site of infection	Organism	Surgery during infective endocarditis (days post diagnosis)	Cause of death
1	52	VSD	—	TV	*S. aureus*	VSD closure/ TV repair (240) TVR (630)	Heart failure
2	13	AS/AR	—	Aortic valve	*S. aureus*	AVR (M) (24) AVR (X) (55) AVR (M) (147) AVR (H) (163)	Haemorrhage
3	13	PA/VSD	—	Ao-pulm coll	*S. aureus*	—	Ruptured collateral
4	54	AS/AR/MR	AVR (X) (45) AVR/MVR (M) (53)	Aortic valve	*S. epidermidis*		Heart failure
5	26	AS/Coarc	Coarc repair (3) Ao valvotomy (8) AVR (H) (16) Redo coarc (21)	Aortic valve	*S. aureus*	—	Heart failure
6	28	PA/VSD	Modified BT shunt (11) Radical repair (15)	Right-sided conduit	*C. burneti*	—	Heart failure
7	18	AS/AR/MR	Coarc repair (3) MV annuloplasty (7) AVR/MVR (H) (17)	Aortic valve	*S. epidermidis*	AVR (H) (7)	Heart failure
8	31	TGA/VSD/PS	Modified BT shunt (3) Waterston (6) Rastelli (8) Change conduit (28)	Right-sided conduit	*S. aureus*	Change conduit (H) (14)	Haemorrhage

Ao = aorta; AR = aortic regurgitation; AS = aortic stenosis; AVR = aortic valve replacement; BT = Blalock–Taussig; Coarc = coarctation; Coll = collateral; H = homograft; M = mechanical; MV = mitral valve; MR = mitral regurgitation; MVR = mitral valve replacement; PA = pulmonary atresia; PS = pulmonary stenosis; TGA = transposition of the great arteries; TV = tricuspid valve; TVR = tricuspid valve replacement; VSD = ventricular septal defect; X = xenograft.

much less affected. This significant incidence of infective endocarditis in left ventricular outflow tract lesions is the same as that found by The Second Natural History Study (NHS-2)[2]. This suggests that infective endocarditis is twice as likely to occur after surgery for aortic stenosis as prior to it. Indeed, a similar incidence of infective endocarditis affecting the left ventricular outflow tract was found in our patients with and without previous surgery. Furthermore, the authors of that study[2] suggested that the development of aortic regurgitation and the persistence of the post-operative gradient may have contributed to the development of infective endocarditis; in this study, similar observations were found. However, even with such an agreement in the surgically related incidence it cannot be generally stated that infective endocarditis is more likely to be surgery related. On the other hand, complete closure of a ventricular septal defect, in the same study and the others[8], appeared to abolish the risk of infective endocarditis unless aortic or mitral valves were abnormal. In fact, an unoperated small ventricular septal defect was one of the commonest congenital lesions in our patients in Group I, which was of a similar incidence to that in the previous study. These findings raise the question about whether closing a small ventricular septal defect would improve prognosis. Perhaps the long-term outlook for such children and adolescents would be improved if the lifelong risk of endocarditis were removed.

Endocarditis in cyanotic congenital heart defects used to be considered unusual. However, despite a decline in the number of cyanosed patients after childhood, 47 (25%) cyanosed patients acquired infective endocarditis. In these, Fallot was the commonest cyanotic condition. After complete repair, the incidence of infective endocarditis lessens and tends to occur only with residual lesions such as regurgitant aortic valve, residual ventricular septal defect, or persistent shunt. It is exceptional to occur with residual pulmonary stenosis and/or regurgitation. Although heart surgery has helped many patients with complex cyanotic heart diseases to survive beyond childhood, it has created or left sites still prone to endocarditis, such as residual lesions, conduits, aorta-pulmonary shunts and congenital collaterals[10–13].

Infective endocarditis rarely, if ever, attacks a native right-sided pulmonary valve but is seen when it coexists with more complex anatomy. It is also rare on a replaced right ventricular outflow tract valve. Only two of the 184 patients in a personal series of right sided homografts have developed new infections. Infection at the time of implantation, though rare, is more of a hazard and diagnosis is often too late[13]. An antibiotically sterilized valve should be considered as a possible source of infection and knowledge of the donor's history can give important information, although few physicians search for it. It should be considered in patients with homografts and non-specific ill health.

In a population of 5000 grown-up congenital heart disease patients it is interesting to see the lesions which were not involved in endocarditis. There was no occurrence of infective endocarditis on pre- or post-operative secundum atrial septal defect, pulmonary valve stenosis, aorta-pulmonary defect, anomalous pulmonary venous drainage, unoperated Ebstein, closed ventricular septal defect or duct[14]. As practiced in the grown-up congenital heart disease unit, such lesions may not need prophylaxis. No infective endocarditis was detected in 100 patients with Fontan and 45 with the Mustard operation, but this is not enough evidence to advise abstaining from prophylaxis.

The antecedent event was 'found' in only 41% (87/214) episodes. This low incidence may be in part due to lack of accurate data documentation or history taking. Preceding dental procedure was the most frequent event[15] and in about half who developed infective endocarditis appropriate prophylaxis had been given, confirming that it is not always protective. There were also cases without a dental procedure but with poor dental hygiene and similar organisms were successfully cultured from the mouth and blood. This reiterates the importance of maintaining good dental hygiene in these patients.

Cardiac catheterization is infrequently associated with infective endocarditis[16]. In the two patients in whom it appeared to be a cause, one had a skin infection at the puncture area and the other had a long procedure. New techniques, such as therapeutic interventions (stent and devices), and transoesophageal echocardiography can also cause infective endocarditis[17,18]. This raises the need for antibiotics prophylaxis for such procedures. In women undergoing abortion and placement of an intrauterine device, prophylaxis is needed. Unusual occupations may lead to infection by unusual organisms. It is necessary to enquire into life-style and occupation. The laboratory should be warned of the possibility of rare organisms and a special culture technique may be required.

Open heart surgery was the most frequently related antecedent event in Group II, particularly when there was long stay in ITU. Intravenous therapy, especially via a central intravenous catheter, and urinary tract instrumentation were the most frequent causative events, with a high incidence of *Staphylococcus aureus* infection in these patients. *Candida* endocarditis can occur in patients receiving long-term intravenous antibiotics and is difficult to diagnose from cultures; antibody titre may be needed.

Echocardiography is important in identifying the site of infection. Transthoracic echocardiography had a positive finding in 59% of our series of patients (61/104), slightly less than other reports[19,20]. This is probably because the majority of our patients were young adults with congenital heart diseases who often have poor echo windows, particularly the anterior structure. Transoesophageal echocardiography is indicated in most patients as it often yields important data[21–24], but should not be performed if a patient is very hypoxic or toxic. Vegetation and/or abscess formation were found with transoesophageal echocardiography in eight of our patients who had negative transthoracic echocardiography findings. However, infection outside the heart, such

as on shunts, collaterals and conduits are difficult to demonstrate by any method. Negative echocardiographic findings do not mean one can exclude the possibility. Magnetic resonance imaging is another useful and reliable technique for diagnosing false aneurysms and the collection of pus around vessels but not for vegetation. If a false aneurysm is suspected, particularly in coarctation, transoesophageal echocardiography is contra-indicated, in our view, because the possible rise in blood pressure which could occur with intubation may cause rupture of the aneurysm. In this case magnetic resonance imaging is superior.

The delay in diagnosis in this series was a lamentable reflection on medical practice. General practitioners and unspecialized hospitals are mainly responsible. One can understand how this happens with many patients to see and a heavy work load. Overlooking the possibility of endocarditis, as well as provision of random antibiotics in these high risk patients is clinically undesirable. Education for patients and doctors is required. Not only must the risk of infective endocarditis be spelt out, but also the need not to delay or suppress diagnosis. The difficulty of isolating unusual organisms and sub-clinical presentation are all contributing to the delay in diagnosis. In our patients there was less delay with *Staphylococci aureus* endocarditis, but days and even hours matter in this situation, and who would be responsible for death by delay. We believe it is important to involve surgeons early in management and preferably before an emergency occurs. Surgery should probably be performed earlier in order to prevent important embolic events and reduce mortality[25,26].

Overall the outcome was good in our patients and would be better if doctors dealing with this group at high risk for endocarditis were more alert to possible complications. The mortality we documented was as low as 4%, which was higher in Group II than Group I and mostly related to recurrent surgery, as previously discussed.

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