CONGENITAL HEART DISEASE

Pericardial effusion after open heart surgery for congenital heart disease

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Objectives: To determine the prevalence and time course of pericardial effusion after open heart surgery for congenital heart diseases and to identify predisposing risk factors.
Design and patients: Prospective assessment of development of pericardial effusion in 336 patients (163 males) undergoing open heart surgery for congenital heart disease by serial echocardiography on days 5, 7, 14, 21, and 28 postoperatively.
Setting: Tertiary paediatric cardiac centre.
Results: The prevalence of pericardial effusion was 23% (77 of 336). Of the 77 patients who developed effusion, 43 (56%) had moderate to large effusions and 18 (23%) were symptomatic. Patients who had a large amount of effusion were more likely to be symptomatic than those with only a small to moderate amount (47.4% *v* 15.5%, p = 0.01). The mean (SD) onset of pericardial effusion was 11 (7) days after surgery, with 97% (75 of 77) of cases being diagnosed on or before day 28 after surgery. The prevalence of effusion after Fontan-type procedures (60%, 6 of 10) was significantly higher than that after other types of cardiac surgery: repair of left to right shunts (22.1%, 43 of 195), repair of lesions with right ventricular outflow tract obstruction (22.6%, 19 of 84), arterial switch operation (6.7%, 1 of 15), and miscellaneous procedures (25%, 8 of 32) (p = 0.037). Univariate analyses showed that female patients (p = 0.009) and those receiving warfarin (p = 0.002) had increased risk of postoperative pericardial effusion. A greater pericardial drain output in the first four hours after surgery also tended to be significant (p = 0.056). Multivariate logistic regression similarly identified warfarin treatment (β = 1.73, p = 0.009) and female sex (β for male = –0.63, p = 0.037) as significant determinants.
Conclusions: Pericardial effusion occurs commonly after open heart surgery for congenital heart disease. Serial echocardiographic monitoring up to 28 days postoperatively is indicated in selected high risk patients such as those with symptoms of postpericardiotomy syndrome and those given warfarin.

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Pericardial effusion occurs commonly after open heart surgery and contributes to postoperative morbidity and mortality.[1–5] Nonetheless, data on its prevalence and time course after surgery for congenital heart disease are limited.[6 7] Furthermore, risk factors that predispose to its development in children and teenagers with congenital heart disease after undergoing open heart surgery remain unknown. In this study, we sought to determine the prevalence and time course of pericardial effusion after different types of open heart surgery for congenital heart disease and, in light of the findings, to identify significant predisposing risk factors.

PATIENTS AND METHODS

A total of 359 children and teenagers who underwent open heart surgery for congenital heart disease between 1996 and 2001 were recruited. Serial two dimensional echocardiography was performed on days 5, 7, 14, 21, and 28 postoperatively using a Hewlett-Packard ultrasound machine (Sonos 1500 or 5500) to assess development of pericardial effusion. Pericardial effusion was assessed in the standard parasternal short axis, long axis, apical four chamber, and subcostal views. The amount of pericardial effusion was graded according to the ratio of maximum separation between pericardium and epicardium at diastole to aortic root size as small ($\leqslant 0.33$), moderate (> 0.33 to $\leqslant 0.67$,) or large (> 0.67). The location of the perfusion was described as circumferential or loculated.

The following data were collected: demographic data, cardiac diagnoses, types of surgery performed, pericardial drain output within the first 48 hours of operation, reoperation for haemostasis, timing of pericardial drain removal, postoperative use of anticoagulant and diuretics, and occurrence of pericardial effusion. In patients who developed pericardial effusion, the timing of onset and duration of effusion, their clinical presentation, and the treatments received were noted.

Data are expressed as mean (SD) unless otherwise stated. The demographic, clinical, and perioperative variables between patients who developed pericardial effusion and those who did not were compared using unpaired Student's *t* test, Mann Whitney U test, Fisher's exact test, or χ^2 test where appropriate. Logistic regression was used to identify risk factors predisposing to development of pericardial effusion. Variables as described above were entered into the multivariate model. A probability value of $p < 0.05$ was considered significant. All statistical analyses were performed using SPSS version 10.0 (SPSS, Inc, Chicago, Illinois, USA).

RESULTS

Of the 359 patients recruited, 23 did not survive the cardiac surgery. The remaining 336 patients (163 males) were included in the final analysis, 102 (30%) of whom had cyanotic congenital heart disease. Cardiac surgery was performed at a median age of 1.7 years (range 1 day to 22.3 years) and a median weight of 10 kg (range 2.2–66 kg). The operations performed were categorised into firstly, repair of left to right shunts (n = 195); secondly, repair of lesions with right ventricular outflow tract obstruction (tetralogy of Fallot with or without pulmonary atresia, ventricular septal defect with infundibular pulmonary stenosis) (n = 84); thirdly, arterial switch operation for transposition of the great arteries

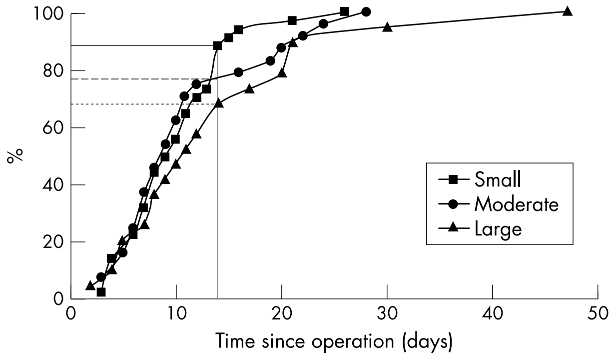

Figure 1 Cumulative percentage of patients who developed pericardial effusion versus the time of onset.

(n = 15); fourthly, Fontan-type procedures (n = 10); and fifthly, miscellaneous procedures including correction of anomalous pulmonary venous drainage, prosthetic valve replacement, repair of left ventricular outflow obstruction, Ross procedure, and Norwood stage I operation (n = 32).

Seventy seven of the 336 (23%) patients developed pericardial effusion postoperatively. The amount of effusion was small in 34, moderate in 24, and large in 19 patients. The effusion was already circumferential in 55 of 77 (71%) at first presentation. Its onset was at 11 (7) days after surgery. Overall, the diagnosis was made on or before day 14 and day 28 after surgery in 79% (61 of 77) and 97% (75 of 77) of patients who developed effusion, respectively. Importantly, 12% (4 of 34), 25% (6 of 24), and 32% (6 of 19) of patients with, respectively, small, moderate, and large amounts of effusion presented beyond the second week after operation (fig 1).

Clinical symptoms or signs were present in only 18 (23%) patients. These were fever in 10 patients, gastrointestinal disturbance such as vomiting or abdominal discomfort in two, signs of fluid retention in three, irritability in two, and evidence of tamponade in one. Patients who had a large amount of effusion were more likely to be symptomatic than those with only a small to moderate amount (47.4% *v* 15.5%, p = 0.01). Likewise, patients with circumferential effusion tended to be more symptomatic than those with loculated effusion (29.7% *v* 9.0%, p = 0.077).

Conservative treatment with fluid restriction and diuretic treatment in 44 (57%) patients with a small to moderate amount of effusion resulted in resolution in all of these patients. Anti-inflammatory medications were started in 21 patients (27%) who, albeit asymptomatic, had a moderate amount of effusion with evidence of progression. Aspirin was prescribed to seven patients and steroid was given to 14. Eighteen patients responded, while three eventually required pericardiocentesis. Pericardiocentesis, either by a surgical or a percutaneous approach, as the initial treatment was performed in 12 (16%) symptomatic patients with a large amount of effusion. The median duration for effusion to resolve completely was eight days (range 1–394 days), with complete resolution achieved in 83% (64 of 77) of patients within four weeks of diagnosis.

Table 1 summarises the demographic, clinical, and perioperative variables of patients with and without pericardial effusion. Significantly more female (28.9%) than male (16.6%) patients developed pericardial effusion (p = 0.009), with a relative risk of 2.05 (95% confidence interval (CI) 1.2 to 3.5). The prevalence of pericardial effusion after Fontan-type procedures (60%) was significantly higher than that after other types of surgery (p = 0.037) (fig 2). Furthermore, pericardial effusions that developed after a Fontan-type procedures were at least moderate to large. Postoperatively, a greater pericardial drain output within the first four hours tended to be associated with a higher risk of developing later effusion (p = 0.056). Warfarin, given to 18 patients who had undergone valve replacement (n = 8), Fontan-type procedures (n = 6), and patch repair of an atrial septal defect (n = 4), also conferred a significant risk of developing a pericardial effusion (relative risk 4.48, 95% CI 1.78 to 12.33, p = 0.002). Logistic regression similarly identified sex (β for male = –0.63, p = 0.037) and warfarin (β = 1.73, p = 0.009) as significant determinants. Nonetheless, it is important to note that in this cohort, warfarin was started in significantly more female than male patients (8.7% *v* 1.8%, p = 0.007). Furthermore, patients who had undergone arterial switch operation, which had the lowest incidence of pericardial effusion, were mostly male (73.3% *v* 26.7%, p = 0.068).

Table 1 Comparisons of demographic, clinical, and perioperative variables between patients with and without development of pericardial effusion

Variable	Effusion present (n=77)	Effusion absent (n=259)	p Value
Median age (years)	2.3	1.7	0.60
Range	0.02–20.1	0–22.3	
Weight (kg)	14.83 (13.8)	14.35 (12.9)	0.79
Sex (male:female)	27:50	136:123	0.009*
Cyanotic:acyanotic	24:53	78:181	0.89
Previous cardiac surgery	11 (14.3%)	38 (14.7%)	1.00
Types of operation			
Left to right shunt repair	43/195 (22.1%)	152/195 (77.9%)	0.037*
RVOT surgery	19/84 (22.6%)	65/84 (77.4%)	
Arterial switch operation	1/15 (6.7%)	14/15 (93.3%)	
Fontan procedure	6/10 (60%)	4/10 (40%)	
Miscellaneous	8/32 (25%)	24/32 (75%)	
Reoperation for haemostasis	3 (3.9%)	3 (1.2%)	0.13
Pericardial drain removal (days post surgery)	2.2 (1.2)	2.1 (1.4)	0.36
Median first 4 hour total drain output (ml)	60	50	0.056
Range	15–1550	0–620	
Median average hourly drain output on operation day (ml/h)	5.8	5.6	0.47
Range	2–101	0–57	
Median average hourly drain output on day 1 postoperation (ml/h)	1.7	1.7	0.98
Range	0–21	0–11	
Warfarin	10 (13%)	8 (3%)	0.002*
Diuretic	69 (90%)	210 (81%)	0.17

*Significant.
RVOT, right ventricular outflow tract.

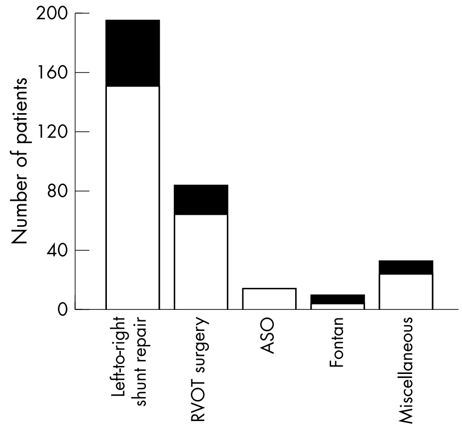

Figure 2 Prevalence of pericardial effusion after open heart surgery for different types of congenital heart disease. Solid areas represent patients who developed pericardial effusion. ASO, arterial switch operation; RVOT, right ventricular outflow tract.

DISCUSSION

The prevalence of pericardial effusion after open heart surgery has been reported to range from 53–85% in earlier studies.[2–6] However, recent studies in both adults and children suggested a decrease in prevalence. Yip and colleagues[8] reported a 16% prevalence in 339 adults undergoing surgical repair of atrial septal defect, while Prabhu and associates[7] reported a 13.6% prevalence in 212 children and teenagers undergoing surgery for congenital heart disease. Our study similarly shows, in a large of cohort of patients, a relatively lower prevalence of pericardial effusion, which has been attributed to improved surgical and anaesthetic techniques, myocardial protection, and improved postoperative haemodynamics.[7] Additionally, our study describes the evolution of the development of pericardial effusion. While pericardial effusion can be detected within the first two weeks of surgery in the majority (79%) of patients, 21% of cases would have been missed if routine echocardiographic screening had been confined to this time period. Interestingly, our finding suggests that pericardial effusion that eventually becomes moderate to large in amount tends to present later.

Symptoms were present in only slightly more than a fifth of our patients who developed pericardial effusion and these symptoms were mostly non-specific. This is in contrast to the findings of Clapp and colleagues,[5] who reported that 16 of 21 children with postoperative effusion developed clinical evidence of postpericardiotomy syndrome. The apparent discrepancy may be because serial echocardiographic assessment allows for early diagnosis and institution of anti-inflammatory treatment before appearance of symptoms. Nonetheless, the presence of symptoms may have important implications, as symptomatic patients were more likely to have a more severe degree of pericardial effusion and hence to be at risk of haemodynamic compromise in the absence of interventions. Close monitoring and early institution of anti-inflammatory treatment are therefore warranted in symptomatic patients.

Data on the efficacy of anti-inflammatory treatment for postpericardiotomy syndrome in children are, however, limited. While aspirin has been widely used, the reports were largely anecdotal[6] and, to date, there have been no controlled trials on the efficacy of non-steroidal anti-inflammatory agents. Prophylactic use of aspirin, on the other hand, has been shown to have no significant benefit in the prevention of postoperative pericardial effusion in children.[6] In a double blind placebo controlled trial of steroid in a small cohort of children with postpericardiotomy syndrome, Wilson and colleagues[9] have shown that steroid hastens the remission in the majority, although two of their 12 patients had a further increase in the amount of effusion despite steroid administration. Likewise, only three of our 21 (14%) patients failed to respond to anti-inflammatory treatment. A trial of anti-inflammatory treatment is hence justified in patients with moderate and increasing amounts of pericardial effusion before contemplation of the more invasive pericardiocentesis.

To our knowledge, this is the first study to examine risk factors predisposing to development of pericardial effusion after open heart surgery for congenital heart disease. While Prabhu and colleagues[7] suggested a higher incidence of effusion incidence after Ross procedure, the number of patients included in their studied was too small to be significant. We found that pericardial effusion occurred more commonly after Fontan-type procedures. On the other hand, infants, mostly boys, undergoing arterial switch operation for transposition of the great arteries had the lowest incidence. Similar to the findings of Stevenson and colleagues,[3] a greater pericardial drain output early postoperation tended to be associated with an increased likelihood of pericardial effusion. It has been proposed that the increased amount of blood accumulated may irritate the pericardium through a hydrophilic action.[10 11] Multivariate analysis showed that postoperative warfarin is a significant risk factor after adjustment of other variables. This finding corroborates those reported in the adult literature.[2 12 13] Warfarin given routinely after Fontan-type procedures probably explains in part the observed higher incidence of pericardial effusion after this operation. The findings that more of our patients taking warfarin were female and that most undergoing arterial switch operation were male may explain the significance of sex in determining the occurrence of pericardial effusion in this cohort. Interestingly, however, female adult patients have been shown to be at higher risk for development of early postoperative cardiac tamponade after open heart surgery in a recent study.[14] While the explanation remains unclear, female sex may indeed be an independent risk factor, even after adjustment for confounding influence.

On the basis of our findings, we recommend serial echocardiography up to 28 days after open heart surgery for congenital heart disease in selected at-risk patients, namely those with symptoms suggestive of postpericardiotomy syndrome and those receiving warfarin.

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IMAGES IN CARDIOLOGY

Pacemaker lead fracture

A 47 year old man with congenital heart block had a permanent DDD pacemaker implanted at the age of 25 years. Six months ago he had a battery change in the right infraclavicular region, which was his seventh box change. The pacemaker check recently undertaken showed satisfactory pacemaker function. On the day of admission he went to have a meal on his son's birthday. As he was stretching his right arm to lift a heavy plate he had a funny sensation in his right arm. Then he noticed that he felt very dizzy and was about to pass out each time he abducted his right arm to have a meal. He came to hospital with his right arm tightly adducted to the chest wall.

A chest *x* ray revealed partial fracture in the ventricular lead, hence it was losing electrical contact during arm abduction. The patient was taken to the catheter laboratory and a new ventricular lead and battery was implanted. This cured his problem and he went home with an asymptomatic handshake!

Lead fracture of a permanent pacemaker is a recognised complication but this sort of dramatic presentation is rare.

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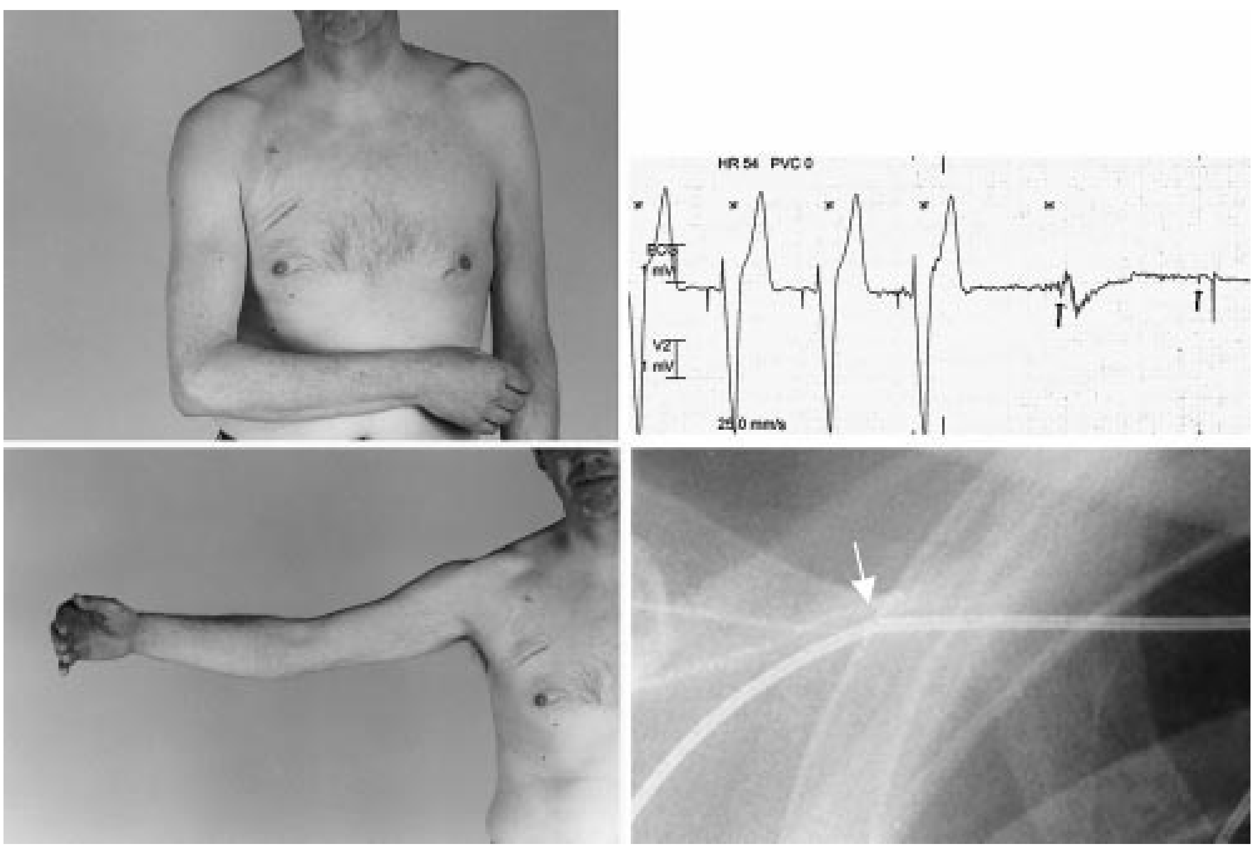

IMAGES IN CARDIOLOGY

Femoral vein delivery of contrast improves transoesophageal detection of intracardiac shunting through a patent foramen ovale

A 33 year old woman on the oral contraceptive pill was investigated after suffering a transient ischaemic attack. On transthoracic echocardiogram her interatrial septum was mobile but not aneurysmal. On transoesophageal echocardiography there was no clear anatomical evidence of a septal defect or patent foramen ovale (PFO). Several agitated saline contrast studies via the right cephalic vein failed to show any evidence of an intracardiac shunt both with and without a Valsalva manoeuvre (below left). This was then repeated via a right femoral vein 5 French sheath and there was notable and immediate passage of contrast into the left atrium, even without a Valsalva manoeuvre (below right).

Paradoxical embolus via a PFO is a potential cause of cerebrovascular events in a young patient. Diagnostic methods include transthoracic and transoesophageal echocardiography with colour Doppler and agitated saline contrast studies. Sensitivity may be further enhanced by cough and the Valsalva manoeuvre. Transcranial Doppler of the middle cerebral artery may also be used. Inferior vena caval flow is preferentially towards the interatrial septum and foramen ovale while the crista interveniens directs superior vena cava flow away from the interatrial septum. Thus, because of this "streaming" effect, femoral vein delivery of agitated saline contrast may be superior to the antecubital route for detection of transient right to left shunting through a PFO.

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