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Original Article

Thrombotic events in critically ill children with myocarditis

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Abstract *Background:* Children with myocarditis have multiple risk factors for thrombotic events, yet the role of antithrombotic therapy is unclear in this population. We hypothesised that thrombotic events in critically ill children with myocarditis are common and that children with myocarditis are at higher risk for thrombotic events than children with non-inflammatory dilated cardiomyopathy. *Methods:* This is a retrospective chart review of all children presenting to a single centre cardiac intensive care unit with myocarditis from 1995 to 2008. A comparison group of children with dilated cardiomyopathy was also examined. Antithrombotic regimens were recorded. The primary outcome of thrombotic events included intracardiac clots and any thromboembolic events. *Results:* Out of 45 cases with myocarditis, 40% were biopsy-proven, 24% viral polymerase chain reaction-supported, and 36% diagnosed based on high clinical suspicion. There were two (4.4%) thrombotic events in the myocarditis group and three (6.7%) in the dilated cardiomyopathy group ($p = 1.0$). Neither the use of any antiplatelet or anticoagulation therapy, use of intravenous immune globulin, presence of any arrhythmia, nor need for mechanical circulatory support were predictive of thrombotic events in the myocarditis, dilated cardiomyopathy, or combined groups. *Conclusions:* Thrombotic events in critically ill children with myocarditis and dilated cardiomyopathy occurred in 6% of the combined cohort. There was no difference in thrombotic events between inflammatory and non-inflammatory cardiomyopathy groups, suggesting that the decision to use antithrombotic prophylaxis should be based on factors other than the underlying aetiology of a child's acute decompensated heart failure.

Keywords: Anticoagulation; cardiomyopathy; myocarditis; stroke

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THE RISK OF THROMBOTIC EVENTS IN CHILDREN with myocarditis is currently unknown, leading to uncertainty regarding the need for antithrombotic therapy. Some studies in children with dilated cardiomyopathy suggest that those with severely diminished or rapidly deteriorating ventricular function are at increased risk of thrombus formation.[1,2] Kuhn et al published a retrospective study of 28 children with myocarditis and reported that

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10.7% experienced intracardiac thrombosis.[3] Embolic arterial ischaemic stroke has also been reported as a complication of myocarditis.[4] No large prospective paediatric cohort studies have been published that examine the risk for thrombotic events in myocarditis. Several factors place children with myocarditis at increased risk of thrombus formation, including stasis of blood in a poorly functioning heart, and inflammation of the myocardium and surrounding structures. Myocarditis mouse models and human ex vivo studies have demonstrated a hypercoagulable state secondary to increased myocardial expression of tissue factor that leads to activation of coagulation.[5]

The risk of thrombus formation in adults with myocarditis is similarly unknown. There is evidence that anticoagulant or antiplatelet therapy reduces the risk of stroke in adults with ventricular dysfunction after myocardial infarction.[6] In particular, the first 2 weeks after myocardial infarction, presumably a time of increased myocardial inflammation, carry a stroke risk of up to 4.7%.[7] In children, inflammation of the heart that occurs in the setting of myocarditis could add to the risk of in situ thrombus formation in much the same way as it does in adults after myocardial infarction.

We therefore hypothesised that thrombotic events in critically ill children with myocarditis are common and that children with myocarditis are at higher risk for thrombotic events than children with non-inflammatory dilated cardiomyopathy. From a single institution, we compared the incidence of thrombotic events in critically ill children with myocarditis versus critically ill children with a non-inflammatory dilated cardiomyopathy.

Materials and methods

The study protocol was approved by the Institutional Review Board.

We performed a retrospective cohort study of all patients admitted to a single tertiary care centre paediatric cardiac intensive care unit with newly diagnosed myocarditis between January 1, 1995 and December 31, 2008, and compared them with a group with newly diagnosed non-inflammatory, dilated cardiomyopathy. The dilated cardiomyopathy comparison group was identified in reverse chronological order, starting from an admission date on or before December 31, 2008 and continuing until the same number of patients was reviewed for each study group. For patients with multiple cardiac intensive care unit admissions, we only included data from the first myocarditis or dilated cardiomyopathy admission, and excluded data from subsequent admissions. All patients were initially identified by searching for "myocarditis" or "dilated cardiomyopathy" in the primary diagnosis field of our centre's cardiac intensive care unit patient database, which captures all admissions to the cardiac intensive care unit with basic demographic, diagnostic, and outcome information during the study time frame.

Our study defined the myocarditis cohort as those patients who had an admission diagnosis of myocarditis and were subsequently treated as having myocarditis. At our centre, myocarditis is routinely treated with intravenous immune globulin unless otherwise contraindicated. Supportive measures are provided as needed, including mechanical ventilation, inotropic support and mechanical circulatory support including extracorporeal membrane oxygenation and ventricular assist device implantation.

Those in the myocarditis group were classified into one of three categories:

- Biopsy-proven: Pathologic confirmation of myocarditis obtained by autopsy, explant or endomyocardial biopsy. Those with "borderline myocarditis" on a pathology report alone did not qualify as "biopsy-proven".
- Viral polymerase chain reaction-supported: One or more positive viral polymerase chain reactions that were considered to be a plausible cause for their myocarditis by the treating clinicians. These patients did not also meet criteria for biopsy-proven myocarditis.
- High clinical suspicion: Patient admitted with suspicion for myocarditis, treated as such, and discharged with the same presumed diagnosis, despite the lack of biopsy or viral polymerase chain reaction evidence.

Dilated cardiomyopathy patients were those with symptomatic left ventricular dysfunction and dilation who did not meet criteria for myocarditis as defined above. Left ventricular dysfunction was determined by a depressed ejection fraction ($<55\%$) or shortening fraction ($<29\%$) by echocardiogram. Left ventricular dilation was determined by a left ventricular end-diastolic dimension z score > 2.[8] The cases with primary hypertrophic, primary restrictive or left ventricular non-compaction cardiomyopathy were excluded, even if they had dilated features, as these conditions may have a different thrombotic risk profile than dilated cardiomyopathy alone.[9–11]

Patients were excluded if their initial cardiac intensive care unit admission for myocarditis or dilated cardiomyopathy was outside of the study period or if they were ≥ 18 years of age at the time of admission. Those with congenital heart disease were excluded. These cases included, but were not limited to, coronary anomalies, unrepaired atrial septal defect, unrepaired ventricular septal defect,

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hypoplastic left heart syndrome, transposition of the great arteries, tetralogy of Fallot and atrioventricular canal defect. All charts were systematically reviewed by two physicians, including relevant admission and discharge summaries, progress notes, laboratory studies, pathology reports, echocardiogram reports, operative reports, medication orders, brain magnetic resonance imaging and computed tomography scan reports, and ultrasound reports. Of note, as this was a retrospective study, the use of each imaging modality was prompted by clinical concerns and was thus not uniform for every patient.

Our primary outcome of thrombotic event included identification of intracardiac clots or embolic ischaemic injury to the brain, kidneys, spleen, liver or distal extremities. Any thrombotic event was confirmed by review by a cardiologist (for intracardiac clots), neurologist (for cardioembolic strokes), or haematologist (for any other embolic phenomena). Cardioembolic stroke was defined as an acute neurologic deficit conforming to a vascular territory and confirmed by the presence of a corresponding arterial-distribution acute infarct on neuroimaging – head computed tomography or brain magnetic resonance imaging. In infants <6 months, where acute focal deficits are unreliable as the presenting symptom, stroke was defined as an acute neurologic syndrome manifest as new onset of depressed mental status and/or seizures associated with arterial-distribution acute infarct on neuroimaging – head computed tomography or brain magnetic resonance imaging. Line-associated thrombi were not included as thrombotic events for purposes of this study. Thrombotic events were only included for analysis if they occurred before initiation of any mechanical circulatory support – that is, extracorporeal membrane oxygenation or ventricular assist device – because of increased thrombotic risks related to the device. In those who went on to heart transplantation, thrombotic events were only included if they occurred before transplantation.

Statistical analysis was performed using Microsoft Excel 2007 and SAS version 9.2 (SAS, Cary, North Carolina, United States of America). Continuous variables were compared using t-tests for normally distributed data, and Wilcoxon's rank sum tests for non-parametric data. Categorical variables were compared using the non-parametric Fisher's exact test. A two-sided probability value of ≤ 0.05 was considered statistically significant.

Results

We identified 45 patients with myocarditis within the study period. A summary of patient characteristics is shown in Table 1. The myocarditis group consisted of 40% biopsy-proven, 24% supported by viral polymerase chain reaction and 36% high clinical suspicion cases. Of those with biopsy-proven or viral polymerase chain reaction-supported myocarditis (n = 29), the most common viruses identified were parvovirus B19 (n = 8) and enterovirus (n = 3). In addition, there were single cases of adenovirus, herpes simplex virus, influenza B and rhinovirus. There was one child who had both parvovirus and human herpesvirus 6 identified in her serum; another had cytomegalovirus (serum and respiratory), parvovirus B19 (respiratory), and rhinovirus (respiratory). The comparison group included 45 newly diagnosed dilated cardiomyopathy cases during the study period. These patients were admitted between July 10, 1995 and December 31, 2008. Arrhythmias that occurred at any time during the hospitalisation were identified on review of the discharge summary and electrocardiograms. These included ventricular tachycardia or fibrillation (n = 19, myocarditis and n = 13, dilated cardiomyopathy), atrial fibrillation (n = 3, myocarditis and

Table 1. Comparison of myocarditis and DCM groups.

Demographics	Myocarditis (n = 45)	DCM (n = 45)	p-value
Male sex	18 (40%)	27 (60%)	0.09
Age (years)	1.7 (IQR 0.9–11.5)	5.9 (IQR 0.5–14.0)	0.57
ECMO	12 (27%)	5 (11%)	0.10
VAD	1 (2%)	9 (20%)	0.02
CPR	13 (29%)	4 (9%)	0.03
IVIG	43 (96%)	14 (31%)	<0.01
Any arrhythmia	26 (58%)	18 (40%)	0.14
SF by TTE on admission	17.9 ± 9	13.1 ± 6	<0.01
LVEDD z score on admission	2.58 ± 2.2	5.05 ± 2.4	<0.01
Length of ICU stay (days)	10 (IQR 5–19)	11 (IQR 5–51)	0.23

CPR = cardiopulmonary resuscitation; DCM = dilated cardiomyopathy; ECMO = extracorporeal membrane oxygenation; ICU = intensive care unit; IQR = interquartile range; IVIG = intravenous immune globulin; LVEDD = left ventricular end-diastolic dimension; SF = shortening fraction; TTE = transthoracic echocardiogram; VAD = ventricular assist device

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Table 2. Antithrombotic regimens employed in myocarditis and DCM groups.

	n (%)					
				Time to initiation (days)		
Therapy	Myocarditis (total, n = 45; non-MCS, n = 33)	DCM (total, n = 45; non-MCS, n = 34)	p-value	Myocarditis	DCM	p-value
Aspirin	15 (33%)	9 (20%)	0.23	15.60 ± 10.4	19.78 ± 20.8	0.23
Therapeutic heparin (goal PTT 60-80)	18 (40%)	17 (38%)	1.00	2.94 ± 4.1	26.24 ± 34.5	<0.01
	7 (21%) non-MCS	6 (18%) non-MCS	1.00	4.43 ± 3.2	18.00 ± 18.3	0.00
Therapeutic enoxaparin	2 (4%)	2 (4%)	1.00	11.00 ± 11.3	28.50 ± 40.3	0.01
Low-dose heparin (10 units/kg/hour)	15 (33%)	20 (44%)	0.39	3.76 ± 6.1	4.30 ± 14.4	0.82
Warfarin	2 (4%)	4 (9%)	0.43	18.00 ± 11.3	35.00 ± 34.8	0.00
No anticoagulation during hospitalisation	16 (36%)	15 (33%)	0.83			
	16 (48%) non-MCS	15 (44%) non-MCS	0.80			

DCM = dilated cardiomyopathy; MCS = mechanical circulatory support; PTT = partial thromboplastin time

Table 3. Outcomes in myocarditis and DCM groups.

Outcomes	Myocarditis (n = 45)	DCM (n = 45)	p-value
Death	2 (4%)	7 (16%)	0.16
Any thrombotic event (pre-MCS)	2 (4%)	3 (7%)	1.00
Intracardiac thrombus	1 (2%)	2 (4%)	
Renal infarction	1 (2%)	0 (0%)	
Splenic/hepatic infarction	0 (0%)	0 (0%)	
Distal extremity infarction	0 (0%)	0 (0%)	
Thromboembolic stroke	1 (2%)	1 (2%)	

DCM = dilated cardiomyopathy; MCS = mechanical circulatory support

n = 1, dilated cardiomyopathy), atrial flutter (n = 0, myocarditis and n = 3, dilated cardiomyopathy) and supraventricular tachycardia (n = 5, myocarditis and n = 3, dilated cardiomyopathy).

The anticoagulation and antiplatelet regimens utilised in both groups of patients are summarised in Table 2. Just over half of the myocarditis and dilated cardiomyopathy patients who never required mechanical circulatory support were treated with either antiplatelet or anticoagulant therapy at some point during their hospitalisation. Our cardiac intensive care unit used a strategy of "low-dose heparin" – heparin dosed empirically at 10 U/kg/hour without a target prolongation of partial thromboplastin time – in over one-third of the patients in our study.

Table 3 summarises the outcomes – death and thrombotic events – seen in both groups. In all, two of the 45 patients (4.4%, 95% binomial exact confidence interval 0.5 to 15.1%) in the myocarditis group and three of the 45 patients (6.7%, 95% binomial exact confidence interval 1.4 to 18.3%) in the dilated cardiomyopathy group had thrombotic complications. Of the two thrombotic events before mechanical circulatory support in the myocarditis group, one was a left ventricular thrombus with ultrasound evidence of embolism to the kidneys and the other was an embolic arterial ischaemic stroke. Of the three thrombotic events in the dilated cardiomyopathy group, two were left ventricular thrombi and the third was an embolic arterial ischaemic stroke. Further details regarding these thrombotic events will be discussed below.

In the myocarditis group, the left ventricular thrombus occurred in a 20-month-old girl with parvovirus myocarditis (Fig 1). Her initial shortening fraction was 18%, and she did not require extracorporeal membrane oxygenation, cardiopulmonary resuscitation or ventricular assist device. She developed a left ventricular thrombus, which was detected by follow-up surface echocardiogram on hospital day 10, while on low-dose heparin (10 U/kg/hour). The thrombus was subsequently confirmed by direct visualisation when she was taken to the operating room for thrombectomy on hospital day 12 because of concern for secondary fungal infection and renal infarction. Her shortening fraction had improved to 21% at the time of detection, but did not normalise until after hospital discharge. The standard prothrombotic work-up was negative.

An embolic arterial ischaemic stroke occurred in an 11-year-old girl with myocarditis by high

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clinical suspicion. Her initial shortening fraction was 14%, and she did not require extracorporeal membrane oxygenation, cardiopulmonary resuscitation or ventricular assist device. Her stroke presented clinically with acute onset of left-sided weakness, dysarthria, and neglect on hospital day 3 while on no anticoagulation or antiplatelet therapies, and was subsequently confirmed by magnetic resonance imaging (Fig 2). Her shortening fraction had improved to 19% on the day of the stroke, but did not normalise during the hospitalisation. No thrombus was visualised by ultrasound of her heart and lower extremity veins. The standard prothrombotic work-up was negative.

In the dilated cardiomyopathy group, the first left ventricular thrombus was identified on hospital day 3 in a 16-year-old patient with severe left ventricular dilation and dysfunction – admission shortening fraction 16%, left ventricular end diastolic dimension z score 5.3 – of unclear aetiology.

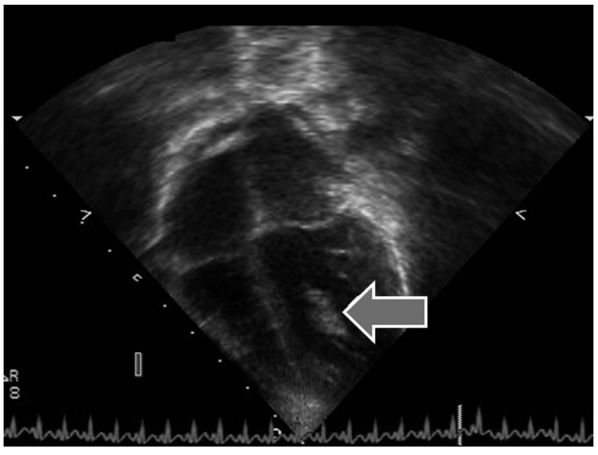

Figure 1.
Left ventricular thrombus (see arrow) identified by echocardiogram in a myocarditis patient.

Endomyocardial biopsy showed no inflammation, and viral studies revealed only respiratory syncytial virus by tracheal aspirate. He had been on low-dose heparin (10 U/kg/hour) when the thrombus was identified by surface echocardiogram. The second left ventricular thrombus was incidentally noted by ventriculogram at the time of cardiac catheterisation in a 14-year-old patient on aspirin with an admission shortening fraction of 12% and a left ventricular end-diastolic dimension z score of 3.1. He was subsequently placed on therapeutic heparin and went on to require left ventricular assist device support as a bridge to successful heart transplantation. Finally, the embolic stroke occurred in an 11-year-old patient while on low-dose heparin (10 U/kg/hour) with an initial shortening fraction of 10% and left ventricular end-diastolic dimension z score of 6.3. This patient also had a significant history of ventricular tachycardia and pulmonary hypertension. The stroke presented clinically with acute onset left-sided weakness and was confirmed by magnetic resonance imaging; no thrombus was visualised by echocardiogram. The patient was kept on low-dose heparin until months later, when he required left ventricular assist device support as a bridge to heart transplantation. This patient died on hospital day 244 because of complications of transplantation. None of the three dilated cardiomyopathy patients with a thrombotic event had a documented prothrombotic work-up.

Potential predictors for thrombotic events were explored (Tables 1 and 2). On univariate analysis, neither the use of any antithrombotic medication, use of intravenous immune globulin, nor the presence of any arrhythmia, nor the need for mechanical circulatory support were predictors of thrombotic events in our myocarditis patients ($p = 1.00$ for all, Fisher's exact test). These factors were similarly not significant when examining the dilated cardiomyopathy group and the combined cohort.

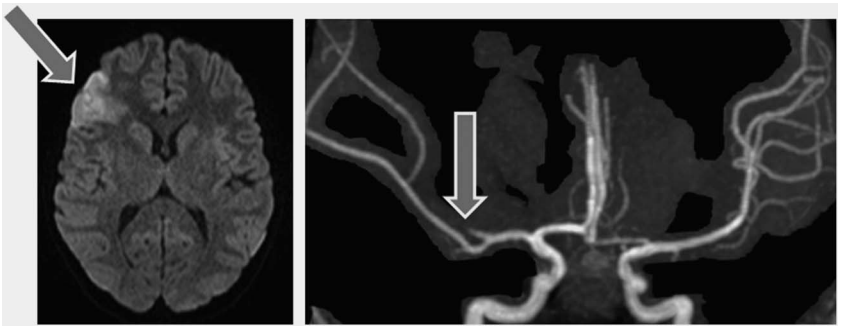

Figure 2.
Magnetic resonance imaging from a myocarditis patient who experienced a left middle cerebral artery stroke.

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Discussion

This retrospective cohort study is novel in its comparison of the incidence of thrombotic events in children with myocarditis compared with a similar cohort with dilated cardiomyopathy. We found a similar rate of thrombotic events during hospitalisation for acute illness at the time of initial diagnosis in children with myocarditis (4.4%) and dilated cardiomyopathy (6.7%). Although there was no statistically significant difference between the incidences of thrombotic events in the two groups, both groups had a thrombotic event rate that should prompt further consideration for prophylactic anticoagulation. We were unable to identify clinical predictors for thrombotic events in either group.

As endomyocardial biopsy is not always performed systematically in children with cardiomyopathy, distinguishing between inflammatory and non-inflammatory causes of left ventricular dysfunction can be difficult. Those with a chronic dilated cardiomyopathy have had more time for their hearts to remodel and dilate, and therefore present with larger left ventricular dimensions than those with acute myocarditis who present in heart failure due to an acute inflammatory process. This was observed in a large cohort study (n = 1495) of children with myocarditis from the Pediatric Cardiomyopathy Registry.[12] The findings in our cohort were consistent with these reports in that those diagnosed with myocarditis did have smaller initial left ventricular end-diastolic dimension z scores than did those in the dilated cardiomyopathy cohort. Although the Pediatric Cardiomyopathy Registry study and older studies of children with myocarditis focused on comparisons of ventricular dimensions and survival outcomes compared with children with dilated cardiomyopathy,[12,13] relative thrombotic risks in these children were not described.

Our cardiac intensive care unit strategy of administering low-dose heparin – run empirically at 10 U/kg/hour without a target prolongation of partial thromboplastin time – is a practice that we use in our congenital heart disease population in the early post-operative period after a Blalock–Taussig shunt has been placed. This has anecdotally decreased the incidence of Blalock–Taussig shunt thrombosis in our centre and others, although little published data about thrombotic events exist for patients managed with this strategy.[14] This strategy of low-dose heparin was extended to over one-third of the patients in our study. The limited number of events in our cohort precludes definitive statements about the efficacy of this strategy in myocarditis or dilated cardiomyopathy. However, it is interesting to note that three of the five observed thrombotic events were in patients on low-dose heparin at the time of thrombotic event discovery. The actual degree of anticoagulation provided to each individual at an empiric heparin dose of 10 U/kg/hour is unknown, although it was not sufficient to prevent thrombus formation in these patients.

There has been considerable interest in the use of antithrombotic therapies as primary prophylaxis against thrombotic events in adults, likely because the morbidity and mortality after a thrombotic event can be quite high. A meta-analysis of adults after myocardial infarction found that systemic embolisation occurred in 11% of patients with a left ventricular thrombus.[15] Two large, randomised trials examining antiplatelet versus warfarin therapy for thrombus prevention in adults with chronic left ventricular systolic dysfunction have recently been published, with neither study demonstrating a significant advantage among agents.[16,17] Adult guidelines still do not conclusively support the use of any antithrombotic therapies in patients with any form of cardiomyopathy unless other risk factors, such as a mechanical valve or atrial fibrillation, are identified.[18]

The most recently published guidelines for antithrombotic therapy in neonates and children are silent as to whether to anticoagulate children with myocarditis or dilated cardiomyopathy, except to give a grade 2C recommendation for vitamin K antagonists in any cardiomyopathy cases by the time they have deteriorated to the point of listing for cardiac transplantation.[19] The same guidelines gave a strong (1C) recommendation for primary thrombophylaxis – with either aspirin, or heparin as a bridge to long-term vitamin K antagonist – in children after Fontan surgery.[19] As reviewed in an editorial by Monagle et al, the reported incidence of venous thromboembolism and stroke after Fontan surgery is 1–7% in studies assessing multiple outcomes, and 3–19% in studies in which thromboembolism was the major outcome.[20] Other clinical scenarios in which the guidelines recommend full anticoagulation for primary thrombophylaxis include primary pulmonary hypertension by the time of vasodilator therapy initiation (2C), Kawasaki disease with moderate or giant coronary aneurysms (2C), ventricular assist device therapy (2C, with additional antiplatelet therapy), mechanical valves (as per adult guidelines), haemodialysis (2C), and cardiac catheterisations with arterial access (1A).[19] The incidence of thrombotic events in children with those conditions is variable.

In this study, we have confirmed that there is a measurable risk of thrombotic events in critically ill children with both myocarditis and dilated cardiomyopathy, with 6% of patients experiencing a thrombotic event. None of the patients were on full

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anticoagulation at the time of the thrombotic event; low-dose heparin or aspirin was in use in four out of five patients when the thrombotic event was discovered. There are theoretical risks of low-dose heparin, including heparin-induced thrombocytopaenia, and aspirin, such as increased inflammation, myocyte necrosis and mortality as seen in animal myocarditis studies.[21] The retrospective nature and small sample size of our study precludes firm conclusions about safety or efficacy of low-dose heparin, aspirin or full anticoagulation in this patient population.

This study did not have adequate power to determine whether full anticoagulation would decrease the risk of thrombotic events in critically ill children with myocarditis or dilated cardiomyopathy at the time of cardiac intensive care unit admission. From the ventricular assist device literature, in which patients are commonly on aggressive antithrombotic regimens, inflammation with or without evidence of infection has been implicated as a risk factor for stroke in some single centre adult ventricular assist device series.[22] However, paediatric and larger adult ventricular assist device studies have not confirmed this relationship.[23,24] Our study similarly does not implicate inflammation alone as a risk factor to prompt consideration for full anticoagulation. A large, randomised controlled trial of full anticoagulation versus placebo or low-dose heparin is necessary to fully evaluate the role of inflammation as a thrombotic risk in paediatric myocarditis. Short of a clinical trial, a larger multi-centre investigation of children with myocarditis and dilated cardiomyopathy to confirm our observed incidence of thrombotic events would be valuable for future, non-randomised efficacy studies in order to understand more about the risk factors for clinically significant thromboembolic events.

We were unable to identify any risk factors for thrombotic events in the myocarditis, dilated cardiomyopathy or combined groups, although this is likely because we were underpowered to detect a difference. Interestingly, there was no higher rate of thrombotic events in the myocarditis group despite a significantly higher rate of intravenous immune globulin administration (Table 1). There was a significantly shorter time to initiation of anticoagulation therapies in myocarditis patients compared with dilated cardiomyopathy patients for those in whom full anticoagulation was used (Table 2), which may have mitigated the theoretically pro-thrombotic effect of intravenous immune globulin. The retrospective nature and small sample size of our study precluded a systematic review of several other potential risk factors. For example, when attempting to document presence or absence of a family history of thrombotic events, we found that information in the medical chart was often missing. Although all potential variations in clinical care between cohort groups cannot be fully determined from a retrospective study, the cohorts were clinically managed by a small cadre of cardiac intensivists who used a relatively consistent diagnostic and management style for these patients.

There were several cases in our cohort that did not meet our pre-specified criteria for thrombotic events, but nonetheless deserve mention. The first was a 13-year-old boy with biopsy-proven myocarditis who clinically recovered and was discharged home on hospital day 10. Upon readmission 17 days later for recurrent heart failure symptoms, he was not on any anticoagulant medications and was found to have biventricular thrombi. He ultimately died because of complications after heart transplantation. In the dilated cardiomyopathy group, there were four additional cases of thrombotic events that occurred in the setting of mechanical circulatory support: three patients experienced left ventricular assist device-related thrombi – two patients developed evidence of embolic arterial stroke, one had evidence of splenic and renal infarcts; one died – and one patient on extracorporeal membrane oxygenation had an embolic arterial stroke and evidence of embolism to the spleen and kidneys. The added thrombotic risks when on mechanical circulatory support are well documented [25–27] and difficult to differentiate from the risk for thrombus formation imparted by the underlying cardiomyopathy.

In critically ill children with heart failure due to either myocarditis or dilated cardiomyopathy, thrombotic events are common and potentially preventable. Current published guidelines recommend antithrombotic prophylaxis in children with comparable risk profiles. Owing to the fact that the consequences of a thrombotic event can be catastrophic, resulting in death or significant neurological impairment from stroke, a strategy of antithrombotic prophylaxis should be considered in this population as well. The most effective medication regimen with the lowest risk/benefit ratio for this population remains to be determined. There was no significant difference in our small cohort in thrombotic events between inflammatory and non-inflammatory cardiomyopathy groups, suggesting that the decision to use antithrombotic prophylaxis should not be based solely on the underlying aetiology of the acute decompensated heart failure.

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Potential Conflicts of Interest/Disclosures

R.N. Ichord: Consultant/Advisory Board, Berlin Heart Clinical Event Committee.

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