The Heart Surgery Forum #2010-1048
14 (3), 2011 [Epub June 2011]
doi: 10.1532/HSF98.20101048

Online address: http://cardenjennings.metapress.com

Sources of Thromboembolism in Patients with Correctly Functioning Mechanical Valves: A Single-Center Transesophageal Echocardiographic Study

Marek Maciejewski, MD, PhD,[1] Katarzyna Piestrzeniewicz, MD, PhD,[1]
Ryszard Jaszewski, MD, PhD,[1] Agata Bielecka-Dabrowa, MD, PhD,[2] Jan H. Goch, MD, PhD[1]

[1]Clinic of Cardiology, Institute of Cardiology and Cardiac Surgery, Medical University of Lodz, Poland;
[2]Department of Hypertension, Chair of Nephrology and Hypertension, Medical University of Lodz, Poland

ABSTRACT

Background: In patients with mechanical prostheses (MP), thromboembolism is one of the most serious complications. The study aim was to assess the incidence of sources of thromboembolism in patients with correctly functioning MP with and without a history of thromboembolism.

Methods: Two hundred ninety-seven patients with correctly functioning MP were enrolled in this single-center, transesophageal echocardiographic (TEE), retrospective, observational study. Two groups were analyzed: Group A, 183 patients with a history of thromboembolism, and Group B, 114 patients with no history of thromboembolism.

Results: Definite sources of thromboembolism were revealed in 59% of patients in Group A, and sources of potential thromboembolism were revealed in 13% of patients in Group B ($P < .001$). Multiple sources of thromboembolism were present in 9% of patients in Group A and 1% of patients in Group B. Localization of sources of thromboembolism included MP ring (59% and 53% of patients in Groups A and B, respectively); left atrium/left atrium appendage (24%/21% and 13%/40% of patients in Groups A and B, respectively); and aorta (12% and 13% of patients in Groups A and B, respectively). Patients with multiple sources of thromboembolism were older ($P < .001$) and in a higher New York Heart Association (NYHA) class ($P = .004$). Patients with sources of thromboembolism in the aorta were older than the rest of the group ($P < .01$).

Conclusions: In patients with correctly functioning MP, sources of thromboembolism are observed 4 times more often in case of the positive history of thromboembolism. The most common source of thromboembolism is thrombosis of MP ring. Age and heart failure predispose multiple sources of thromboembolism. One might consider control TEE after mechanical valve implantation, but only in selected group of patients without embolic events but with a higher risk of thromboembolism.

Received March 16, 2010; received in revised form July 16, 2010; accepted September 7, 2010.

Correspondence: Agata Bielecka-Dabrowa, MD, PhD, Department of Hypertension, Chair of Nephrology and Hypertension, Medical University of Lodz; +48606644176 (e-mail: agatbiel7@poczta.onet.pl).

INTRODUCTION

Prosthetic valve thrombosis and cerebral thromboembolism are the most serious complications in patients with mechanical prostheses [Edmunds 1982; Grunkemeier 1988; Butchart 2001; Chang 2001; Aagaard 2005]. Transesophageal echocardiography (TEE) is currently the test of choice in patients with prosthetic valves and a history of thromboembolism [Gueret 1995; Tong 2004]. The incidence of thromboembolic complications as well as predisposing factors in patients with various types of prosthetic valves are commonly known [Butchart 2003; Durrleman 2004; Laplace 2004].

The aim of the study was to assess the occurrence of sources of thromboembolism in patients with correctly functioning prosthetic valves with and without a history of thromboembolism.

MATERIAL AND METHODS

Patient Population

Between November 1990 and December 2003, 297 patients with correctly functioning prosthetic mechanical valves were enrolled in this single-center, transesophageal echocardiographic, retrospective, observational study. The criteria of inclusion were clinical and echocardiographic evidence of correctly functioning prosthetic valves. The blockage of the mechanical valve or the restriction of disc mobility in echocardiographic examination and a history or suspicion of endocarditis were regarded as exclusion. Two groups were analyzed: Group A included 183 patients with a history of thromboembolism: 38 patients (26%) were men, and the mean age was 53.4 ± 11.4 years (range, 34-68 years). Group B included 114 patients with no history of thromboembolism: 26 patients (23%) were men, and the mean age was 52.1 ± 10.9 years (range, 30-77 years). Patients from Group B were assessed as a comparison group referring to sites of potential thrombi in patients with mechanical valve prostheses versus patients in Group A (with a positive history of embolism). We assessed the additional factors that may predispose to thromboembolism in patients with prosthetic valves with and without echocardiographical sources of thromboembolism in Group A and potential thromboembolism in Group B.

Table 1. Clinical Characteristics of Patients with Correctly Functioning Mechanical Prosthetic Valve (MPV)*

	Group A: History of Embolic Events	Group B: No History of Embolic Events
Age, y	53.4 ± 11.4 (34-68)	52.1 ± 10.9 (30-77)
Sex, M(%)/F	38(26)/145	26(23)/88
NYHA classification	1.52	1.46
Mitral MPV, n (%)	111 (65)	70 (61)
Aortic MPV, n (%)	49 (27)	34 (30)
Double MPV, n (%)	16 (8)	10 (8)
Time from valve replacement, y	7 ± 3.5 (0.5-25)	6.5 ± 4.0 (0.7-22)
Mitral commisurotomy, n (%)†	34 (19)	29 (25)
Atrial fibrillation, n (%)	112 (61)	56 (49)
Embolic events, n (%)	183 (100)	—
Stroke/TIA, n (%)	130 (71)	—
Stroke, n (%)	85 (46)	—
TIA, n (%)	45 (25)	—
Peripheral, n (%)	53 (29)	—
INR below therapeutic range, n (%)‡	135 (74)	54 (47)

*Data for age and time from valve replacement are presented as mean ± standard deviation (range). Data for New York Heart Association (NYHA) classification are presented as median. TIA indicates transient ischemic attack; INR, international normalized ratio.

†Before mitral valve replacement.

‡Therapeutic range of INR, 2.5-3.5.

The groups did not differ with regard to demographic characteristics (Table 1). All thromboembolic events occurred after implantation of the prosthetic valve. Transthoracic (TTE) and transesophageal echocardiography (TEE) were performed according to currently accepted standards. The time interval between the event and the echo study in all cases was 2 to 6 weeks after embolic event in Group A. Control TEE was performed in Group B. The following sources of thromboembolism were diagnosed: thrombosis of prosthetic valve, thrombus in the left atrium or left appendage, thrombus in the left ventricle, and thrombus or complex atherosclerotic plaque in thoracic aorta. Based on TEE, the following possible and probable sources of thromboembolism were also diagnosed: spontaneous echo contrast in left atrium, left appendage, or left ventricle; patent foramen ovale with right-to-left shunt; atrial septal aneurysm; and filamentous strands.

Thrombus on prosthetic valve ring was determined as a separate, low-density, well-outlined echo linked to the valve, visible throughout the cardiac cycle. Based on the longest dimension of the thrombus, small (<5 mm) and large (≥5 mm) thrombi were distinguished. Thrombus mobility was recognized as high if it moved between adjacent cardiac chambers and as low if its mobility was limited to a single chamber. Figure 1 presents examples of thrombi on the prosthetic valve and in the heart chamber.

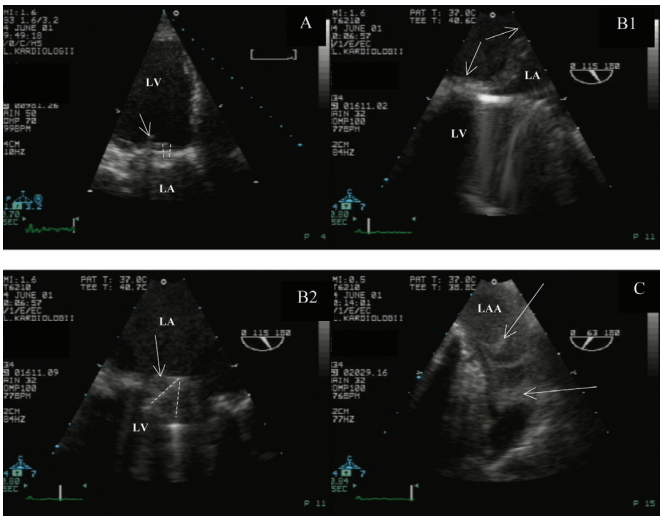

Figure 1. Data from a 70-year-old patient 3 years after the mitral valve replacement with no history of embolic events, New York Heart Association (NYHA) class II, and inadequate anticoagulation control. A, Thrombus on the St. Jude Medical 31 mitral valve prosthesis revealed on transthoracic echocardiography (TTE). B, Transesophageal echocardiography (TEE) (B1 and B2) confirmed the presence of a large thrombus on the atrial surface of the prosthetic valve ring. C, Additional thrombus in the left appendage was found. Discs of the prosthetic valve were marked with a dashed line. LA indicates left atrium; LAA, left atrium appendage; LV, left ventricle.

Filamentous strands were defined as highly mobile, fine filamentous structures less than 1 mm thick and more than 2 mm long.

Protocol of Examination and Patient Subgroups

Sources of thromboembolism were sought on TTE. TEE was performed directly after TTE.

The advantage of TEE in recognizing the sources of potential thromboembolism is presented in Figure 2. The incidence of sources of thromboembolism was assessed. Based on TTE results, 2 subgroups were distinguished in both groups of patients: TTE positive for sources of thromboembolism (TTE positive) and TTE negative for sources of thromboembolism (TTE negative) (Table 2).

Statistical Analysis

Continuous variables were expressed as average values ± standard deviation (SD), and Student *t* test was used for comparative analysis. Categorical variables were expressed as percentage values, and the χ^2 test was applied for comparisons. Results were considered statistically significant at $P < .05$. The Statistica 7.1 software package (StatSoft, Tulsa, Oklahoma, USA) was used for statistical analysis.

RESULTS

Sources of Potential Thromboembolism

TTE was positive for sources of thromboembolism in 30 patients. Thrombosis of mitral prosthetic valve was found

Table 2. Echocardiographic Diagnostic Strategy in Patients with Correctly Functioning Mechanical Prosthetic Valves (MPV) and a history of embolic events (Group A) and without embolic events (Group B).

Study Group
Patients with correctly functioning mechanical prostheses on clinical and transthoracic echocardiography (TTE) examination
↓
Group A
Group B
↙↘
Subgroup TTE negative for sources of thromboembolism — Subgroup TTE positive for sources of thromboembolism
↓ ↓
Transesophageal echocardiography (TEE)
Thromboembolism negative — Thromboembolism positive
↓ ↓ ↓
Other findings (paravalvular leak, pannus) — Thrombosis of mechanical prosthetic valve ring — Another localization

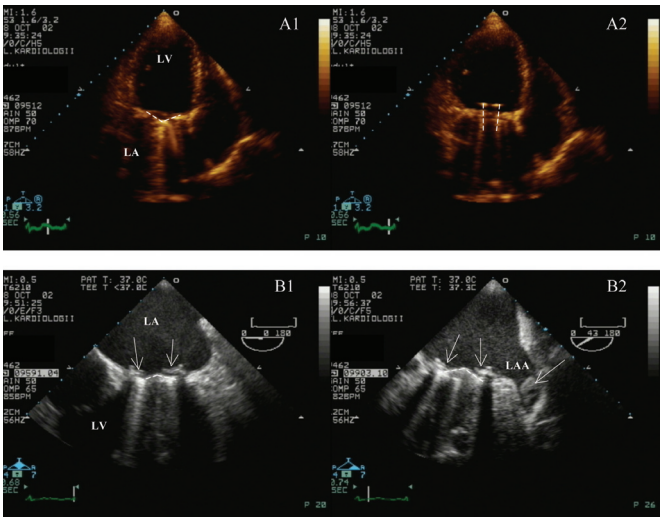

Figure 2. Data from a 53-year-old patient 6 years after mitral valve replacement with a transient ischemic attack history, New York Heart Association (NYHA) class III, and inadequate anticoagulation control. A1/A2, Correct function of Sorin Bicarbon mitral valve and no sources of embolization were found on transthoracic echocardiography (TTE). B1/B2, Thrombi on the prosthetic valve ring and in the left appendage were diagnosed on transesophageal echocardiography (TEE). Discs of the prosthetic valve were marked with a dashed line.

in 14 patients in Group A and in 3 individuals in Group B with no history of thromboembolism. Thrombi in heart chambers were detected in 13 patients in Group B. TEE confirmed the result of TTE in 27 patients, and 11 additional cardioembolic sources were detected, mainly in Group A. In 267 patients, TTE was negative for sources of thromboembolism. The sources of thromboembolism were found on TEE in 107 out of 183 patients in Group A (59%) and in 15 out of 114 individuals in Group B (13%, $P < .001$). Prosthetic valve thrombosis was detected in 71 patients: 63 in Group A (34%) and 8 in Group B (7%). Thrombosis of mechanical valve affected 59% of patients with sources of thromboembolism in Group A and 53% of patients with sources of thromboembolism in Group B. Thrombotic material in another site was present in 34 patients: in the left atrium and left appendage in 19 and 28 patients, respectively, and in the aorta in 13 individuals (exclusively in Group A). Thrombi in the left appendage were visualized in 22 patients from Group A (15% of patients without previous commisurotomy, 21% of patients with diagnosed sources of thromboembolism, and 50% of patients with extravalvular location of thrombotic material) as well as in 6 patients from Group B (7% of patients without previous commisurotomy, 40% of patients with diagnosed sources of thromboembolism, and 75% of patients with extravalvular location of thrombotic material).

In 18 patients (6% of the study group), more than 1 source of thromboembolism was identified: 17 patients in Group A (9%) and 1 patient in Group B (<1%). In patients with multiple sources of thromboembolism, the following parameters were significantly higher than in the rest of the study group: age (61 versus 52 years, $P < .001$), left atrium dimension (6.9 ± 2.85 cm versus 5.4 ± 1.86 cm, $P = .0045$), and functional New York Heart Association (NYHA) class (2.3 ± 0.71 versus 1.8 ± 0.49, $P = .004$). Age of patients with sources of thromboembolism in thoracic aorta was significantly higher (63 versus 57 years of age, $P < .01$). The total number of sources of thromboembolism was 143: 127 sites in 107 patients in Group A and 16 sites in 15 patients in Group B. Sources of thromboembolism were not found in 172 cases: 73 patients in Group A (39%) and 99 patients in Group B (87%).

There was no significant difference in left atrial dimension between the patients with thrombi in left atrium or left appendage and the rest of the study group (5.7 ± 2.45 cm versus 5.5 ± 2.11 cm). The target organ of the embolic event was the central nervous system in 71% of patients (128 patients with mitral main portal vein [MPV] thrombosis and 2 patients with aortic MPV thrombosis) and peripheral in 29% of patients (51 patients with MPV thrombosis and 2 patients with aortic MPV thrombosis). The patients who suffered from stroke had computed tomography results that excluded cerebro-cerebral embolism and cerebral bleeds, based on experienced neurologist opinion.

Echocardiographic Characteristics. Echocardiographic characteristics of thrombi on the prosthetic valve ring are described in Table 3. On TTE, large mobile thrombi were detected during diastolic left ventricle inflow. On TEE, thrombotic material was usually found on the atrial surface of mitral prosthetic valve ring. In the majority of cases, the detected thrombi were small (68%), showing limited mobility (87%).

Possible and Probable Sources of Potential Thromboembolism. Spontaneous echo contrast in left atrium was observed on TEE in 17% of patients without history of

Table 3. Echocardiographic Characteristics of Nonobstructed Prosthetic Valve Thrombi (NPT)*

	Mobility		Size	
	Low	High	Small	Large
TTE NPVT+, n = 15	8 (1†)	7 (1†)	5 (2†)	10
TEE NPT+	11	6	6	11
TTE NPVT–, n = 156	—	—	—	—
TEE NPT+	51	3	42	12
Total TEE NPT+, n (%)	62 (87)	9	48 (68)	23

*TTE indicates transthoracic echocardiography; NPVT, nonobstructed prosthetic valve thrombosis; TEE, transesophageal echocardiography.
†False positive.

Table 4. A, Presence of Possible and Probably Sources of Thromboembolism in Patients with Correctly Functioning Prosthetic Valves and a History of Thromboembolism (Group A) and without Embolic Events in the Past (Group B). B, Coexistence of the Spontaneous Echo Contrast and Sources of Thromboembolism in the 2 Groups of Patients*

A	Sources of Thromboembolism	Possible and Probable Sources of Thromboembolism			
		SEC+	PFO+	ASA+	FS+
Group A, n = 183, n (%)	107 (58.5)	74 (41)	18 (10)	12 (6)	62 (34)
Comparison	P < .001	P < .001	NS	NS	P < .01
Group B, n = 114, n (%)	15 (13.2)	19 (17)	13 (11)	7 (6)	16 (14)

B	Sources of thromboembolism	Spontaneous echo contrast (SEC)+, n (%)
Group A, n = 183	STE+, n = 107	45 (42)
	Comparison	NS
	STE–, n = 76	30 (39.5)
Group B, n = 114	STE+, n = 15	7 (47)
	Comparison	P < .01
	STE–, n = 99	12 (12)

*SEC indicates spontaneous echo contrast; PFO, patent foramen ovale; ASA, atrial septal aneurysm; FS, filamentous strands.

embolic events and in 41% of individuals with such history ($P < .001$). Atrial septal aneurysm was found in 12 patients in Group A (6%) and in 7 patients in Group B (6%, not significant). Filamentous strands were found in 62 patients in Group A with history of thromboembolism (34%) and in 16 patients in Group B (14%, $P < .01$). Patent foramen ovale was present in 18 patients in Group A (10%) and in 13 patients in Group B without history of thromboembolism (11%, not significant) (Table 4).

Additional TEE Findings. Insignificant paravalvular leak was detected in 18 patients and pannus in 8 patients.

Predisposing Conditions for Thromboembolism. In Group A, atrial fibrillation was present in 65 out of 97 patients (67%) with sources of thromboembolism and in 47 out of 76 individuals (62%, not significant) without them. In Group B, atrial fibrillation was observed in 12 out of 15 patients (80%) with sources of thromboembolism and in 44 out of 99 patients without sources (44%, $P = .01$). During the time of treatment, acenocumarol was the only available anticoagulant with the International Normalized Ratio (INR) control. About 75% of patients had subtherapeutic INR control in similar percentages in both groups of patients. The target therapeutic range of INR was 2.5 to 3.5.

In Group A, inadequate antithrombotic therapy was revealed in 78 out of 97 patients (80%) with sources of thromboembolism and in 57 out of 76 patients with no sources of thromboembolism (75%, not significant). In Group B, inadequate antithrombotic therapy was documented in 13 out of 15 patients (87%) with sources of thromboembolism and in 41 out of 99 patients with no sources of thromboembolism (41%, $P < .002$).

The important risk factors for thromboembolism and cerebrovascular events in both groups are presented in Table 5.

Types of Valve Prostheses with Nonobstructed Thrombosis

Thrombosis occurred on mitral valve prostheses in 67 patients and aortic valve prostheses in 4 cases. Thrombosis on artificial valve ring was detected in more than 20% of patients with disc-type caged-ball valves as well as early-generation tilting-disc valves; in more than 10% of patients with Sorin (Milan, Italy) and Björk-Shiley (Shiley Inc., Irvine, California) valve prostheses; and in slightly more than 5% of

Table 5. Comparison of Risk Factors for Thromboembolism and Cerebrovascular Events in Both Groups

Risk Factors for Thromboembolism and Cerebrovascular Events	Group A, %	Group B, %	*P*
Left ventricular dysfunction			
Ejection fraction > 40%	40	45	ns
Ejection fraction < 40%	15	17	
Diabetes mellitus	7	8	ns
Hypertension arterialis	45	42	ns
Cigarette smoking	2	3	ns
Carotid disease	—	—	—
Chronic inflammatory condition	—	—	—

patients with bileaflet or Medtronic-Hall tilting-disc valves (Medtronic, Minneapolis, Minnesota). Differences between the above-distinguished subgroups of prosthetic valves were statistically significant ($P < .005$).

DISCUSSION

Meticulous surveillance of antithrombotic therapy and, in selected cases, inclusion of anti-platelet therapy should lead to a decrease in occurrence of thromboembolic complications in patients with prosthetic heart valves [Bonow1998; Massel 2001].

Information derived from echocardiographic examination may facilitate the achievement of this goal. Diagnosis of thrombosis of prosthetic valve leading to its blockage is based on clinical data. Systemic thromboembolism is often the first clinical manifestation of thrombosis of prosthetic valve, which does not block disc mobility or thrombosis at a different location [Roudaut 2003a; Roudaut 2003b].

Potential Sources of Thromboembolism in Patients with Prosthetic Valves

Transthoracic and especially transoesophageal echocardiography are important steps in the diagnosis of sources of thromboembolism in patients with prosthetic heart valves [Montorsi 2000]. The cause of thromboembolism is most often linked to the mechanical valve, and therefore the diagnostic procedure after a systemic embolism is predominantly directed at the prosthetic valve. Assessment of placement of the potentially embolic material and determination of its characteristics may be of paramount importance for subsequent clinical interventions and in selected cases also may lead to a decision on reoperation [Lin 2000; Shapira 2000; Roudaut 2003a; Roudaut 2003b].

In previously published studies [Vandenbogaerde 1992; Mirode 1993; Paemelaere 1996] concerning sources of thromboembolism, patients with implanted prosthetic heart valves formed only a part of analyzed groups or were excluded from the study or the authors dealt only with specific aspects of this problem. In the present study, the material includes only patients with implanted heart valve prostheses. Subdivision of the study cohort into groups was based on clinical data and on results of transthoracic echocardiographic examination.

Echocardiography in Search of Sources of Thromboembolism in Patients with Implanted Prosthetic Heart Valves

Pearson and co-workers [1991] found thrombotic material in patients after a brain stroke or a transient ischemic attack using transthoracic echocardiography in 15% of patients; transesophageal echocardiography allowed them to find it in 57% of patients. Vandenbogaerde and co-workers [1992] detected embolic material during transesophageal examination in 83% of patients who underwent a peripheral embolism. Mirode and co-workers [1993] proved the presence of embolic material in a group of patients after a systemic embolism, with documented cardiac disease or atrial fibrillation in 12% of investigated patients by the transthoracic method and in 50% of patients by the transesophageal method. Paemelaere and co-workers [1996] stressed the higher detection rate of sources of thromboembolism in patients with cardiac disease or atrial fibrillation (65.9% versus 29.7% in patients with a negative history of cardiac disease).

In the present study, potentially embolic material was found using the transthoracic echocardiography in 13% and 2% of patients in the embolic and non-embolic groups, respectively. During transesophageal echocardiography, potential sources of thromboembolism were found in 58% and 13% of patients in each group, respectively. Intracardiac thrombogenesis occurred in this study's patients despite administration of antithrombotic therapy; it should, however, be stressed that in 74% of patients from Group A, monitoring of this treatment was inadequate. In Group B, antithrombotic therapy was inadequately monitored in 13 out of 15 patients with potential sources of thromboembolism detected during TEE.

Validity of Transthoracic Echocardiography in Diagnosis of Some Cardioembolic Sources in Patients with Prosthetic Heart Valves

The superiority of transesophageal examination in determination of potential sources of thromboembolism has currently been decided beyond discussion; however, transthoracic examination may also supply some important information. Mügge and co-workers [1991], in their retrospective assessment of validity of transthoracic echocardiography in the group of patients with documented presence of thrombi or intracardiac tumors, estimated the sensitivity of transthoracic echocardiography in recognition of thrombi in the left atrium (excluding left appendage) at 69%. In the present study, transthoracic echocardiography made it possible to visualize thrombi in left atrium in 29% of patients with transesophageal confirmation of thrombotic material. The difference may be explained by commonly known technical problems arising from the typical acoustic shadow of the prosthetic valve that may be responsible for false negative results.

Prosthetic valve thrombosis was recognized by transthoracic echocardiography in a total of 19% of patients with such locality of thrombotic material confirmed by transesophageal method. Transthoracic echocardiography is useful in detection of larger thrombi, which show significant mobility

Table 6. Sensitivity, Specificity, and Positive and Negative Predictive Value of Transthoracic Echocardiography in Searching of Sources of Thromboembolism in 183 Patients with Correctly Functioning Prosthetic Valves (PV) and a History of Thromboembolic Events

	Potential Sources of Thromboembolism	
	PV Thrombosis	Left Atrium*
Sensitivity	19	38.5
Specificity	98.3	99.4
Positive predictive value	85.7	90.9
Negative predictive value	69.8	90.7
Accurate	71	90.7

*Excluding left appendage.

(Table 3). As is apparent from the present study, sensitivity of transthoracic echocardiography in detecting sources of thromboembolism in patients with prosthetic valves is generally low and does not depend on the location of thrombotic material (Table 6).

Validity of Transesophageal Echocardiography in Diagnosing Sources of Thromboembolism in Patients with Implanted Prosthetic Heart Valves

In the study group, transesophageal examination made it possible to visualize a total of 127 localities of potentially embolic material in 107 out of 183 patients (58%) with a history of systemic thromboembolism (Group A) as well as in 15 out of 114 patients (13%) with negative medical history with regard to embolic event or transient ischemic attack (Group B). The significantly more frequent ($P < .001$) occurrence of thrombotic material in patients with a history of systemic thromboembolism in comparison with subjects without such history confirms the existence of a link between intracardiac thrombosis and occurrence of thromboembolism. Multiple potential sources of thromboembolism were detected in 17 patients. A notable circumstance is the significantly higher age and worse clinical state of patients with several potential sources of thromboembolism. Thrombi were detected on the prosthetic heart valve in 63 patients (34%), in the left atrium in 26 patients (14%), and in the left ventricle in 4 patients.

Nonobstructed prosthetic valve thrombosis was detected in 24% of the study group: in 34% of patients in Group A and in 7% of patients in Group B ($P < .001$). It is worth stressing that the percentage of patients with nonobstructed valve thrombosis among patients TEE-positive for sources of thromboembolism from Groups A and B did not differ significantly (59% and 53% patients, respectively; not significant).

The left appendage and thoracic aorta are common localities of thrombotic material that are inaccessible to transthoracic examination [Stoddard 1995; The French Study of Aortic Plaques in Stroke Group 1996].

In the present study, thrombus in left appendage was diagnosed in 9% of the total number of patients and in 12% of patients who had previously undergone mitral commisurotomy by the closed method. The percentage of left appendage thrombosis was significantly higher ($P = .04$) among patients with a history of systemic embolism. On the other hand, the percentage of patients with thrombi in left appendage among those with thrombotic material detected during TEE in both assessed groups of patients did not differ significantly (50% and 75% of patients, respectively; not significant).

Spontaneous echo contrast in the left atrium and left appendage could be observed during transesophageal examination in 41% of investigated patients. Within this subgroup, no statistically significant differences were detected between patients with additionally visualized embolic material and patients without any embolic material. Seventeen percent of patients without a history of thromboembolism and 75% of patients with such history ($P < .001$) show spontaneous echo contrast in left atrium. It is, however, worth stressing that the percentage of patients with spontaneous echo contrast in the left atrium among patients with thrombotic material detected during TEE in Groups A and B did not differ significantly (42% and 47% of patients, respectively; not significant). Black and co-workers [1991] reported the occurrence of embolic complications in 44% among 75 patients with spontaneous echo contrast in the left atrium. In the group of patients without any embolic history, spontaneous echo contrast in the left atrium was more frequent in patients with intracardiac thrombi. Also in patients with non-rheumatic atrial fibrillation, Tsai and co-workers [1997] detected thrombi in the left atrium in 8 out of 34 patients with spontaneous echo contrast.

An interesting observation was presented by Barbetseas and co-workers [1997], who reported more frequent occurrence of intracardiac thrombi in patients after a brain stroke and more common occurrence of spontaneous echo contrast in the left atrium in patients after a transient ischemic attack. Black and co-workers [Black 1991] reported the occurrence of embolic complications in 44% among 75 patients with spontaneous echo contrast in the left atrium. Tsai and co-workers [1997] detected thrombi in left atrium in 8 out of 34 patients with non-rheumatic atrial fibrillation and with spontaneous echo contrast.

In the study presented, no correlation could be found between the occurrence of spontaneous echo contrast in left atrium and the presence of thrombi in cardiac chambers in patients from Group A (Table 4).

Aortic Atherosclerosis as a Potential Source of Thromboembolism in Patients with Implanted Prosthetic Heart Valves

Simons and co-workers [1992] described features of aortic atherosclerosis in 8 out of 259 patients sequentially examined using the transesophageal method. The age of these patients varied between 57 and 73 years (mean, 67 years), and for 4 of them no abnormalities could be shown in cardiac structure or function. Karalis and co-workers [1991] detected complex atherosclerotic plaques in 7% of patients examined using the transesophageal method. Eleven out of 36 patients in his study had a history of embolic complications, including 2 of 7 patients with implanted prosthetic heart valves. Schwartzbard and co-workers [2000] underlined the dynamic character of thrombi that appear in the aorta. Mitusch and co-workers

[1997] described the dependence of embolic events' occurrence on echocardiographic characteristics of atherosclerotic changes in the aorta, assigning the poorest prognostic value to complex plaques and plaques containing mobile elements. This type of plaque constitutes an especially serious threat of thromboembolism in patients who undergo heart catheterization or coronary angiography [Karalis 1996], and they also have prognostic significance in risk assessment of significant stenosis of coronary vessels in the population of advanced age patients [Roijer 1996]. In the investigated group of patients after a systemic embolism, atherosclerotic changes in the aorta predisposing to embolic complications were detected in 13 patients (9% in comparison to 2% in the group without any history of embolism). Age of the patients was older than 60 years. This observation is consistent with statements by other authors [Karalis 1996; Roijer 1996]. Finkelhorn and co-workers reported embolic events in patients with spontaneous echo contrast in the thoracic aorta [Finkelhorn 1995; Finkelhorn 1999]. In the presented material, this type of abnormality was visible in 3 patients with complex atherosclerotic plaques in the thoracic aorta.

Patent foramen ovale was visualized in 10% of patients in the investigated group, and it seems not to have had any impact on the emergence of thrombotic and embolic complications. This conclusion is consistent with statements by other authors who accept the influence of patent foramen ovale on the occurrence of ischemic stroke and transient ischemic attack exclusively in patients without an organic cardiac disease [Pearson 1991]. Both presented groups of patients with implanted prosthetic heart valves did not differ in a statistically significant manner with regard to the presence of a patent foramen ovale (Table 4).

Limitations of the Study

Including in the analysis only patients with a documented event of systemic thromboembolism may lead to too small of a study group, especially because no information is gathered from patients who died as a result of embolic complications. The abdominal aorta and carotid arteries were not included in the study, although both locations may also be a source of thromboembolism. Application of a single-plane transesophageal probe during the years 1990–1997 might have made it more difficult to detect small thrombi on the prosthetic valve ring.

The delay between the embolic event and echocardiographic examination in individual patients was varied. Patients with prosthetic valve blockage were also excluded from the study because some of them were qualified for reoperation exclusively based on an unequivocal result of transthoracic examination, and no transesophageal examination was performed.

CONCLUSIONS

1. In patients with correctly functioning mechanical valve prostheses sources of thromboembolism are 4 times more often observed in case of the positive history of thromboembolism.
2. The most common source of thromboembolism is prosthetic valve thrombosis.
3. Age and heart failure predispose to multiple sources of thromboembolism.

It seems probable that the frequency of thromboembolism sources in patients without a history of thromboembolic events and inadequate antithrombotic therapy is the same like in patients with a history of thromboembolism.

REFERENCES

Aagaard J, Tingleff J. 2005. Fifteen years' clinical experience with the CarboMedics prosthetic heart valve. J Heart Valve Dis 14:82-8.

Barbetseas J, Pitsavos C, Aggeli C, et al. 1997. Comparison of frequency of left atrial thrombus in patients with mechanical prosthetic cardiac valves and stroke versus transient ischemic attacks. Am J Cardiol 80:526-8.

Black IW, Hopkins AP, Lee LC, Walsh WF. 1991. Left atrial spontaneous echo contrast: a clinical and echocardiographic analysis. J Am Coll Cardiol 18:398-404.

Bonow RO, Carabello B, de Leon AC, et al. 1998. ACC/AHA guidelines for the management of patients with valvular heart disease. A report of the American College of Cardiology/American Heart Association. Task Force on Practice Guidelines (Committee on Management of Patients with Valvular Heart Disease). J Am Coll Cardiol 32:1486-588.

Butchart EG, Ionescu A, Payne N, Giddings J, Grunkemeier GL, Fraser AG. 2003. A new scoring system to determine thromboembolic risk after heart valve replacement. Circulation 108:II68-74.

Butchart EG, Li HH, Payne N, Buchan K, Grunkemeier GL. 2001. Twenty years' experience with the Medtronic Hall valve. J Thorac Cardiovasc Surg 121:1090-100.

Chang BC, Lim SH, Kim DK, et al. 2001. Long-term results with St. Jude Medical and CarboMedics prosthetic heart valves. J Heart Valve Dis 10:185-94.

Dürrleman N, Pellerin M, Bouchard D, et al. 2004. Prosthetic valve thrombosis: twenty-year experience at the Montreal Heart Institute. J Thorac Cardiovasc Surg 127:1388-92.

Edmunds LH Jr. 1982. Thromboembolic complications of current cardiac valvular prostheses. Ann Thorac Surg 34:96-106.

Finkelhorn RS, Lamont WE, Ramanavarapu SK, Bahler RC. 1995. Spontaneous echocardiographic contrast in the thoracic aorta: factors associated with its occurrence and its association with embolic events. Am Heart J 130:1254-8.

Finkelhorn RS, Youssefi ME, Lamont WE, Bahler RC. 1999. Embolic risk based on aortic atherosclerotic morphologic features and aortic spontaneous echocardiographic contrast. Am Heart J 137:1088-93.

Grunkemeier GL, Starr A. 1988. Twenty-five year experience with Starr-Edwards heart valves: follow-up methods and results. Can J Cardiol 4:381-5.

Gueret P, Vignon P, Fournier P, et al. 1995. Transesophageal echocardiography for the diagnosis and management of nonobstructive thrombosis of mechanical mitral valve prosthesis. Circulation 91:103-10.

Karalis DG, Chandrasekaran K, Victor MF, Ross JJ Jr, Mintz GS. 1991. Recognition and embolic potential of intraaortic atherosclerotic debris. J Am Coll Cardiol 17:73-8.

Karalis DG, Quinn V, Victor MF, et al. 1996. Risk of catheter-related emboli in patients with atherosclerotic debris in the thoracic aorta. Am

Heart J 131:1149-55.

Laplace G, Lafitte S, Labèque JN, et al. 2004. Clinical significance of early thrombosis after prosthetic mitral valve replacement: a postoperative monocentric study of 680 patients. J Am Coll Cardiol 43:1283-90.

Lin SS, Tiong IY, Asher CR, Murphy MT, Thomas JD, Griffin BP. 2000. Prediction of thrombus-related mechanical prosthetic valve dysfunction using transesophageal echocardiography. Am J Cardiol 6:1097-101.

Massel D, Little SH. 2001. Risks and benefits of adding anti-platelet therapy to warfarin among patients with prosthetic heart valves: a meta-analysis. J Am Coll Cardiol 37:569-78.

Mirode A, Tribouilloy C, Adam MC, Kacem LH, Rey JL, Lesbre JP. 1993. Contribution of transesophageal ultrasonography in the etiologic evaluation of a systemic embolic accident. Apropos of 451 patients [article in French]. Arch Mal Coeur Vaiss 86:1701-8.

Mitusch R, Doherty C, Wucherpfennig H, et al. 1997. Vascular events during follow-up in patients with aortic arch atherosclerosis. Stroke 28:36-9.

Montorsi P, De Bernardi F, Muratori M, Cavoretto D, Pepi M. 2000. Role of cine-fluoroscopy, transthoracic, and transesophageal echocardiography in patients with suspected prosthetic heart valve thrombosis. Am J Cardiol 85:58-64.

Mügge A, Daniel WG, Haverich A, Lichtlen PR. 1991. Diagnosis of noninfective cardiac mass lesions by two-dimensional echocardiography: comparison of the transthoracic and transesophageal approaches. Circulation 83:70-8.

Paemelaère JM, Sirinelli A, Dreyfus X, Maillard L, Pottier JM, Raynaud P. 1996. Transesophageal echography and systemic ischemic incidences: 235 cases [article in French]. Rev Neurol (Paris) 152:27-31.

Pearson AC, Labovitz AJ, Tatineni S, Gomez CR. 1991. Superiority of transesophageal echocardiography in detecting cardiac source of embolism in patients with cerebral ischemia of uncertain etiology. J Am Coll Cardiol 17:66-72.

Roijer A, Lindgren A, Rudling O, et al. 1996. Potential cardioembolic sources in an elderly population without stroke. A transthoracic and transesophageal echocardiographic study in randomly selected volunteers. Eur Heart J 17:1103-11.

Roudaut R, Lafitte S, Roudaut MF, et al. 2003. Fibrinolysis of mechanical prosthetic valve thrombosis: a single-center study of 127 cases. J Am Coll Cardiol 41:653-8.

Roudaut R, Roques X, Lafitte S, et al. 2003. Surgery for prosthetic valve obstruction. A single center study of 136 patients. Eur J Cardiothorac Surg 24:868-72.

Schwartzbard A, Freedberg RS, Kronzon I. 2000. The value of repeat transesophageal echocardiography in the evaluation of embolism from the aorta. J Am Soc Echocardiogr 13:1124-6.

Shapira Y, Herz I, Vaturi M, et al. 2000. Thrombolysis is an effective and safe therapy in stuck bileaflet mitral valves in the absence of high-risk thrombi. J Am Coll Cardiol 35:1874-80.

Simons AJ, Carlson R, Hare CL, Obeid AI, Smulyan H. 1992. The use of transesophageal echocardiography in detecting aortic atherosclerosis in patients with embolic disease. Am Heart J 123:224-6.

Stoddard MF, Dawkins PR, Price CR, Ammash NM. 1995. Left atrial appendage thrombus is not uncommon in patients with acute atrial fibrillation and a recent embolic event: a transesophageal echocardiographic study. J Am Coll Cardiol 25:452-9.

The French Study of Aortic Plaques in Stroke Group. 1996. Atherosclerotic disease of the aortic arch as a risk factor for recurrent ischemic stroke. N Engl J Med 334:1216-21.

Tong AT, Roudaut R, Ozkan M, et al. 2004. Transesophageal echocardiography improves risk assessment of thrombolysis of prosthetic valve thrombosis: results of the international PRO-TEE registry. J Am Coll Cardiol 43:77-84.

Tsai LM, Chen JH, Lin LJ, Teng JK. 1997. Natural history of left atrial spontaneous echo contrast in nonrheumatic atrial fibrillation. Am J Cardiol 80:897-900.

Vandenbogaerde J, De Bleecker J, Decoo D, et al. 1992. Transesophageal echo-Doppler in patients suspected of a cardiac source of peripheral emboli. Eur Heart J 13:88-94.