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Differentiating Thrombus From Pannus Formation in Obstructed Mechanical Prosthetic Valves: An Evaluation of Clinical, Transthoracic and Transesophageal Echocardiographic Parameters

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Objectives. **We sought to determine the clinical and echocardiographic parameters that differentiate thrombus from pannus formation as the etiology of obstructed mechanical prosthetic valves.**

Background. **Distinction of thrombus from pannus on obstructed prosthetic valves is essential because thrombolytic therapy has emerged as an alternative to reoperation.**

Methods. **We analyzed clinical, transthoracic and transesophageal echocardiography (TEE) data in 23 patients presenting with 24 obstructed prosthetic valves and compared the findings to pathology at surgery.**

Results. **Fourteen valves had thrombus and 10 had pannus formation. Patients with thrombus had a shorter duration from time of valve insertion to malfunction, shorter duration of symptoms, but similar New York Heart Association functional class at the time of operation. Patients with thrombus had a lower rate of adequate anticoagulation (21% vs. 89%; $p = 0.0028$). Pannus formation was more common in the aortic position (70% vs. 21%; $p = 0.035$). Abnormal prosthetic valve motion was detected by TEE in all cases with thrombus formation but in 60% with pannus ($p = 0.0198$). Thrombi were larger than pannuses (total length 2.8 ± 2.47 cm vs. 1.17 ± 0.43 cm; $p = 0.038$). This was mostly due to extension of thrombi into the left atrium in prosthetic mitral valves. Thrombi appeared as a soft mass on the valve in 92% of cases, whereas 29% of pannuses had a soft echo density ($p = 0.007$). Ultrasound video intensity ratio, derived as the videointensity of the mass to that of the prosthetic valve, was lower in the thrombus group (0.46 ± 0.14 vs. 0.71 ± 0.17, $p = 0.006$). A videointensity ratio of <0.70 had a positive predictive value of 87% and a negative predictive value of 89% for thrombus. Duration from onset of symptoms to reoperation of <1 month separated thrombus from pannus formation. The best objective clinical parameter for prediction of thrombus was inadequate anticoagulation, whereas the best TEE parameters were qualitative and quantitative ultrasound intensity of the mass. The presence of either inadequate anticoagulation or a soft mass by TEE improved the predictive power of either parameter alone and was similar to that of ultrasound videointensity ratio.**

Conclusions. **Duration of symptoms, anticoagulation status and qualitative and quantitative ultrasound intensity of the mass obstructing a mechanical prosthetic valve can help differentiate pannus formation from thrombus and may therefore be of value in refining the selection of patients for thrombolytic therapy of prosthetic valve obstruction.**

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Since 1960 when the first intracardiac mechanical prostheses were implanted, a considerable improvement in valve design resulted in a decrease in prosthetic valve complications. Despite these innovations, thrombogenicity of prosthetic valves remains the most common problem, estimated from 0.1% to 4% per year, depending on valve site, type and adequacy of anticoagulation (1). Clinical manifestations of this entity range between embolism, valve obstruction or regurgitation (1–4). Valve dysfunction may also be the result of fibrous tissue ingrowth or pannus formation (5–8). Recently, thrombolytic therapy has emerged as a successful alternative to reoperation in selected cases of thrombosed prosthetic valves (9–15). Therefore, the distinction between pannus and thrombus formation as the underlying etiology of valve dysfunction is essential. While a history of poor anticoagulation may be predictive of thrombus formation, distinction between thrombus formation and pannus based on clinical grounds may be difficult and does not necessarily predict success of thrombolysis. Furthermore, traditional methods of fluoroscopy to evaluate valve motion and cardiac catheterization for valve hemodynamics do not provide the means to assess the underlying etiology of valve obstruction.

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Doppler echocardiography is currently the noninvasive method of choice for evaluating prosthetic valve function (16–20). Transthoracic echocardiography (TTE) is, however, limited in assessing valve mobility and the mechanism of valve obstruction. With the advent of transesophageal echocardiography (TEE), improved definition of valve structure can be achieved compared with the TTE approach (16,21–27). Whether TEE can identify the etiology of valve obstruction and differentiate thrombus from pannus formation has not been previously evaluated. We hereby describe the clinical, echocardiographic and TEE findings in a series of patients with malfunctioning prosthetic valves due to pannus and/or thrombus formation which were documented at surgery. Clinical findings and qualitative and quantitative echocardiographic parameters of valvular abnormalities were evaluated to assess their accuracy in differentiating pannus from thrombus formation.

Methods

Patient population. The study group consisted of 23 consecutive patients with obstruction of mechanical prosthetic valves detected by Doppler echocardiography at the echocardiography laboratories of The Methodist Hospital, Houston, Texas, or The Hippokration Hospital, Athens, Greece, who underwent a TEE within 4 weeks prior to redo valve replacement. Patients with suspected endocarditis were excluded. There were 17 women and 6 men, with a mean age of 60 ± 12 years. In the 23 patients, there were 24 malfunctioning mechanical prosthetic valves: 13 bileaflet St. Jude Medical valves, 7 tilting disc, 3 caged-ball and 1 caged-disc valve. All patients had surgical and pathologic confirmation of pannus and/or thrombus as the underlying cause of the prosthetic valve obstruction. Demographic information, clinical data, operative details and pathologic results were obtained from medical records.

Echocardiographic studies. The TTE and TEE studies were performed using commercially available ultrasound machines (Hewlett-Packard Sonos 500, 1000, 1500 and 2500 [Andover, Massachusetts or Advanced Technology Laboratories [Bothell, Washington], Ultramark 9) and recorded on videotape. A multiplane or biplane transesophageal probe (5 MHz) was used in 14 cases, whereas a monoplane 5 MHz probe was used in the 9 early cases, prior to biplane technology. The TTE-Doppler studies were performed using well-established techniques for assessment of mitral or aortic prosthetic valve function (18,19). The TEE studies were performed preoperatively and/or intraoperatively using standard views, with particular attention directed at defining prosthetic valve mobility, structure and presence of any mass (or masses) on the valve and adjacent cardiac chamber. A total of 19 preoperative and 14 intraoperative TEE studies were performed. In nine patients with both preoperative and intraoperative examinations, the intraoperative study was used as the index TEE because of its time proximity to the surgical and pathologic evaluation. Mean time between TTE and TEE was 2.4 days (range 0 to 21 days) and mean time between TEE and surgery was 3.6 days (range 0 to 25 days).

Echocardiographic analysis. An observer unaware of the surgical and pathologic findings reviewed the echocardiograms. From the TTE studies the following parameters were derived. For aortic prostheses, maximum and mean gradients (mm Hg) were calculated as well as effective aortic valve area (cm^2) and Doppler velocity index (18), that is, the ratio of velocity in the left ventricular outflow to the velocity of the aortic jet. For mitral prosthetic valves, mean gradient (mm Hg), pressure half time (ms) and mitral valve area by pressure half-time (cm^2) were calculated (28,29). Ejection fraction (%) was measured using the multiple diameter method (30). The presence and severity of concomitant prosthetic valve regurgitation were evaluated by TTE and TEE, using conventional criteria for prosthetic aortic and mitral prostheses (23,29).

On the TEE studies, the motion of the valve was classified as normal or abnormal depending on whether the motion of the disc(s) or ball of the valve was normal or restricted. Any mass seen on a prosthetic valve was assessed as follows. The length (cm) of the mass and its area (cm^2) were measured from the view showing its largest extent. Furthermore, the length and area of the portion of the mass within the surgical ring was measured. Any extension of the mass beyond the limits of the prosthetic valve ring to adjacent cardiac structures was noted. The presence or absence of mobile portions of the mass was also assessed. The ultrasound intensity of the mass was classified visually as soft or dense. In addition, quantitative analysis of the videointensity was performed using computer software (TomTec Imaging Systems, Inc., Colorado), as follows. The area of the mass was traced and an average videointensity was determined. The highly echogenic part of the mechanical prosthesis was also traced and its videointensity determined. The mechanical prosthesis was chosen as reference because of its high ultrasound intensity and its similar depth (and gain settings) to the mass. A videointensity ratio was subsequently derived in each case as the ratio of the ultrasound videointensity of the mass to that of the mechanical prosthetic valve.

Reproducibility. Reproducibility of the qualitative and quantitative parameters of ultrasound intensity of the mass was assessed in 10 randomly selected studies. These studies were analyzed by two independent observers and by the first observer at a later day. Reproducibility of Doppler derived gradients and valve areas has been published previously from our laboratory (18,19).

Statistical analysis. Statistical association between categorical variables in the pannus and thrombus groups were assessed using the chi-square test or the Fisher exact test where appropriate. The unpaired *t* test was used for comparisons of means in the two groups. When the data did not follow a Gaussian distribution, the Mann–Whitney rank sum test was applied. Sensitivity, specificity, positive and negative predictive values were assessed in the standard manner. A p value <0.05 was regarded as significant.

Table 1. Demographic and Clinical Parameters of Patients With Obstructed Valves Secondary to Pannus or Thrombus Formation

	Thrombus	Pannus	p Value
n	14	9	
Age (yrs)	62 ± 13	56 ± 11	0.30
LVEF (%)	49 ± 14	57 ± 10	0.13
Atrial fibrillation	43%	33%	0.69
Time from initial onset of symptoms to reoperation (days)	9 ± 6	305 ± 234	0.0006
Time from valve replacement to reoperation (months)	62 ± 57	178 ± 52	0.0006
Adequate anticoagulation	21%	89%	0.0028
NYHA class III or class IV symptoms	79%	67%	0.64

Data presented are mean value ± SD or % of patients. LVEF = left ventricular ejection fraction; NYHA = New York Heart Association.

Results

The 24 dysfunctional valves included 10 aortic and 14 mitral prosthetic valves. Surgical and pathologic results revealed that the underlying cause of malfunction was thrombus in 12 cases, pannus formation in 10 cases and a combination of thrombus and pannus in 2 cases. Twenty-one valves had severe obstruction alone or were associated with mild or moderate regurgitation, and 3 had combined severe obstruction and regurgitation.

Clinical characteristics of patients with pannus versus thrombus formation. Demographic and clinical data of patients with malfunctioning prosthetic valves due to thrombus or pannus formation are shown in Table 1. The two patients with combination of thrombus and pannus were included in the thrombus group because of the inherent implication for thrombolytic therapy. Moreover, results were similar whether these two patients were included or excluded. Patients with valve thrombosis and those with pannus formation had similar age, left ventricular ejection fraction, incidence of atrial fibrillation and New York Heart Association functional class (Table 1). Although functional class was overall similar at the time of reoperation, symptoms of heart failure in patients with pannus were more insidious. Three patients with pannus formation were asymptomatic, and valve malfunction was diagnosed during echocardiographic examination after abnormal auscultation. The remaining patients with obstruction due to pannus had longer duration of progression of symptoms until reoperation compared to patients with thrombus. Three patients with obstruction due to pannus had an acute deterioration of symptoms before reoperation. The interval from valve insertion to reoperation was longer in the valves with pannus formation. Adequate anticoagulation was defined as International Normalized Ratio (INR) ≥ 2.5 at the time of diagnosis. Eleven patients (48%) were considered to have adequate anticoagulation, 8 in the pannus group and 3 in the thrombus group. Of the patients with thrombosed valves, two were not receiving coumadin and were only on antiplatelet agents and another two had valve thrombosis after noncardiac surgery. Adequate anticoagulation was more frequent in patients with pannus compared to thrombus. Pannus formation was more common in the aortic position compared to the mitral position (70% vs. 21%, $p = 0.035$).

Transthoracic echocardiographic findings: pannus versus thrombus formation. Results of valve hemodynamics by transthoracic Doppler are shown in Table 2. In general, the severity of obstruction was similar with either pannus or thrombus formation. Maximal and mean gradients, valve area and Doppler velocity index were similar for obstructed aortic valves by either etiology. For mitral valves, the mean gradient was less in patients with pannus formation, and valve areas were similar in the two groups. Imaging with TTE was not helpful in assessing valve motion or evaluating the underlying etiology of valve obstruction. In only one case was TTE suggestive of a mass on a mitral prosthesis.

Transesophageal echocardiography findings: pannus versus thrombus formation. Descriptive and quantitative findings by TEE in valves with thrombus formation or pannus are shown in Table 3. The TEE imaging revealed abnormal motion of the disc(s) or the ball of the prosthesis in all patients with valve thrombosis and in only six (60%) valves with obstruction due to pannus. In three of the cases with pannus and normal

Table 2. Transthoracic Echocardiographic Doppler Parameters of Malfunctioning Valves With Pannus or Thrombus Formation

	Thrombus (n = 14)	Pannus (n = 10)	p Value
Aortic Position			
n	3	7	
Maximum gradient (mm Hg)	83 ± 18 (64–100)	101 ± 27 (71–149)	0.26
Mean gradient (mm Hg)	44 ± 7 (40–52)	59 ± 15 (31–79)	0.077
Doppler velocity index	0.20 ± 0.04 (0.16–0.24)	0.19 ± 0.02 (0.15–0.22)	0.76
Valve area (cm^2)	0.77 ± 0.19 (0.55–0.90)	0.65 ± 0.11 (0.50–0.81)	0.43
Mitral Position			
n	11	3	
Mean gradient (mm Hg)	19 ± 5 (12–27)	11 ± 2 (9–12)	0.026
Pressure half-time (ms)	310 ± 61 (244–423)	223 ± 40 (195–251)	0.23
Valve area (cm^2)	0.73 ± 0.12 (0.52–0.90)	1.0 ± 0.13 (0.88–1.13)	0.28

Data are presented as mean value ± SD and range.

Table 3. Qualitative and Quantitative Parameters by TEE in Obstructed Valves Secondary to Thrombus or Pannus Formation

	Thrombus	Pannus	p Value
Detection of abnormalities by TEE			
Abnormal valve motion	14/14 (100%)	6/10 (60%)	0.0198
Mass visualized on valve	13/14 (93%)	7/10 (70%)	0.27
Characteristics of mass by TEE			
n	13	7	
Layered mass ≤3 mm thick	15%	29%	0.59
Mobile portion(s) of mass present	46%	29%	0.64
Total mass area (cm^2)	2.23 ± 2.1	1.22 ± 0.63	0.13
Total mass length (cm)	2.8 ± 2.47	1.17 ± 0.43	0.038
Extension of mass into LA/LAA in prosthetic mitral valves	4/11 (36%)	0/3 (0%)	0.25
Soft ultrasound intensity	92%	29%	0.007
Ultrasound videointensity ratio	0.46 ± 0.14	0.71 ± 0.17	0.006

Data presented are number (%) of valves or masses, or mean value ± SD. LA/LAA = left atrium/left atrial appendage; TEE = transesophageal echocardiography.

valve motion by TEE, a mass was found at surgery just below the valve, obstructing the left ventricular outflow tract without interfering with motion of the valve. An abnormal mass on the prosthetic valve could be seen by TEE in 93% of thrombosed valves and in 70% of valves with pannus formation. The TEE imaging was unsuccessful in three cases with pannus: in an aortic Starr–Edwards valve where pannus ingrowth was in the form of a concentric ring just below the valve, and in two mitral prosthetic valves (Björk–Shiley and Cooley–Cutter) where a small amount of pannus on the hinges of the valve was affecting the mobility of the disc. The only thrombus which was not seen by TEE was also small, limited to the hinges of an aortic St. Jude Medical valve.

In the cases where a mass was detected by TEE, the shape of the mass on the prosthetic valve did not differentiate the two etiologies. Pannuses and thrombi were visualized as a rounded or irregular mass in 71% and 85% of cases, respectively, and as a thin layer (≤3 mm thick) in 29% and 15%, respectively. The presence of a mobile portion of the mass also did not differentiate thrombus from pannus formation. Overall, thrombi were larger than pannuses (Table 3, Fig. 1). The difference in size of the mass was contributed to by the extension of the thrombus into the left atrium in four prosthetic mitral valves with thrombosis and in none of the mitral valves with pannus formation (Fig. 2). A tendency was observed for the portion of the mass confined within the surgical ring to be larger in valve thrombosis compared to pannus formation (area: 1.7 ± 1.9 vs. 1.22 ± 0.63 cm^2, $p = 0.41$; length: 1.36 ± 0.72 vs. 1.17 ± 0.43 cm; $p = 0.49$, respectively).

Qualitative and quantitative parameters of ultrasound intensity were significantly different in thrombi compared to pannus formation. Of the 13 thrombi detected with TEE, 12 (92%) appeared visually to have a soft echo intensity similar to myocardium (Fig. 2), compared to 29% (2 of 7) of pannus formation ($p = 0.007$) (Figs. 3 and 4). The ultrasound videointensity ratio was lower for thrombi compared to pannus (Table 3, Fig. 5). Although overlap in ultrasound intensity existed between the two groups, the use of this quantitative parameter allowed the use of cutoffs to improve the prediction of either entity. The receiver-operator curve for the prediction of thrombus formation with the ultrasound videointensity ratio when a mass is detected on the valve by TEE (n = 20) is shown in Fig. 6. All thrombi had a videointensity ratio of <0.7 (sensitivity 100%, specificity 71%). A videointensity ratio of ≤0.4 was 100% specific for thrombi, while a ratio ≥0.7 was 100% specific for pannus formation.

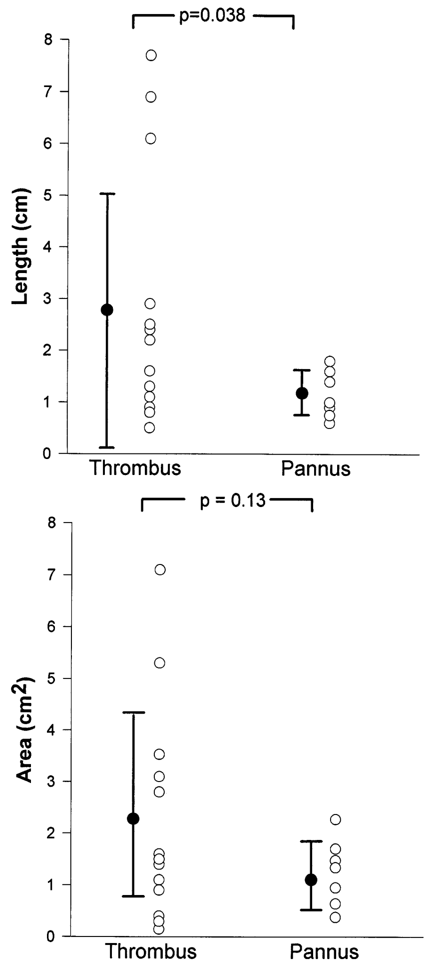


Figure 1. Plots of total mass length (**top**) and total mass area (**bottom**) of the 13 thrombi and 7 pannuses that were identified by TEE.

Reproducibility. The interobserver and intraobserver agreement for visual assessment of the mass as soft versus dense was 90%. There were no statistical differences between the videointensity ratio derived by the two observers or by the first observer at a later day. The mean difference in ultrasound videointensity ratio was −0.021 ± 0.037 (interobserver) and −0.014 ± 0.041 (intraobserver).

Prediction of thrombus formation. From a clinical standpoint, a duration of onset of symptoms to reoperation of <1 month separated all thrombi from pannus formation in the present series. However, the best objective clinical parameter

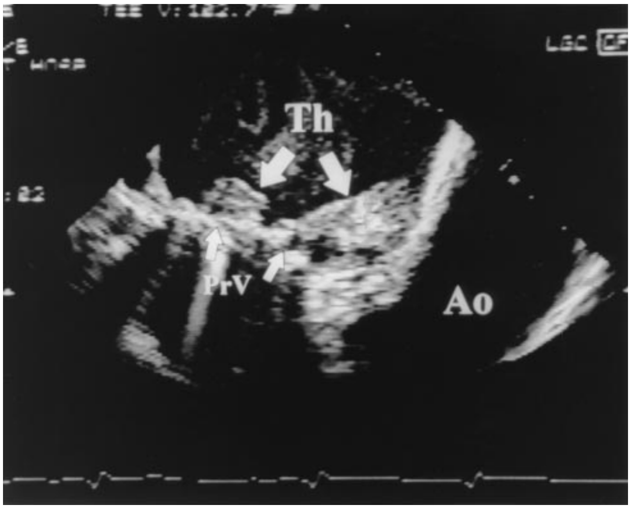
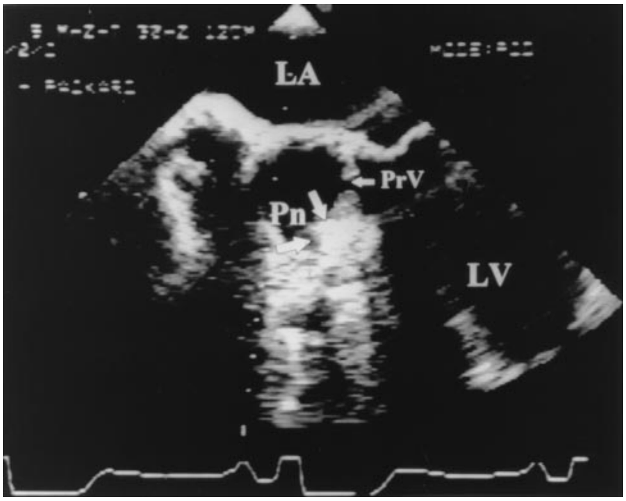


Figure 2. Transesophageal echocardiogram showing a thrombus **(large arrows)** visualized as a soft mass on the atrial side of a bileaflet mitral prosthetic valve. There is extension of the thrombus to the left atrial wall. **Small arrows** indicate the level of the prosthesis. Ao = aorta; PrV = prosthetic valve; Th = thrombus.

for prediction of thrombus was inadequate anticoagulation. On the other hand, the best TEE parameters for prediction of thrombus were qualitative and quantitative intensity of the mass. Table 4 shows the sensitivity, specificity and predictive values of anticoagulation status and TEE parameters in the prediction of thrombus formation for all 24 valves (including those without visualization of mass on the valve by TEE). For prediction of thrombus, the negative predictive value of inadequate anticoagulation was 75% and of a soft mass by TEE was 80%. This increased to 89% with a videointensity ratio of <0.7. The presence of either inadequate anticoagulation or a soft mass by TEE improved the predictive power of either parameter alone and was similar to that of videointensity ratio.

Figure 3. Transesophageal echocardiogram showing a pannus **(large arrows)** visualized as a dense mass on a tilting-disc aortic prosthesis. **Small arrow** indicates the valve ring. LA = left atrium; LV = left ventricle; Pn = pannus; PrV = prosthetic valve.



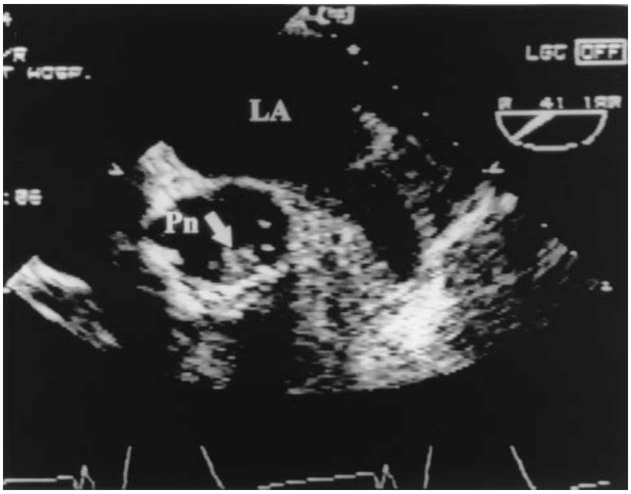
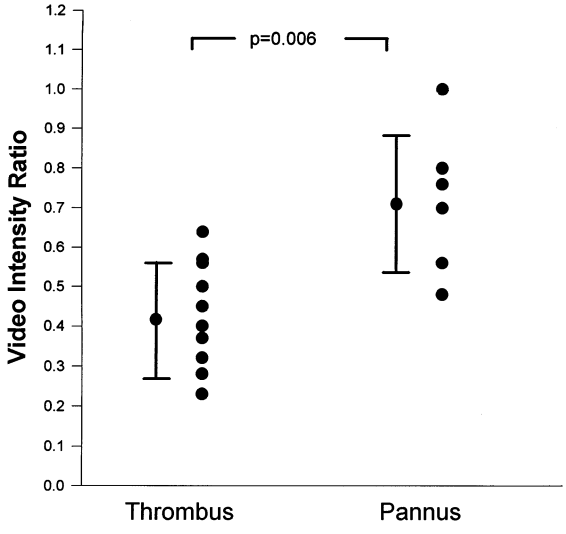


Figure 4. Transesophageal echocardiogram showing a pannus **(arrow)** visualized as a soft mass on a bileaflet aortic prosthesis. LA = left atrium; Pn = pannus.

Discussion

The present study is the first to evaluate the usefulness of clinical and echocardiographic parameters in assessing the etiology of prosthetic valve obstruction, namely differentiating thrombus from pannus formation. Clinically, patients with thrombus formation had shorter duration of symptoms to reoperation and had more often inadequate anticoagulation. Using TEE, a significant overlap existed between the morphologic characteristics of the two etiologies. Compared to pannus formation, thrombi were usually larger and, in the case of mitral prostheses, extended more often into the left atrium. The most important TEE parameter that differentiated thrombus from pannus was the ultrasound intensity of the mass. A videointensity ratio of <0.7 had the best negative predictive value for thrombi. Similar predictive accuracy was achieved

Figure 5. Plots of the ultrasound videointensity ratio in the 13 thrombi and 7 pannuses that were visualized by TEE.



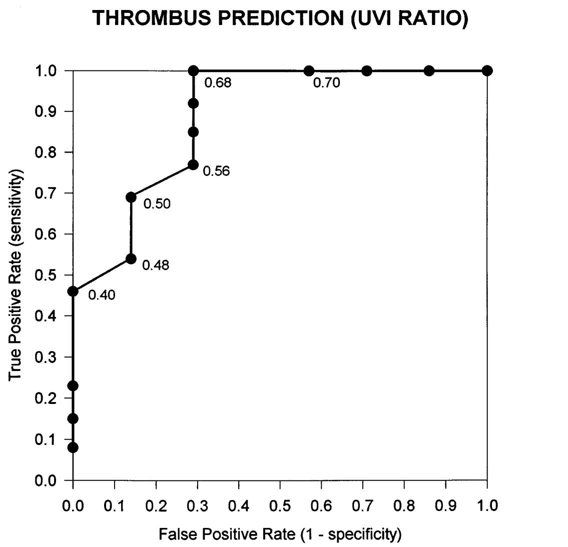


Figure 6. Receiver-operator curve for prediction of thrombus using the ultrasound videointensity ratio. UVI = ultrasound videointensity.

with the combination of inadequate anticoagulation or the presence of a soft mass by TEE.

Differentiating thrombus from pannus formation. The incidence of prosthetic valve obstruction has been recently estimated at 0.1% to 4% per year, and is dependent on several factors including valve size, type and location, and adequacy of anticoagulation (1). The underlying etiology of prosthetic valve obstruction is most commonly thrombus formation (5–8). In a study by Deviri et al. (8) evaluating the surgical findings of 112 obstructed mechanical valves, pannus formation was the underlying cause in 10.7% of valves, pannus in combination with thrombus was present in 11.6%, whereas thrombus alone or with little pannus formation was found in 77.7%. The prediction of thrombus formation as the predominant mechanism of obstruction has important clinical implications because thrombolytic therapy has recently emerged as an alternative to reoperation (9–15). A high negative predictive value for thrombus would allow detection of most thrombi and therefore identify patients with pannus formation who can forgo attempts at thrombolytic therapy and undergo immediate valve surgery, particularly when presenting with hemodynamic instability.

Table 4. Sensitivity, Specificity and Predictive Accuracy of Inadequate Anticoagulation and TEE Parameters for Prediction of Prosthetic Thrombosis in 24 Obstructed Valves

	Sensitivity (%)	Specificity (%)	PP Value (%)	NP Value (%)
Inadequate anticoagulation	79	90	92	75
Soft mass by TEE	86	80	86	80
UVI ratio <0.70	93	80	87	89
Inadequate anticoagulation or soft mass by TEE	93	80	87	89
Inadequate anticoagulation or UVI ratio <0.70	93	80	87	89

NP = negative predictive; PP = positive predictive; TEE = transesophageal echocardiography; UVI = ultrasound videointensity.

Among clinical variables affecting the incidence of thrombus formation, long-term anticoagulation is the most important (1,2,8,11,13–15). In patients with valve obstruction requiring reoperation or thrombolytic therapy, inadequate anticoagulation has been reported between 48% and 92% (2,8,11,13,14). In the only case series that has related the adequacy of anticoagulation to pathologic findings, 48% (13 of 27) of patients with prosthetic valve obstruction secondary to thrombus had inadequate anticoagulation (2). There are no reports in the literature assessing the level of anticoagulation in patients with pannus formation. In the present study, suboptimal anticoagulation was present in 78% of valve thrombosis and in only 11% of pannus formation, further confirming the clinical suspicion that patients with valve obstruction in the setting of therapeutic anticoagulation are more likely to have pannus formation.

Time from valve insertion to malfunction was longer in patients with pannus. A period of 6 months or longer after implantation is usually needed for tissue overgrowth in a mechanical prosthesis (5,6), although a shorter time interval from valve replacement has been reported (7). In the present study the minimum time was 12 months in a valve with a combination of pannus and thrombus and 78 months in a valve with sole pannus formation. In addition, patients with thrombus had a shorter duration from onset of symptoms to reoperation. This finding is in agreement with observations by Silber et al. (14). However, Kontos et al. (2) have reported more prolonged symptoms in patients with malfunctioning prosthetic valves due to thrombus formation (56% had symptoms for more than a month before reoperation). There is currently no information about the duration of symptoms in patients with valve obstruction due to pannus formation. In our population, six patients had progression of symptoms from 1 month to 2 years, three of whom had acute deterioration a few days prior to reoperation, while another three patients were asymptomatic. The patient with the longest duration of symptoms had two malfunctioning prosthetic valves due to pannus, but also had severe tricuspid regurgitation, which could have contributed to his symptomatology. Overall, the prolonged duration of symptoms in patients with valve obstruction due to pannus formation may reflect the long, slow process of pannus growth until a severe subvalvular obstruction is created or the valve mechanism is blocked. Although duration of heart failure symptoms prior to reoperation was seemingly the best parameter in differentiating the two etiologies in the present series, it is subjective, determined by the timing of the intervention, and may be confounded by the presence of ventricular dysfunction or other valvular lesions (2). Furthermore, this parameter is not a predictor of successful thrombolysis (11,13,14). Among more objective clinical variables, adequacy of anticoagulation differentiated best between patients with thrombus and pannus formation.

Transthoracic and transesophageal echocardiographic findings. Transthoracic echocardiography is limited in evaluating structural abnormalities of prosthetic valves because of attenuation and acoustic shadowing (16,21–27). This was further supported in the present investigation where only one valve was suspicious of a thrombus by TTE. In contrast, TEE provides a unique tool to assess valvular details. In 83% of obstructed valves, an abnormal structure on the prosthesis was detected. In the cases where TEE failed to identify an etiology, it was more often a small mass, usually pannus, interfering with the hinges of the prosthesis.

The TEE examination showed that thrombi leading to valve obstruction were overall larger than pannuses. In mitral valves, extension of the mass into the left atrium was specific for thrombus formation but occurred in 36% of cases. Other characteristics of the mass, such as features of a thin layer, the presence of mobile portions or its size alone, did not adequately differentiate between the two etiologies. The ultrasound intensity of the mass imaged by TEE, however, helped differentiate pannus from thrombus. A structure with soft echodensity, similar to myocardium, was more often seen with thrombus. Quantitative assessment of the echo intensity by the ultrasound videointensity ratio slightly improved the differentiation between pannus and thrombus but importantly provided an objective and quantitative parameter for ultrasound intensity and allowed the use of cutoff values to enhance prediction of either entity. A videointensity ratio <0.7 had the best negative predictive value (89%) for thrombi compared to all other parameters, which increased to 100% in valves where a mass was identified by TEE. The combination of inadequate anticoagulation or a low ultrasound intensity of the mass by TEE (qualitatively or quantitatively) achieved the same predictive accuracy compared with videointensity ratio alone. Although this may provide redundant information, it would further strengthen the clinical diagnosis and may improve the selection of patients for thrombolysis or redo valve surgery. Whether these parameters help predict the success of thrombolysis and the merit of quantitation of ultrasound intensity of the mass in this prediction remains to be determined.

Study limitations. The present study is retrospective and pathologic data were obtained from medical records. Although the different kinds of prostheses evaluated may potentially be a limitation, this allows testing the usefulness of TEE in a variety of mechanical valves. Requirement of a recent TEE prior to surgery and exclusion of patients who underwent thrombolysis limited the number of patients studied, but allowed evaluation of the usefulness of TEE in this condition. Studies were performed with a multiplane or biplane TEE probe in the majority of patients; the remaining patients were evaluated prior to this technology. However, every attempt to modify plane position in addition to side flexion was performed. It is of interest that two of the four nonvisualized etiologies of valve obstruction (one aortic and one mitral) had multiplane studies. Ultrasound intensity was assessed qualitatively and quantitatively. Limitations of videodensitometry include, among others, gain dependency and logarithmic compression. The videointensity ratio attempts to normalize the ultrasound intensity in an image, where gains are usually optimized for identification of cardiac structures. Qualitative assessment of ultrasound intensity related well to this quantitative index, which provided a more objective parameter of ultrasound intensity.

Conclusions. In obstructed mechanical prosthetic valves, duration of symptoms and adequacy of anticoagulation are helpful in differentiating thrombus from pannus formation. The use of TEE can assess the mechanism and etiology of obstruction. Thrombus is overall larger than pannus and often extends into the left atrium in prosthetic mitral valves. The best parameter by TEE that differentiates the two entities is the ultrasound intensity of the mass. The combination of clinical parameters and ultrasound density of the mass by TEE further strengthens the differentiation of thrombi from pannus formation and may therefore be of value in refining the selection of patients for thrombolysis. Whether TEE can further improve the safety of thrombolysis of prosthetic valve thrombosis by selecting patients with small, nonmobile thrombi remains to be determined.

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