Detection of Prosthetic Valve Strands by Transesophageal Echocardiography: Clinical Significance in Patients With Suspected Cardiac Source of Embolism

DAVID A. ORSINELLI, MD, FACC, ANTHONY C. PEARSON, MD, FACC

Columbus, Ohio

Objectives. The purpose of this study was to determine how frequently prosthetic valve strands are associated with prosthetic mitral and aortic valves, as detected by transesophageal echocardiography, and to assess their significance in relation to clinical cardioembolic events.

Background. Strands attached to prosthetic mitral valves are a recently described finding of uncertain clinical significance. There are no reports of strands attached to aortic valve prostheses, and data are limited concerning the relation of valvular strands to cardioembolic events.

Methods. We identified all transesophageal echocardiographic studies performed during a 5-year period at our institution for evaluation of valve dysfunction or a suspected cardioembolic event in patients with a valve prosthesis. All studies were reviewed. The presence of strands was noted and the prevalence compared between patients evaluated for a suspected cardioembolic event and those evaluated for valve dysfunction. In patients with no strands detected, the presence of other potential cardiac sources of embolism was noted.

Results. Strands were detected in 56 (26%) of 214 studies. There was a significant difference (p = 0.0001) in the prevalence of strands between studies performed for a suspected cardioembolic event (34 [53%] of 64) versus those performed for suspected valve dysfunction (22 [15%] of 150). Strands were more prevalent on mitral than on aortic valves (32% vs. 13%, p = 0.0004) and were more frequently detected on mechanical than bioprosthetic valves (27% vs. 8%, p = 0.003). Among patients with a suspected cardioembolic event and normal valves, other potential cardiac sources of embolism were detected in 67%.

Conclusions. Prosthetic valve strands are frequently detected by transesophageal echocardiography. They are more commonly detected in patients being evaluated for a suspected cardioembolic event and thus represent a potential cardiac source of embolism. In patients with apparently normal valves, other potential sources of embolism are frequently detected. Thus, transesophageal echocardiography may have a significant impact on the management of these patients.

(J Am Coll Cardiol 1995;26:1713–8)

As experience with transesophageal echocardiography grows and as image quality improves, more findings of uncertain clinical significance are being identified. Native and prosthetic valve strands, which appear as highly mobile linear echodense structures attached to the valve or sewing ring, are one of these findings (8,12,13).

The purpose of the present study was to determine how frequently prosthetic valve strands are associated with mitral and aortic valves in patients undergoing transesophageal echocardiography for the evaluation of a suspected cardioembolic event. In addition, we assessed the presence of other potential cardiac sources of embolization in patients with a suspected cardioembolic event whose prosthetic valves showed no strands. Finally, we compared the presence of prosthetic valve strands in these patients with that in patients undergoing transesophageal echocardiography to evaluate suspected prosthetic valve dysfunction.

Methods

Patient identification. All transesophageal echocardiographic studies performed at our institution in patients with prosthetic cardiac valves over a 5-year period (October 1989...
through November 1994) were identified from a computerized data base in our laboratory. During the study period, a total of 359 transesophageal echocardiographic studies performed in patients with prosthetic valves were available for review; an additional 10 studies performed during this period were not available for review. Intraoperative studies were excluded from consideration. All studies were performed for clinical indications and written informed consent was obtained for each study. Clinical and demographic information, and the indication for the transesophageal echocardiogram were obtained from a review of the echocardiography consultation form and the clinical history documented on the final clinical report.

To avoid the possibility of identifying small vegetations as strands, we subsequently excluded transesophageal echocardiographic studies performed in patients because of suspected prosthetic valve endocarditis and follow-up studies performed to reassess previously documented valve abnormalities. The current study thus included a total of 214 studies performed because of a suspected cardioembolic event, prosthetic valve dysfunction or non-valve-related indications in 182 patients with a mitral or aortic prosthetic valve, or both.

**Echocardiography.** Transesophageal echocardiography was performed in a standardized fashion with commercially available equipment (14). The majority of studies were performed with a Hewlett-Packard single plane (model 21362A), biplane (model 21363A) or multplane (model 21364A) probe in conjunction with a Hewlett-Packard Sonos 500, 1000 or 1500 imaging system. Several studies done early in the series were performed with an ATL single plane probe using an ATL Ultramark 9 imaging system (Advanced Technologies Laboratory). Patients were studied after a fast of ≥4 h. Transesophageal echocardiography was performed after administration of local pharyngeal anesthesia with a topical lidocaine or Cetacaine (Cetalyte Industries) spray and intravenous sedation with midazolam or meperidine, or both, as needed. Patients who were not being treated with antibiotics were given antibiotic prophylaxis according to the recommendations of the American Heart Association (15,16). All studies were recorded on videotape for subsequent review. No complications attributable to the procedure were reported.

**Strands.** Prosthetic valve strands were defined as mobile linear echodense structures attached to the valve sewing ring, struts or hinge points (Fig. 1). They are typically 1 to 2 mm in width and several mm in length. Strands are distinct from larger valvular masses such as thrombus or vegetations. They were differentiated from loose sutures, which tend to be shorter, brighter and spaced regularly around the sewing ring. These strands are also different from prosthetic valve microbubbles, which appear as bright, highly mobile echoes that move rapidly away from the valve at the time of valve closure, whereas strands are fixed to the valve and are seen in the same position on the valve from beat to beat (17).

**Echocardiographic review.** All transesophageal echocardiographic studies were independently reviewed by an experienced echocardiographer who had no knowledge of the patient's clinical status. The reviewer determined the presence or absence of prosthetic valve strands and analyzed the study with regard to prosthetic valve function, presence of left atrial spontaneous contrast and global left ventricular function. This interpretation of the echocardiogram was then compared with the clinical report generated by the physician who performed and interpreted the study. Disagreements were resolved by consensus.

**Statistics.** Continuous variables are expressed as mean value ± SD. Dichotomous variables were compared by using contingency table and chi-square analysis. A p value < 0.05 was considered statistically significant.

**Results**

Over the 5-year study period, a total of 214 transesophageal echocardiographic studies were performed in 182 patients with a prosthetic valve for the evaluation of a suspected cardiac source of embolus, suspected prosthetic valve dysfunction or miscellaneous non-valve-related indications. Patients underwent 1 to 4 studies (mean 1.2 ± 0.5). The patients had a mean age of 55 ± 15 years; 45% were men.

Sixty-four of the 214 studies were performed in 59 patients to evaluate a possible cardiac source of embolization. The other 150 studies were performed in 133 patients to evaluate the prosthesis because of new or changing symptoms (135 studies) or non-valve-related indications (15 studies). Thus, 10 patients underwent a transesophageal echocardiogram for both indications. Because of the small number of studies performed for miscellaneous reasons (n = 15), subsequent analysis was performed comparing the 64 studies assessing patients for a cardiac source of embolization with the remaining 150 studies.
Prevalence of strands. Prosthetic valve strands were detected in 56 (26%) of the 214 studies. Of the 64 studies performed to evaluate a cardiac source of embolization, prosthetic valve strands were found in 34 (53%). In contrast, strands were detected in only 22 (15%) of the 150 remaining studies (p = 0.0001). Patients studied to evaluate a possible cardiac source of embolization were more likely to have a mechanical valve than were patients being evaluated for suspected prosthetic valve dysfunction or miscellaneous reasons (89% vs. 70%, p = 0.003). In addition, studies in patients with a mechanical valve were significantly more likely to show prosthetic valve strands than were studies in patients with a bioprosthetic valve (31% vs. 10%, p = 0.002).

To exclude the possibility that the association of strands with cardioembolic events merely reflected a higher prevalence of mechanical prostheses in our study patients, we analyzed the studies of mechanical and bioprosthetic valves separately. Of the 162 studies in patients with a mechanical valve, strands were detected in 32 (56%) of 57 studies performed for a cardioembolic event compared with 19 (18%) of the remaining 105 studies (p = 0.0001). Of the 52 studies in which only a bioprosthetic valve was present, strands were detected in 2 (29%) of 7 studies performed for a cardioembolic event compared with 3 (7%) of the 45 remaining studies (p = 0.07).

In 34 studies, both an aortic and a mitral valve prosthesis were present. Thus, a total of 248 valves (130 mitral and 118 aortic) were evaluated, and strands were detected on 56 (23%) of the 248 valves. As in the preceding analysis of results by study, a similar analysis of all valves by indication for study revealed that strands were significantly more likely (p = 0.0001) to be detected on valves studied for a cardioembolic event (34 [47%] of 72) than on the remaining valves being evaluated (22 [13%] of 176).

Strands were detected on 41 mitral valves (32%) compared with 15 aortic valves (13%) (p = 0.0004). Strands were more frequently detected on mechanical than on bioprosthetic valves (27% vs. 8%, p = 0.003). Figure 2 depicts the prevalence of strands by valve location and type. Subgroup analysis of the prevalence of strands by valve type and location (data not shown) was similar to the overall analysis described earlier.

A total of 26 patients underwent more than one study. To eliminate the assessment of a given valve more than once, the results were reanalyzed by entering only the first study performed, regardless of indication or presence of valvular strands, or both, into the analysis. Of the 182 initial studies, 53 were performed for a cardiac source of embolism and 129 to assess the prosthetic valve or for miscellaneous reasons. A total of 212 individual valves (108 mitral and 104 aortic prostheses) were studied in the 182 patients. As in the analysis of the overall study group, strands were more common (p = 0.0001) in studies performed to evaluate a cardioembolic event (28 [53%] of 53) than in the remaining studies (18 [14%] of 129). In addition, the analysis concerning the prevalence of strands when assessed by valve type and location (data not shown) was similar to the overall analysis described earlier.

Patients with multiple studies. A total of 26 patients underwent multiple studies. In 20 patients (42 studies), strands were either present (5 patients, 10 studies) or absent (15 patients, 32 studies) in all studies performed. Discordant results (i.e., strands present in some but not all studies) were noted in the other six patients (16 studies). In three patients (eight studies) evaluated on all occasions for suspected prosthetic valve dysfunction, strands were detected in one study in each and absent in all other studies. The remaining three patients underwent eight studies; strands were detected in three of the five studies performed to rule out a cardiac etiology of a suspected embolic event, whereas no strands were
detected in two of the three studies performed for suspected prosthetic valve dysfunction.

**Findings in patients with a normal prosthesis.** Of the 30 studies performed in patients with a suspected cardioembolic event in whom no strands were detected on the prosthesis, 20 showed other abnormalities that have been associated with systemic embolization, including definite sources of embolism in 6 studies (left atrial thrombus in 3, unsuspected prosthetic mitral valve vegetations in 2 and prosthetic valve thrombus in 1). Possible sources of embolism included spontaneous left atrial contrast in eight studies, an atrial septal defect or patent foramen ovale in five, atrial septal aneurysm in two, mitral valve prolapse in two and aortic atherosclerosis (plaque) in seven. In eight studies (including three of the studies with definite sources of embolism), more than one potential cardiac source of embolism was detected.

**Representative cases: surgical-pathologic correlation.** We have surgical and pathologic data on three patients who underwent valve replacement for repeated cardioembolic events. All three patients had a transesophageal echocardiogram that demonstrated prosthetic valve strands. A fourth patient is described to highlight the utility of transesophageal echocardiography in this patient group even if no strands are detected.

**Patient 1.** This 49-year old man with a 10-year old Starr-Edwards mitral prosthesis had a history of multiple cerebral embolic events despite adequate anticoagulation. Transesophageal echocardiography demonstrated prosthetic valve strands (Fig. 3). He underwent valve replacement. At operation, the surgeon described “filamentous strands of fibrous material” were described by the surgeon.

**Patient 2.** This 42-year old man presented with multiple transient ischemic attacks that were thought to be cardioembolic in origin. Transesophageal echocardiography on two occasions 1 month apart demonstrated multiple mobile strands attached to his Starr-Edwards mitral valve. He underwent valve replacement and has since done well with no repeated events. At operation, the surgeon described “fronds of material and calcification over the atrial surface of the sewing ring,” with “frayed cloth” present. The pathology report noted pannus formation on the cage and sewing ring.

**Patient 3.** A 39-year old woman with a 3-year old Starr-Edwards mitral prosthesis presented with a transient ischemic attack. A transesophageal echocardiogram demonstrated prosthetic valve strands attached to the medial and lateral aspects of the sewing ring. The patient had repeated transient ischemic attacks. A second transesophageal echocardiogram, performed 4 months later, demonstrated persistence of the strands despite therapeutic prothrombin times. She underwent valve replacement, and at the time of operation, the surgeon described “a large ring of clot around the prosthesis.” However, the pathology report described no thrombus or pannus. Since the operation she has done well with no further neurologic events.

**Patient 4.** This 61-year old man with a Starr-Edwards mitral prosthesis underwent four serial transesophageal echocardiograms. On the initial study, performed to assess possible prosthetic valve dysfunction, the valve appeared normal. The second study, performed 9 months later after a transient ischemic attack in the setting of a therapeutic prothrombin time, demonstrated strands attached to the valve. Dipyridamole was added to the patient’s regimen and a repeat transesophageal echocardiogram, performed 6 weeks later, showed no strands on the valve. This patient had another transient ischemic attack several months later, and repeat transesophageal echocardiography demonstrated a normal prosthesis. Spontaneous left atrial contrast, seen on prior studies, was still present, and a new left atrial appendage thrombus was detected.
Discussion

With the increasing use of transesophageal echocardiography for evaluation of prosthetic cardiac valves, it has become more important to understand the normal appearance of these valves and to differentiate subtle abnormalities from normal findings. Several studies (9-11,18,19) have described the normal appearance and function of prosthetic valves as assessed by transesophageal echocardiography and have demonstrated an increased sensitivity over transthoracic echocardiography in the detection of prosthetic valve abnormalities.

Comparison with prior studies. Valve strands detected on prosthetic valves are a recently described finding of uncertain clinical significance (12,13,20,21). Stoddard et al. (12) reported on their prevalence in 13 patients with a St. Jude mitral valve who underwent 26 transesophageal echocardiographic studies. Strands were present on 38% (5 of 13) of the valves at the time of initial study. Five patients with initially negative findings on transesophageal echocardiography underwent serial transesophageal echocardiographic studies; prosthetic valve strands were subsequently detected in four of these patients. Thus, 9 (69%) of 13 patients had mitral valve strands detected on at least one occasion. No relation between strands and cerebral emboli was reported.

Isada et al. (13) reported on 76 patients with a prosthetic mitral valve who underwent 83 transesophageal echocardiographic studies. Prosthetic mitral valve strands were detected in 18% of all studies and were significantly more frequent on mechanical valves. Of the 83 studies, 71 were performed to assess valve function; only 7 were performed specifically to detect a cardiac source of embolism. Strands were detected more frequently on mechanical valves. These authors reported an association of strands with embolic events, but only seven studies were performed to specifically evaluate the patient for a cardioembolic event.

In a recent report on "nonobstructive thrombosis" of mitral prostheses (22), small thrombi were detected on 18% of 114 mitral valves studied for a variety of reasons. An association between these thrombi and embolic events was reported. Whether some of these thrombi represented strands cannot be ascertained from the description of the findings in that report.

In the current study, we detected strands in 26% (56 of 214) of studies in a group of patients undergoing transesophageal echocardiography for the evaluation of a suspected cardioembolic event, suspected prosthetic valve dysfunction or non-valve-related indications. This represented a prevalence of strands in 23% of all individual valves studied. Unlike a prior study (13), our study compared the prevalence of strands in patients specifically undergoing echocardiography to evaluate a suspected cardioembolic event with that of patients being studied for other indications, and we found a significantly greater prevalence of strands in the former group. Strands were more common in patients with a suspected cardioembolic event than in those studied for other indications among patients with a mechanical valve and among those with a bioprosthetic valve.

Previously published reports have been limited to studies of mitral valve prostheses. In the present study, 15 (63%) of 24 St. Jude mitral valves had strands, a prevalence of strands similar to that reported by Stoddard et al. (12). In this study we also described differences in the prevalence of strands between mechanical and bioprosthetic valves, as well as among different types of mechanical valves.

The present study is the first to report on the presence of strands on aortic valves. Strands were more frequently detected on mitral than on aortic valves. This finding may reflect a true difference in the prevalence of strands on mitral versus aortic prostheses or may merely be due to better visualization of mitral than aortic valves by transesophageal echocardiography. As with mitral prostheses, strands on aortic prostheses were more often detected on mechanical than on bioprosthetic valves and in studies performed to evaluate a suspected cardioembolic event than in those performed for other reasons.

Clinical implications. The present study highlights the important role that transesophageal echocardiography may play in the evaluation and management of patients with prosthetic valves who have an embolic event, which is often ascribed to the valve. A study demonstrating a normal valve may exculpate the valve as a source of embolism and thus preclude potentially unwarranted valve replacement. This may be especially true if another potential source of embolism is detected, as was the case in 67% of our patients, including six patients (20%) who were found to have a definite source of embolism. In contrast, persistence of strands in association with cardioembolic events, as was demonstrated in three patients in our series, may lead to valve replacement as a therapy to prevent recurrence.

Although limited, the present study does provide some correlation between strands detected by transesophageal echocardiography and surgical-pathologic data. In contrast to a previous study (13) that reported no surgical or pathologic data consistent with strands in patients who underwent valve replacement, our study did find evidence at operation or pathologic study of findings consistent with the transesophageal echocardiographic description of strands. These strands may therefore represent fibrin, small thrombus or pannus formation. When detected in patients with a cardioembolic event, intensification of anticoagulant therapy or the addition of antiplatelet agents, or both, may be warranted. These strands are a potential cardiac source of embolism, given the strong association with cardioembolic events. Because their natural history is unknown, it is not clear how best to manage patients in whom strands are detected during studies for other indications. These patients warrant careful follow-up and perhaps more aggressive antithrombotic treatment as well.

Limitations. The present study has several important limitations. First, it was a retrospective study and we have incomplete information regarding the prosthetic valves (e.g., valve age or size) as well as limited clinical information, such as the patients' anticoagulation status and anti-platelet therapy. Also, these patients were studied for a suspected cardiac
source of embolization and may have had a noncardioembolic origin of their clinical event. Follow-up data on these patients are minimal. Finally, we have limited surgical or pathologic data on valves with strands. The pathologic data available are not entirely consistent with either the echocardiographic or surgical appearance of the valves and there is no confirmation as to the composition of the strands. We also cannot exclude the possibility that strands were detected with greater frequency because patients studied for cardioembolic events may have had a more meticulous examination of the prosthesis in search of strands. This is unlikely as the findings reported are similar to the results in the first 91 studies initially analyzed before the potential clinical significance of strands was recognized.

Despite these limitations, the significantly greater prevalence of strands in patients undergoing transesophageal echocardiography for a suspected cardiac source of embolization suggests that prosthetic valve strands are related to the patients’ clinical presentation and represent a potential cardiac source of embolization. Alternatively, strands may be a marker for another process that results in systemic embolization.

**Conclusions.** Among patients with a prosthetic cardiac valve, strands attached to the valve are found significantly more often in those with a suspected cardioembolic event than in those being evaluated for other indications. These strands may indicate an abnormal valve with thrombus, fibrin or pannus formation and would appear to have a high potential for systemic embolization. In patients with apparently normal valves, transesophageal echocardiography may detect other potential cardiac sources of embolus and thus may alter patient management.

We thank Robyn Dozier, RN and Nancy Palnick, RN for assistance in performance of the transesophageal echocardiographic studies, Peter Gray, BA for assistance in data collection and Teresa Mrkvicka Henderson for assistance in manuscript preparation.

**References**


