PERIVALVULAR EXTENSION OF INFECTION IN PATIENTS WITH ENDOCARDITIS

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Perivalvular extension of infection (PVEI) is a serious complication of infective endocarditis. With rare exceptions, which will be noted, PVEI requires surgery for cure. The purpose of this discussion is to review the utility of the non-surgical techniques available to diagnose this complication (64).

The definition of PVEI for the purposes of this discussion is listed in Table 1.

Table 1

DEFINITION OF PVEI

I. Perivalvular Abscess (PVA) - Extension Into Cardiac Tissue Adjacent to the Valve Ring
II. Aneurysms
III. Intracardiac Fistulas
IV. Valve Dehiscence
- Not Included:
    A. Valve Ring Abscesses
    B. Leaflet Perforation

PVEI will include perivalvular abscesses (PVA) which are an extension of the infection from the valve ring into adjacent cardiac tissue. Aneurysms primarily refers to sinus of valsalva and aortic root aneurysms due to infective endocarditis of the aortic valve. Intra-cardiac fistulas imply linear fistulization of the infection through myocardial tissue with or without aneurysm or abscess formation. Valve dehiscence means complete rupture of the valve leaflet from the valve ring. This diagnosis is usually made on clinical grounds when the patient develops hemodynamic deterioration. Most of the literature reviewed will not include specific references to this anatomy. It should be noted that PVEI as used here specifically excludes ring abscesses or infections confined to the valve ring and leaflet perforation.

The specific techniques that will be evaluated during this discussion are listed in Table 2.

Table 2

TECHNIQUES EVALUATED

I. EKG
II. Echocardiography
    A. Transthoracic 2D
    B. Transesophageal
    C. Doppler, Color Doppler, 2D Contrast
III. CT
IV. MRI
V. Cardiac Catheterization

These include the electrocardiogram, three different types of echocardiograms, CT Scan, MRI, and cardiac catheterization. Each technique will be initially individually reviewed. Then the

relative utility of these techniques will be evaluated by reviewing selected published literature in which multiple techniques were used to diagnose PVEI and an algorithm will be proposed for management of patients with suspected PVEI.

INCIDENCE OF PVEI

It is very difficult to determine the exact incidence of PVEI. This is due primarily to the fact that almost all of the studies that have been published have significant methodologic drawbacks. These problems include different definitions of PVEI used by different authors and heterogeneous demographic characteristics of the patients reported (some with native valve infection, some with prosthetic valve infection, etc). Some series have as a denominator of only surgical autopsy cases while others look only at cases caused by specific organisms and still others use a combination of these criteria. Table 3 gives an overview of the salient points concerning the incidence of PVEI while Table 4 reviews the literature that has been published.

Table 3

INCIDENCE OF PVEI

I. Problems with Published Studies
II. Significantly Higher with Prosthetic Valve Endocarditis
III. Aortic Valve Involved More Frequently than Mitral Valve
IV. Tricuspid Valve - Rare

Table 4

INCIDENCE OF PERIVALVULAR EXTENSION OF INFECTION

Reference	Type of Series	Patients With Prosthetic Valve Endocarditis		Patients With Native Valve Endocarditis		
		Aortic	Mitral	Aortic	Mitral	Tricuspid
2	Autopsy	--*	--	41%	6%	15%
4	Autopsy	100%	100%	--	--	--
3	Autopsy	--	--	--	--	9%
5	Surgical	4/22 had PVEI with aortic valve endocarditis. Unable to tell if native or prosthetic valve endocarditis.				
6	Surgical	2/50 total patients, both with aortic prosthetic valves had PVEI.				
7	Surgical	66%	0%	0%	0%	0%
8	Surgical	66%	33%	7%	0%	--
9	Surgical	--	--	6%	0%	0%
10	Surgical	Overall 17/51 (33%) - Specific valve and whether prosthetic or native valve not indicated.				
11	Surgical	54% of patients with prosthetic valve and 41% with native valve endocarditis had PVEI. Data not available on specific valve involved.				

* -- Not evaluated

Adapted from Reference 64 (RID 13:127-138, 1991)

Overall, the surgical series are probably more informative than the autopsy series because they are less skewed as they do not select for those patients who have died and who clearly would have very

severe disease. Since PVEI is a significant complication of infectious endocarditis, autopsy series would also be expected to grossly over estimate their incidence. As noted in Table 3 and documented in the literature in Table 4, there is a significantly higher incidence of PVEI in patients with prosthetic valve endocarditis compared to theose with native valve endocarditis and an increased risk of this complication when the aortic valve is involved (2-11). The articles published by Sussman and Muller-Haake and their co-authors clearly document these propensities (7-8). It should be noted that the tricuspid valve rarely leads to the development of PVEI. The article by Roberts and Bookbinder is a autopsy study of only patients with right sided endocarditis and hence the relative frequency of PVEI noted with tricuspid valve endocarditis is skewed (4). It should be noted that in the surgical series the relative incidence of PVEI is low in patients with native valve endocarditis (8,9).

DIAGNOSTIC MODALITIES

Electrocardiography

The electrocardiogram is the easiest, most readily obtainable diagnostic modality available to physicians to diagnose PVEI. As noted in Table 5, it is critical to understand the anatomy of the conduction system in order to understand the likelihood that infection of a given valve will cause conduction abnormalities and to be able to interpret the clinical relevance of development of conduction abnormalities in a patient with endocarditis.

Table 5

EKG AND PVEI

I. Anatomy
   - A. Valves
   - B. AV Node
   - C. Bundles
   - D. Septum

II. Conduction Abnormalities and Endocarditis - Differential Diagnosis
   - A. PVEI
   - B. Medications
   - C. Infarction
   - D. Myocarditis

III. Pathophysiology
   - A. Edema Versus Tissue Invasion (Note Concept of Pseudoaneurysm - Byrd, et al) - First Degree Heart Block
   - B. Bundle Branch Block - Tissue Invasion
   - C. Complete Heart Block - Tissue Invasion

IV. Surgical Indication in Patients with Conduction Abnormalities *+
   - A. Conduction Defect Develops on or Progresses with Therapy for Endocarditis
   - B. Aortic Valve Involvement
   - C. No Other Cause Identified

* Patients with New Conduction Abnormalities Must be in a Monitored Situation

\+ Complete Heart Block is an Absolute Indication for Surgery

Figures 1 and 2 demonstrate this anatomy quite well (13,59).

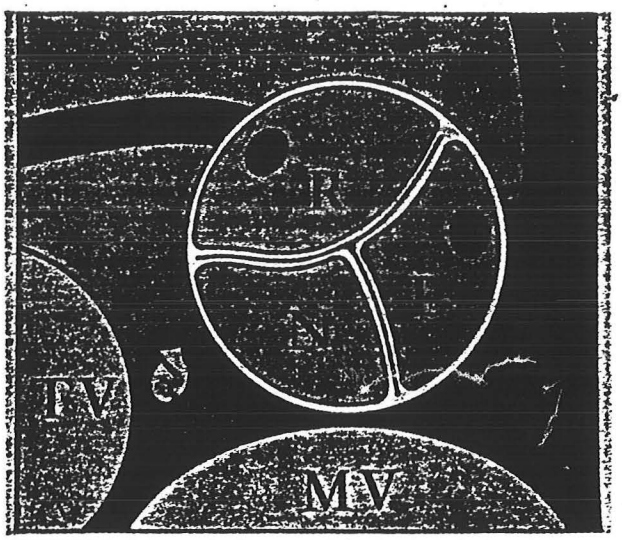
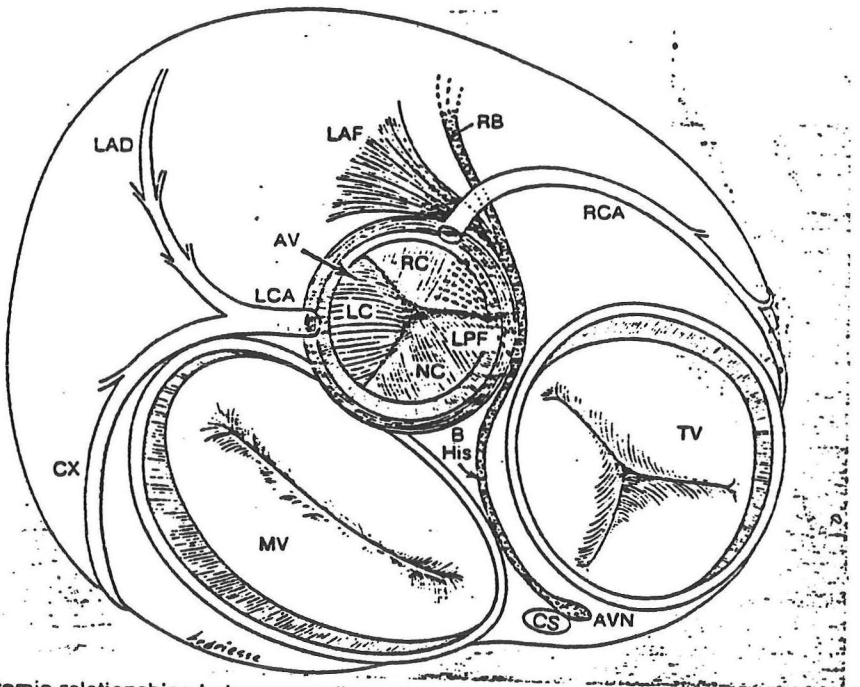


FIGURE 1. Schematic diagram of aortic perivalvular anatomy at end-diastole, shown in the short-axis view of 2-dimensional echocardiography. Coronary arteries arise from right and left Valsalva's sinuses. Lying between medial aspect of noncoronary sinus and tricuspid valve is atrioventricular portion of the membranous septum, through which run the atrioventricular nodal fibers. L = left sinus; MV = mitral valve; N = noncoronary sinus; R = right sinus; TV = tricuspid valve.



Anatomic relationships between cardiac valves and conduction system as viewed from above (superiorly). MV indicates mitral valve; TV, tricuspid valve; AV, aortic valve; LC, left coronary cusp; RC, right coronary cusp; NC, noncoronary cusp; LCA, left coronary artery; LAD, left anterior descending artery; CX, circumflex artery; RCA, right coronary artery; CS, coronary sinus; AVN, atrioventricular node; B His, common bundle of His; LPF, left posterior fascicle of left bundle branch; LAF, left anterior fascicle of left bundle branch; and RB, right bundle branch.

Figure 2

The AV node is distant from the aortic valve and close to both the mitral and tricuspid valves. The bundle of His lies between the mitral and tricuspid valves (closer to the mitral valve) and the left bundle, and to a degree the right bundle, passes very close to the aortic valve and in particular to its non-coronary cusp. Hence, it would be anticipated that PVEI of mitral valve endocarditis would most likely lead to 1st degree or 2nd degree heart block and 3rd degree or complete heart block would be unusual and if present would be narrow complex. PVEI from the aortic valve effecting the conduction system would primarily occur when the non-coronary cusp is involved and would more frequently lead to a higher grade of block such as bundle branch block and complete heart block. The relative distances of the conduction system from the respective valves is consistent with the relative rates of conduction abnormalities and the reason for the lack of conduction abnormalities with tricuspid valve endocarditis. It should be noted that in reality extension of PVEI causing EKG abnormalities is basically extension of the infection into the septum.

There are multiple potential causes besides PVEI for conduction abnormalities in patients with endocarditis as noted also in Table 5. These include the use of medications (digitalis being the prototype), myocardial infarction, myocarditis, etc. These must all be ruled out in the appropriate manner before any new conduction abnormalities are attributed to PVEI.

The pathophysiology of conduction abnormalities in patients with endocarditis is due either to actual tissue invasion by the infection which would be a true PVEI or only edema of the tissue as part of the host reaction to the valve infection. Edema would generally not require surgical therapy since actual tissue invasion is not present. Edema usually causes only 1st degree AV block. It should also be noted that several authors have noted that true PVEI with tissue invasion with conduction abnormalities can evolve into pseudo aneurysms with antibiotic therapy (59). When bundle branch blocks develop in patients with endocarditis it almost inevitably indicates true tissue invasion and not edema and is almost always an indication for surgery. Complete heart block always indicates tissue invasion and is an absolute indication for surgery. As noted, first degree heart block is the one type of conduction abnormality in which simple edema in the conducting system can be the cause of the conduction abnormality and might not necessarily require surgery especially if it is transient.

The published literature is summarized in Table 6 (14-19,65).

Table 6

ELECTROCARDIOGRAMS IN PATIENTS WITH PERIVALVULAR EXTENSION OF INFECTION

Reference	Total Number of Patients	Abnormal EKG*	Sensitivity of Abnormal EKG for PVA	Specificity of Abnormal EKG for PVA
14	212	20	20%	89%
15	142 (6 complete heart block)	20	--	100% for complete heart block
16	24	22	--	86%
17	19	6	83%	92%
11	66	11 (bundle branch or complete heart block)	27%	90% (bundle branch block or complete heart block)
18**	19	11	58%	--
19	22	10	47%	63%
65	100	5	0%	0%

* New conduction blocks or arrhythmia
* Not stated by authors
** All aortic valve disease

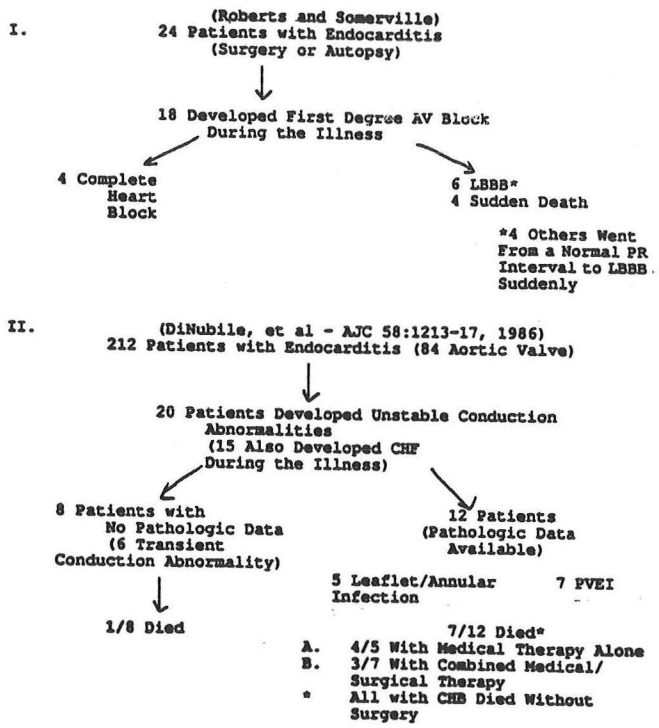
Adapted from Reference 64 (RID 13:127-138, 1991)

It is clear that the EKG is not a sensitive test for diagnosing a PVEI but was quite specific for a PVEI when a conduction abnormality is present except in the recent study of Weisse and Khan (65).

Two studies noted in Table 7 have attempted to determine how physicians should interpret the development of new conduction abnormalities in patients with endocarditis (14,16).

Table 7

ENDOCARDITIS AND EKG ABNORMALITIES



Robert and Sommerville reported 24 patients with endocarditis who either went to surgery or had an autopsy. Eighteen developed first degree AV block during their illness. Four of these went on to develop complete heart block and six developed left bundle branch block with 4 subsequently suffering sudden death. It should be noted four other patients progressed from a normal PR interval to a left bundle branch block suddenly without first developing AV block. It is this rapid progression and potentially bad prognosis of first degree block that leads to the recommendation that any patient with endocarditis with a new conduction abnormality must be in a monitored situation. Clearly, even with only first degree AV block, surgery must be anticipated based on this data. DiNubile, et al, prospectively evaluated 212 patients (84 of whom had aortic valve disease). Twenty-four patients developed unstable (new) conduction abnormalities during antibiotic therapy. It should be noted that 15 of these patients concomitantly developed congestive heart failure. The manner in which the data was reported makes it very difficult to tell which type of conduction abnormality the patients had but it would appear that one quarter of them had only first degree AV block. Eight of the patients either had transient abnormalities (questionably first degree AV block) and/or no

pathologic data was obtained and only one of these eight patients died implying that the transient (presumably usually first degree heart block) EKG abnormalities have a relatively good prognosis. Twelve patients either went to surgery or autopsy. Seven patients had PVEI while five had infection limited to the valve leaflet or had a valve ring infection. Seven of these twelve patients died and all of those with complete heart block died unless they went to surgery. The prognosis was somewhat worse in those patients who received only medical therapy .

Hence, review of the literature on the EKG in patients with endocarditis would seem to indicate that surgery is indicated if a conduction defect develops or progresses with adequate medical therapy for endocarditis (Table 5). The article by Weisse and Khan which suggests a much lower specificity for this finding than other articles disputes this approach and must be kept in mind when managing a patient (65). However, it is based on a relatively small number of cases. Transient conduction abnormalities (with transient being defined as those that disapper within three to five days) implies only presence of edema and is almost exclusively limited to first degree heart block. It should be noted, however, that no studies have conclusively documented this pathophysiology. Presence of aortic valve involvement usually means that surgery will be indicated. It must be noted that surgery should not be undertaken until other causes, particularly medication, myocardial infarction, etc. have been ruled out. Again, it should be emphasized that complete heart block is an absolute indication for surgery as well as transient placement of a pacemaker. Patients with bundle branch block also almost inevitably require surgery.

Echocardiography

Table 8 tabulates the various echocardiographic techniques which are available and Table 9 indicates the type of pathology that these echocardiograms can detect.

Table 8

ECHOCARDIOGRAPHIC TECHNIQUES

I. Transthoracic 2D
II. Transesophageal
*III. Doppler
*IV. Color Flow Doppler
V. Contrast 2D

* Doppler Technology Can Be Used With Either Transthoracic or Transesophageal Echocardiography

Table 9

TYPE OF PATHOLOGY DETECTED

I. Transthoracic and Transesophageal Echocardiogram
  A. Fixed Anatomic Lesions
    1. Perivalvular Abscesses
    2. Myocardial Abscesses
    3. Sinus of Valsalva Aneurysms
    4. Aortic Root Aneurysms
II. Doppler and 2D Contrast
  A. Regurgitant Lesions
    1. Detection/Quantitation
    2. Demonstration of Location
  B. Fistulous Tracts
    1. Into Myocardium
    2. Between Cardiac Chambers

The standard 2D transthoracic echocardiogram (TTE) and the transesophageal echocardiogram (TEE) are most adept at detecting fixed anatomic lesions such as perivalvular abscesses, myocardial abscesses, sinus of valsalva aneurysms, aortic root aneurysms, etc. Doppler, color flow doppler, and contrast 2D echocardiographs are primarily designed to detect and quantitate regurgitant lesions, determine their location (valvular or perivalvular), and to find fistulous tracts either into the myocardium or between cardiac chambers. It should be noted that doppler technology can be used with either transthoracic or transesophageal echocardiography.

Table 10 reviews the published literature that include significant number of patients that evaluates the utility of the TTE in PVEI (5,6,7,8,9,10,19,22-29,57,58,60,61,67).

Table 10

UTILITY OF TWO DIMENSITONAL (2-D) ECHOCARDIOGRAMS IN DETECTING PERIVALVULAR EXTENSION OF INFECTION

Author	Total Number of Pts with Endocarditis	PVEI on 2-D Echo	Sensitivity of 2-D Echo for PVEI	Specificity of Echo for PVEI
5	50	5	100%	100%
22	12	8	67%	97%
19	46	19	86%	88%
23	23	8	88%	100%
24		4 case reports of aortic valve ring abscesses		
25	9*	9	100%	--+
26	20**	13	65%	--
6	50	4	--	67%
27	21	2	100%	100%
7	36	3	100%	100%
8	34	1	20%	100%
9	72	0	0%	--
28	4	1	33%	--
29	3	1	33%	--
10	51	3	18%	100%
57	73	29	0%	--
58	70	7	43%	100%
59	10	10	100%	100%
60	118	46	28%	98.6%
61	41	6	0%	--
67	7	7	100%	100%

*All patients had aortic perivalvular abscesses
+ Not stated by authors
**All patients had surgery and aortic valve ring abscesses

Adapted from Reference 64 (RID 13:127-138, 1991)

It should be noted that there are several limitations to the studies listed as tabulated in Table 11.

Table 11

LIMIT OF STUDIES - TRANSTHORACIC 2D

I. Selection Bias
II. Retrospective
III. Unblinded
IV. Inconsistent Definitions of PVEI
V. Number of Patients with Native Valve and Prosthetic Valve Endocarditis Not Consistently Stated

These include selection bias in which some series only include patients who went to autopsy or surgery and others included all patients seen at an institution with infectious endocarditis. The former series over-estimate the incidence of PVEI. A large number of the series are retrospective, unblinded and there are

inconsistent definitions from one series to another as to what constitutes PVEI. In addition, the number of patients with native and prosthetic valve endocarditis frequently can not be determined from each series. However, with these limitations in mind the literature does provide a significant amount of data.

The significant conclusions that can be reached are summarized in Table 12.

Table 12

TRANSTHORACIC 2D CONCLUSIONS

I. Underestimates Size of PVA When Detected
II. Sensitivity
    A. = 70% (0-100%) - Note recent large articles <50%
    B. Frequently effected by technically inadequate study
    C. Particular problem with prosthetic valves
III. Specificity - Excellent
IV. Positive and Negative Predictive Value

Transthoracic 2D echocardiograms underestimated the size of the perivalvular abscess as documented by surgical or autopsy data. The overall sensitivity of the technique would appear to be approximately 70% with the range of 0-100%. It should be noted that the two most recent large articles by Daniel and by Omari found a significantly lower percentages of PVEI (28% and 0% respectively) (57,60). However, the small series by Byrd offers more positive data (59). Frequently the reason that the TTE is not successful in detecting PVEI is because of technical problems that prevent an adequate image from being obtained. It should be noted that the TTE has particular problems with prosthetic valves. The specificity of finding a perivalvular abscess by TTE is quite high (usually well over 90%). Hence, the detection of a PVA by TTE in general indicates the necessity for surgery. The positive and negative predictive values of the TTE can only be inconsistently calculated due to design problems of the studies and are so limited and variable as to be of minimal clinical value.

The transesophageal echocardiogram (TEE) is a new echocardiographic technique which is quite effective in

demonstrating PVEI. Technically it consists of attaching a transducer to the end of a modified endoscope, placing the scope in the esophagus and viewing the cardiac structures from behind (posterior). Table 13 details the technical attributes of this technique compared to TTE.

Table 13

INDICATION FOR TRANSESOPHAGEAL ECHOCARDIOGRAPHY

I. Technical Attributes
   A. Close to Pathology - Especially to the mitral valve
   B. Avoids "Transthoracic" Problem
      1. Obesity
      2. Chest Deformity
      3. COPD
      4. Post-Op Apparatus
      5. Ventilator
   C. Use of High Frequency Transducer - Greater Resolution

II. Clinical Uses
   A. Predicted or actual technical problem with transthoracic study
   B. Clinical PVEI with negative technically - adequate transthoracic study

These consists of the TEE having its transducer much closer to the heart than the TTE and hence to the pathology which allows the use of a high frequency transducer which gives much greater resolution. It is particularly close to the mitral valve compared to the TTE. In addition, it has proven to be quite accurate in defining infections that have spread from the aortic valve to the mitral aortic intraventricular septum and subsequently to the mitral valve apparatus and left atrium (66). In addition, the TEE avoids many of the transthoracic pathologic problems seen with the TTE such as obesity, chest deformity, COPD, post-surgical state, ventilator, etc. TEE is indicated if there are predicted or actual technical problems with the transthoracic study (TTE) or if PVEI is suspected clinically with a negative, technically adequate TTE. Table 14 details the large studies evaluating TEE.

Table 14

UTILITY OF TRANSESOPHAGEAL ECHOCARDIOGRAM (TEE) IN DIAGNOSING PVEI

Reference	Total No. of Patients with Endocarditis	No. With PVEI On TEE	Utility of Trans-Esophageal Echo-Cardiogram in In Detecting PVEI	
			Sensitivity	Specificity
33	5	3	100%	100%
61	41	6	100%	100%
60	118	40	87%	94.6%

As can be noted, the sensitivity that is reported in the literature is close to 100% with over 50 cases now reported and the specificity also approaches 100%. It is clear that if PVEI is demonstrated on the TTE surgery is almost inevitably indicated.

Since this technique is relatively invasive compared to the TTE, safety must be also looked at carefully. Table 15 clearly documents the safety of this procedure.

Table 15

SAFETY OF TRANSESOPHAGEAL ECHOCARDIOGRAPHY

I. All (10149) patients - 0.88% complications rate
II. Unconscious/Acutely Ill (= 1200) - 1.6% complications rate

Daniel, et al, have reported their experience with over 10,000 patients (63). They noted a complication rate of less than 1%. It is more important when applying the technique to a patient with endocarditis to look at the complication rate in the unconscious or acutely ill patients. In this population of 1200 patients there was still a complication rate of only 1.6% with only 1 death reported.

The utility of doppler echocardiography and contrast 2D echocardiography to detect fistulous tracts and regurgitant lesions has not been as well studied as have those echocardiographic techniques that detect anatomical complications. This is because such fistulous tracts and regurgitant lesions are either very unusual or can be adequately detected by physical examination. It should be noted that the contrast 2D echocardiogram has been looked at least frequently because of the extra step that it takes to perform the procedure. It requires intravenous injection of an agitated solution in which micro-bubbles serve as the contrast. It requires the presence of a cavity that can be filled by contrast media to demonstrate abscesses and the bubbles must be physically able to enter the fistulous tract in order to demonstrate the fistula. Overall, the published literature on these techniques basically consists of a series of 1 or 2 case reports usually demonstrating the utility of these procedures. Cooper, et al, published the most interesting article utilizing these procedures (43). They reported a patient who had a 2D echocardiogram with an aortic root vegetation extending into the right atrium above the septal leaflet of the tricuspid valve. Subsequent 2D echocardiogram after the patient had been treated with antibiotics revealed a sinus of valsalva aneurysm and the 2D doppler showed flow from the aorta into the right atrium indicating a rupture into the right atrium. Contrast echocardiography by repeated aortic root injection clearly indicated an intra-cardiac shunt which interestingly was not demonstrated by cardiac catheterization which did show the sinus of valsalva aneurysm. The largest series concerning transesophageal color flow doppler was published by Smiley and co-authors (32). They described five patients of their

own and document one from the literature. They do not provide details of these cases and did not compare this technique with other methods.

Cardiac Catheterization

Cardiac catheterization has until recently been considered the gold standard for diagnosing PVEI against which all other techniques have been judged. However, with the improved technology of the other techniques it is now be viewed as a relatively invasive but effective modality for diagnosing PVEI. Tables 16-18 address cardiac catheterization. Table 16 indicates the limitations of the published series tabulated in Table 18 (17,18,25,26,28,50-53).

Table 16

LIMITATIONS OF STUDIES - CARDIAC CATHETERIZATION

I. Selection Bias
II. Retrospective

These include selection bias in which some of the series include only patients who went to autopsy or had surgical intervention and the fact that all studies were retrospective in nature. Hence, there has not been any prospective study demonstrating the utility of cardiac catheterization in this setting. Table 17 gives an overview of data presented in Table 18.

Table 17

ABILITY OF CARDIAC CATHETERIZATION TO DETECT PVEI

I. Useful
   A. Aneurysms
   B. Valve Dehiscence
   C. Perivalvular Abscesses
II. Problems
   A. Septal and Myocardial Abscesses
   B. Fistulas - because of rapid opacification of overlapping structures

Table 18

UTILITY OF CARDIAC CATHETERIZATION IN DETECTING PERIVALVULAR EXTENTIONS OF INFECTION (PVEI)

Reference	Total Number of Patients Undergoing Catheterizations	Total Number PVEI at Surgery	Total Number PVEI Detected by Catheterizations	Number of Patients with Significant Side Effects
50	19	6	3	3 (pulmonary edema, bradycardia, brachial artery occlusion)
51	38	9	9	1 (atrial fibrillation)
17	19	6	5	0
52	9	4	0	0
28	4	4	4	0
18	19	14	14	0
25	6	6	5	0
26	9	9	7	0
53	7	3	0	1 (embolus)

Adapted from Reference 64 (RID 13:127-138, 1991)

As noted, with the exception of the original series published by Mills et al in 1977, the sensitivity of cardiac catheterization for the detection of PVEI approaches 100% in the large series (17,18,50,51). Mills and co-authors noted a sensitivity of only 50% (50). Cardiac catheterization is particularly efficacious in detecting aneurysms in the aortic root and sinus of valsalva, valve dehiscence and perivalvular abscesses. It was not particularly efficacious in detecting septal or myocardial abscesses which is not surprising because cardiac catheterization requires the dye to be present in an abnormal space in order for pathology to be detected and walled of abscesses may not communicate with the intracardiac chamber. It would be anticipated that fistulas could be detected. However, because of rapid opacification of overriding structures during the cardiac catheterization they can easily be missed. Several smaller series note an inconsistent sensitivity of the procedure (25,26,28,52,53). The complications noted in two of the larger series and one small series are also quite interesting (50,51,53). The primary concern with cardiac catheterization has always been that the catheter will traumatize the vegetation and cause it to embolize. This has only been documented in one patient in over 100 reported catheterizations (53). Development of pulmonary edema, bradycardia, brachial artery occlusion, and atrial fibrillation which are expected complications have been documented but clearly occur in a low incidence. Thus, it would appear that cardiac catheterization is an effective means to diagnose PVEI. However, although it has an acceptable complication rate it would also appear that it is no more efficacious than other less invasive techniques.

Computer Tomography and Magnetic Resonance Imaging

There have been only a handful of adequately documented cases where the CT has been utilized to detect PVEI (54, 55). Hence, its utility can not be determined.

There have been more reported articles on the MRI. Table 19 provides an overview of these studies.

Table 19

MRI AND PVEI

I. Utility - Anatomical Structure
II. Sensitivity/Specificity - "100%"
III. Unique Aspects
    A. Several Patients Recovered With Only Medical Therapy
    B. Anatomical Definition Better Than Other Studies
IV. Limitation
    A. Small Number of Cases
    B. Aortic Valve Primarily Studied
    C. Metal Prosthesis

The MRI is most useful for detecting anatomic abnormalities as opposed to fistulas. Its sensitivity and specificity is reported to

approach 100% but at the present time the articles reported have all been testimonial case reports or small series (29,47b,55,56). Further studies with larger number of patients will be required to determine the true utility of the technique. Specific unique aspects of the MRI that should be noted are that it does seem to provide better anatomic definition than other studies and several patients in whom PVEI has been diagnosed by MRI recovered with medical therapy only which is unusual. Whether these cases were oddities or whether they mean that the MRI is so sensitive that it picks up very small PVA's that other techniques will consistently miss that can be treated with antibiotics still remains to be determined. If the latter is the case then a PVEI diagnosed with an MRI may not necessarily mean the patient needs surgery and the clinical significance of the quantitative size, etc. of the PVEI will have to be more fully evaluated. The limitations of the studies published, as noted, include the small number of cases and the fact that the aortic valve has been the primary valve studied to date. The specific problems noted with metal prostheses could be anticipated.

Comparative Studies

When multiple techniques are evaluated it is important to review the literature in which more than one of the techniques were utilized/evaluated in the same series. This enables a more accurate determination of the relevant clinical utility of the techniques in the clinical management of patients. Table 20 tabulates the larger series in which the utility of different diagnostic modalities in the detection of PVEI have been evalauted (7,10,17,18,19,25,26,28,29,33,53,57,59,60,61).

Table 20

COMPARISON OF UTILITY OF DIFFERENT DIAGNOSTIC MODALITIES IN THE DETECTION OF PERIVALVULAR EXTENSION OF INFECTION

Authors	Total Number of Cases	+EKG	+ 2-D Echocardiogram	+Transesophageal Echocardiogram	+Cardiac Catheterization	+MRI
19	22	9	20			
25	9	5/9	9/9		5/6	
NVE	4	3/4	4/4		2/3	
PVE	5	2/5	5/5		3/3	
26	20		14/20		7/9	
NVE	14		11/14		4/6	
PVE	6		3/6		3/3	
7	3	3/3	3/3			
10	17		3/17	13/17		
33	3		0/3	3/3		
19	6	5/6			5/6	
28	4		0/3		4/4	
18	19	11/19			14/19	
NVE	6	1/6			5/6	
PVE	13	10/13			9/9	
53	3		0/3		0/3	
29	3		0/3		1/1	3/3
59	10	6	10			
60	46		13	40		
61	6		0	6		

NVE = Native Valve Endocarditis
PVE = Prosthetic Valve Endocarditis

Adapted from Reference 64 (RID 13:127-138, 1991)

Table 21 is a summary of these findings.

Table 21

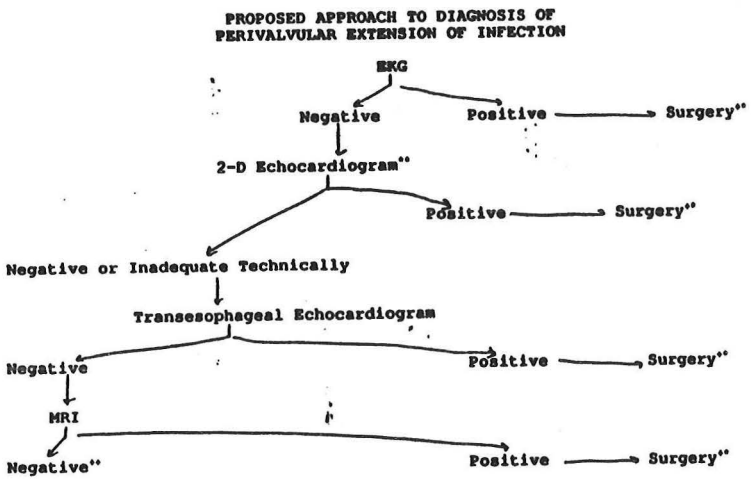
COMPARATIVE STUDIES

I. EKG Least Sensitive
II. 2D (TTE) Echo = Cardiac Catheterization
III. Transesophageal ECHO (TEE) - Consistently more Sensitive than TTE
IV. MRI - Probably Superior to TTE and Cardiac Catheterization
V. Doppler/Color Flow Doppler and 2D Contrast Echo - No Adequate Published Comparison to Other Techniques

Clearly, the EKG would appear to be the least sensitive technique although it is as specific as any other techniques. The 2D TTE echocardiogram has about the same sensitivity as the cardiac catheterization. Several, more recent studies seem to indicate that the TTE is less sensitive than previously thought (60,61). The series published by Byrd et al however documents the continuing utility of the procedure compared to the EKG in a small series (59). Cardiac catheterizations were not done in these recent series and the relative sensitivity of the two techniques can not be determined to date. The TEE is consistently more sensitive that the TTE. The most recent large series by Daniel, et al most clearly documented this point (60). MRI has not been studied as extensively as the echocardiographic techniques but it would appear to be superior to the TTE and cardiac catheterization in the one study published. In this study, even though cardiac catheterization demonstrated the same pathology as the MRI did, it did not demonstrate it in such clear, concise, anatomic detail. The doppler, color flow doppler and 2D contrast echocardiogram has not been adequately compared to the other techniques and as noted they are most efficacious in detecting different kinds of pathology.

Clearly the optimal approach to diagnosis of PVEI has not been established. However, Figure 3 is a proposed overview of how to approach the diagnosis of PVEI in a patient with endocarditis (64).

Figure 3



* If elected to not perform surgery, patient should be treated as though perivalvular abscess defini present

* Cardiac catheterization may be desired by cardiovascular surgeon before surgery.

** Ideally with doppler, color doppler, contrast 2-D echocardiogram

** Medical therapy or cardiac catheterization

All patients with endocarditis should have an initial EKG. A persistent new heart block of any degree implies the development of a myocardial septal abscess (PVEI). Bundle branch blocks and complete heart blocks almost inevitably indicate PVEI and waiting to see if they resolve with medical therapy is probably wishful thinking. First degree heart block as noted may be transient and disappears within 3-5 days if due to edema. Patients with first degree heart block if they are not going to be operated on expeditiously at least need to be in a monitored situation. The utility of serial EKG's has been not well studied but it would be anticipated that patients with prosthetic valve endocarditis would be more likely candidates for this testing than those with native valve endocarditis due to their higher incidence of PVEI. The transthoracic 2D echocardiogram is the next most available procedure in this country. If it demonstrates a perivalvular abscess surgery is indicated. If it is negative or technically inadequate transesophageal echocardiogram is indicated at those institutions where it is available. If it is positive, surgery is indicated and if negative consideration should be given to the performance of an MRI if the question of the PVEI remains based on clinical criteria or if the TEE is technically inadequate. It should be noted that color doppler techniques should be utilized with the TTE and TEE if available because they are more efficacious in diagnosing and quantitating valvular insufficiency and the development of fistulous tracts. The place of cardiac catheterization with the development of these new techniques is ill-defined. It would appear that it adds minimal data to the more non-invasive techniques and clearly is potentially a more dangerous technique. However, some thoracic surgeons still insist on its use before surgery and use it as a "road map" in planning their surgery.

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