RADIOLOGY

Cineradiographic Evaluation of Prosthetic Cardiac Valves

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SUMMARY

Forty-nine patients whose clinical symptoms suggested a leaking cardiac prosthetic valve were studied by both cineradiography and angiocardiography. We found a wider range of tilting motion of the nonleaking mitral valve than has been previously shown. An angle of tilt greater than 6° for the prosthetic aortic valve strongly suggests separation of the prosthesis from its bed with a paravalvular leak, while the angle of tilt suggestive of a paravalvular leak for a prosthetic mitral valve is 12°. However, a tilt of less than these values does not entirely exclude the existence of a leak. We strongly suggest that routine cineradiography be done in each patient shortly after surgery, as a basis for comparison if the patient later develops a murmur or congestive heart failure.

Additional Indexing Words:

Aortic valve, prosthetic — Mitral valve, prosthetic — Valvular tilt
Paravalvular leak — Angiocardiography

THE USE OF PROSTHETIC CARDIAC VALVES has become commonplace. Occasionally, these patients do poorly postoperatively as a result of leaking around the prosthetic valve ring. These paravalvular leaks are often difficult to detect clinically[1, 2, 3, 4] Cineradiography has been used by Bjork and Bjork[8] to study the motion of prosthetic aortic valves, and by Gimenez et al.[5] to study prosthetic aortic and prosthetic mitral valves. These authors defined the range of angular tilting motion for nonleaking valves, and pointed out that a paravalvular leak can cause an increased tilting motion. To date, these findings have not been confirmed with angiography in most cases.

The present study was undertaken to evaluate the usefulness of cineradiographic examinations of prosthetic cardiac valves and to further define the normal range of motion of these valves using a relatively large series of patients, all angiographically proven.

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Materials and Methods

This series consists of analyses of cineradiographic and angiographic studies of 49 patients with Starr-Edwards prosthetic cardiac valves, examined between 1967 to 1970 in the Cardiac Catheterization Laboratory of the Massachusetts General Hospital, for the clinical suspicion of a leaking prosthetic valve.

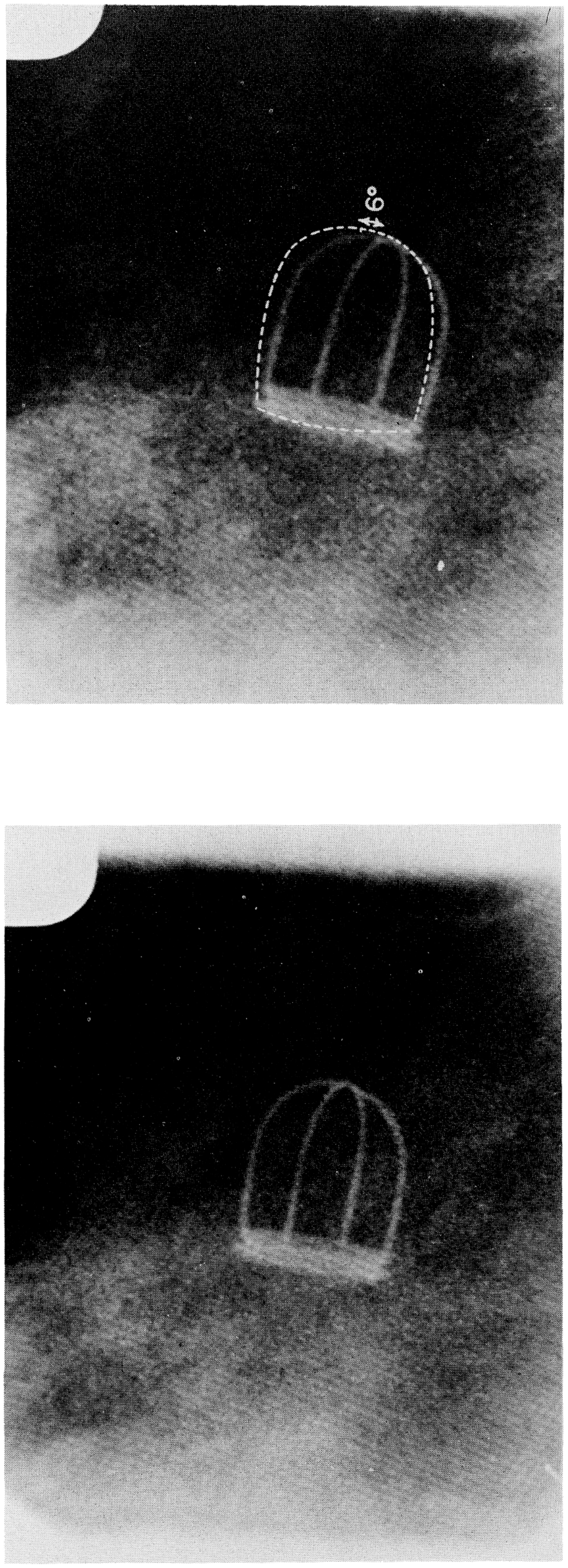
Cineradiographic examinations were performed in left anterior oblique, anteroposterior, and a right anterior oblique projections with suspended respiration. A six-inch image amplifier with 35 mm cineradiography was used. The degree of tilt of the valve along its long axis was measured on successive frames of the cineradiographic film strip, when projected frame by frame. (fig. 1-4)

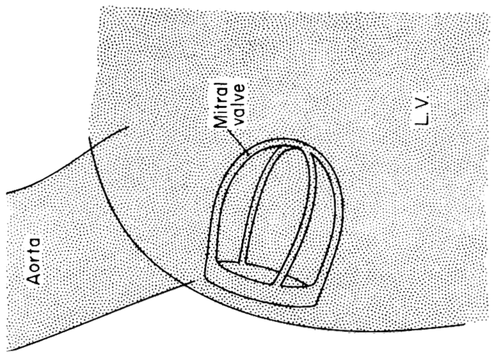
The maximum degree of tilt in each of these three projections was recorded (table 1). The largest of these was recorded as the maximum tilt. No attempt was made to measure rotatory motion.

Left ventricular angiograms were performed in all patients with mitral valve prostheses. Aortic root aortograms were done in cases with aortic prostheses. The severity of the parvalvular leak if present was recorded in each case.

Results

The cineradiograms of 21 patients with prosthetic aortic valves with angiographic evidence of a paravalvular leak showed a range of tilt of 2° to





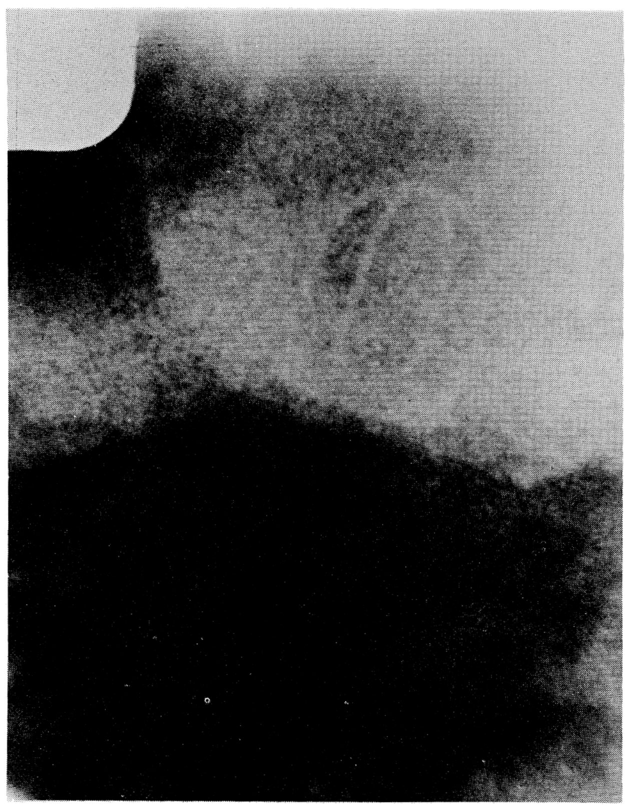
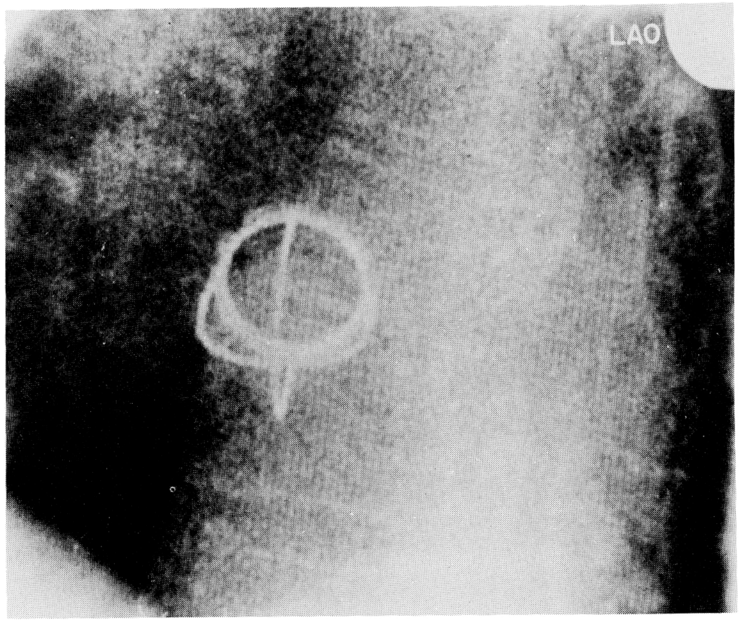
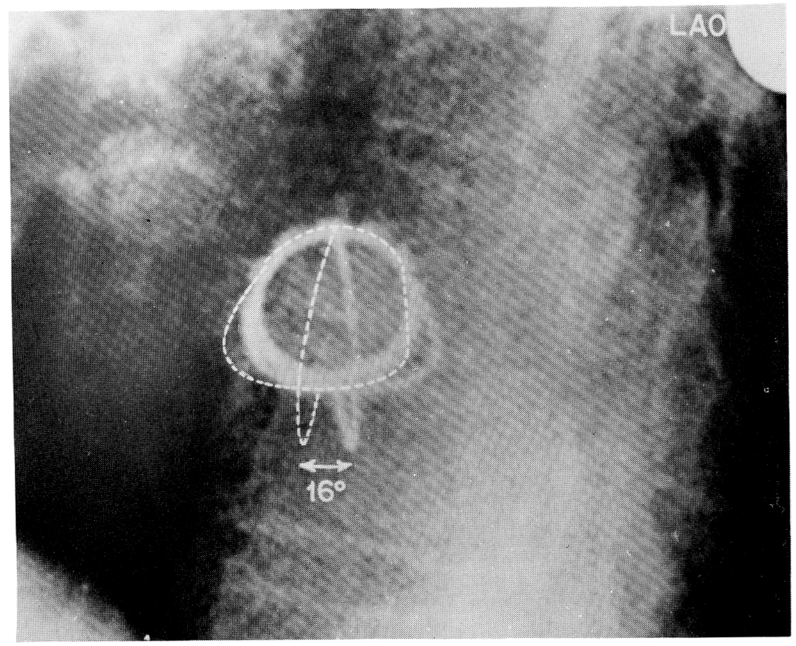
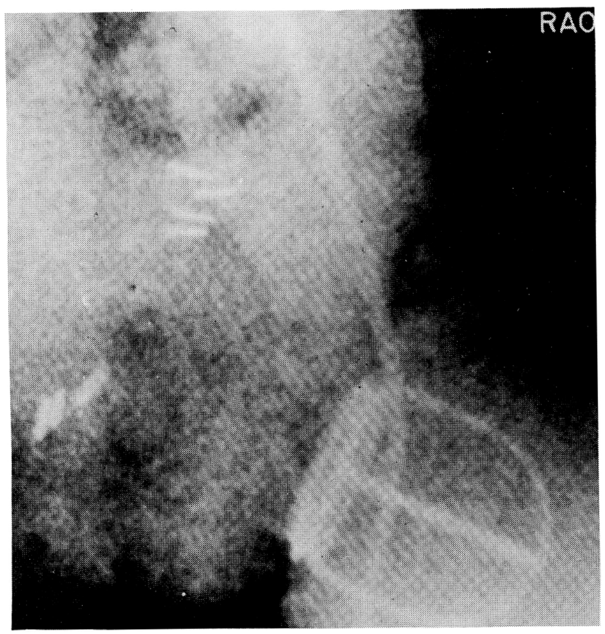


Figure 1

Studies of a 49-year-old male with prosthetic mitral valve. Upper left: Diastole (RAO). Note position of mitral prosthesis. Upper right: Systole (RAO). There has been a 6° tilt compared to position in diastole. Lower left: Left ventricular angiogram (RAO) shows no paravalvular leak. Lower right: Line drawing of left ventricular angiogram (RAO).







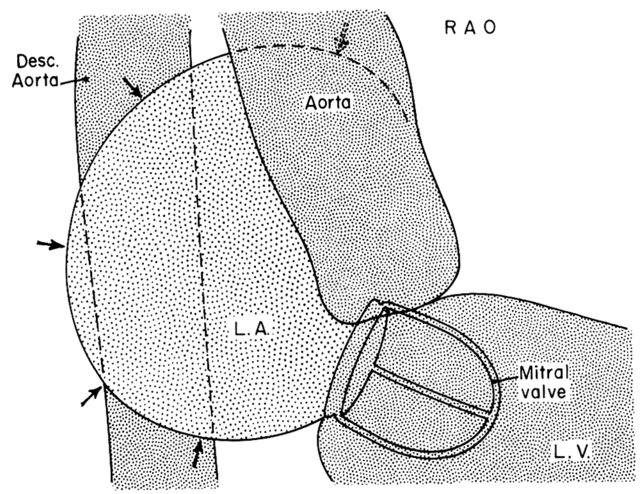
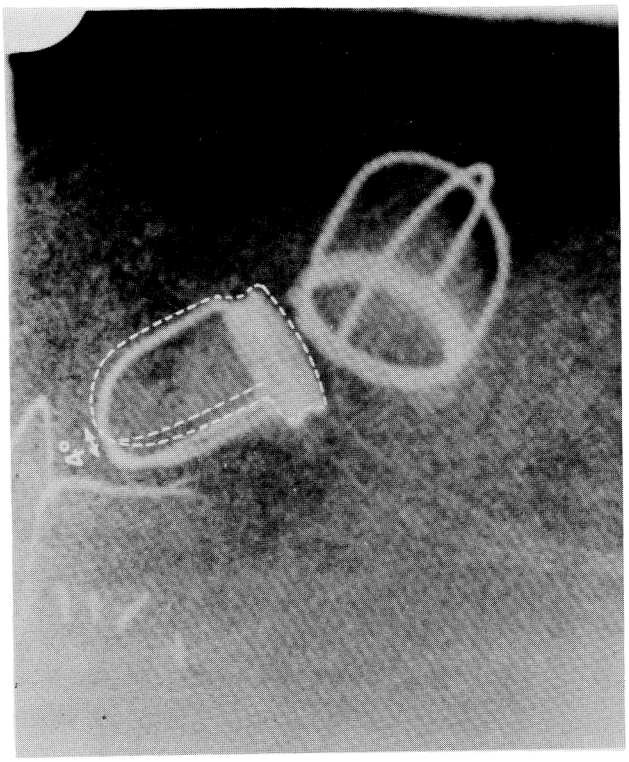
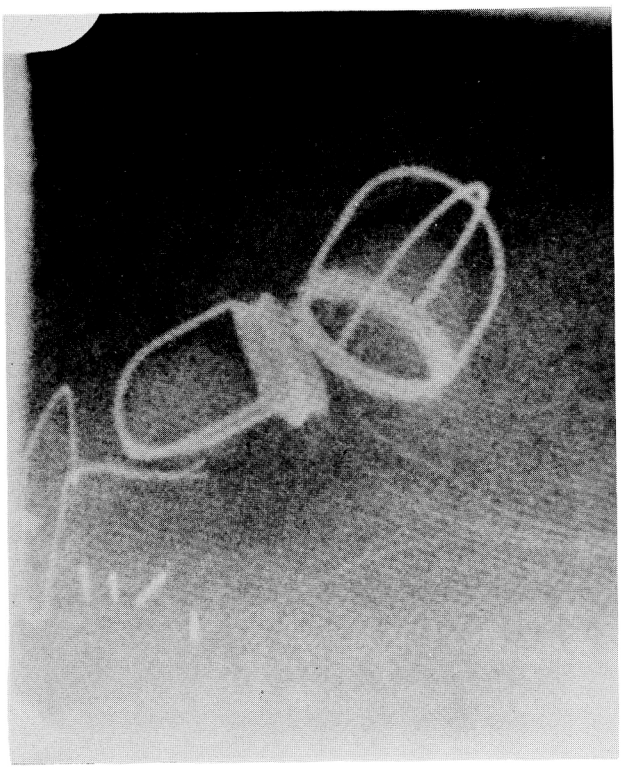
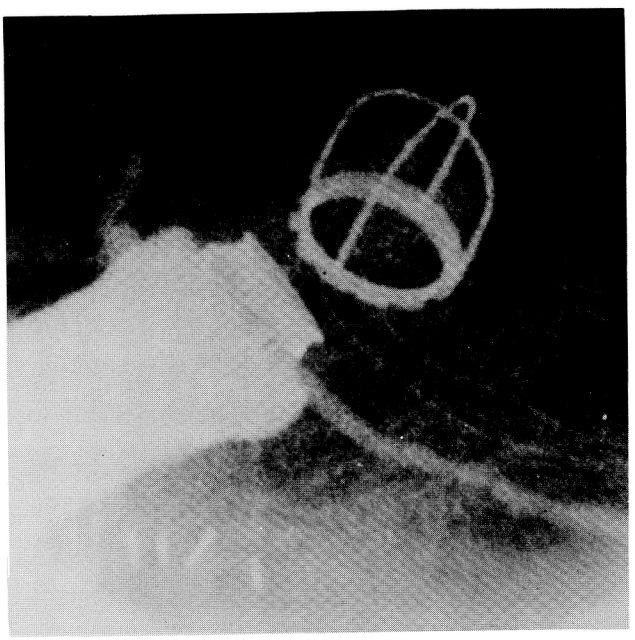


Figure 2

Studies on a 63-year-old female with prosthetic mitral valve. Upper left: Diastole (LAO). Upper right: Systole (LAO). There has been tilt of 16° compared to position in diastole. Lower left: Left ventricular angiogram shows paravalvular leak with opacified left atrium. Surgically confirmed. RAO projection was used for aortogram even though maximum tilt was in LAO. Lower right: Line drawing of 2C.







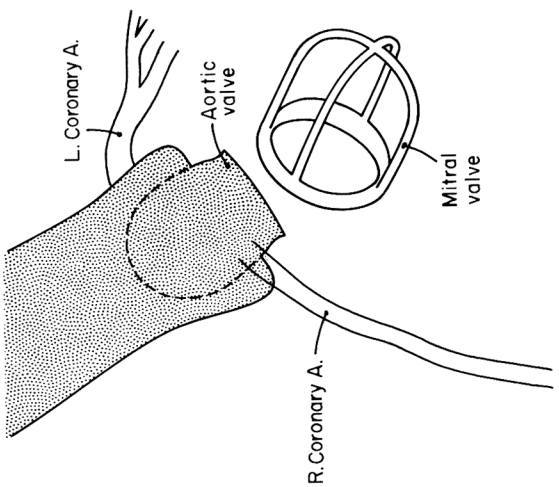
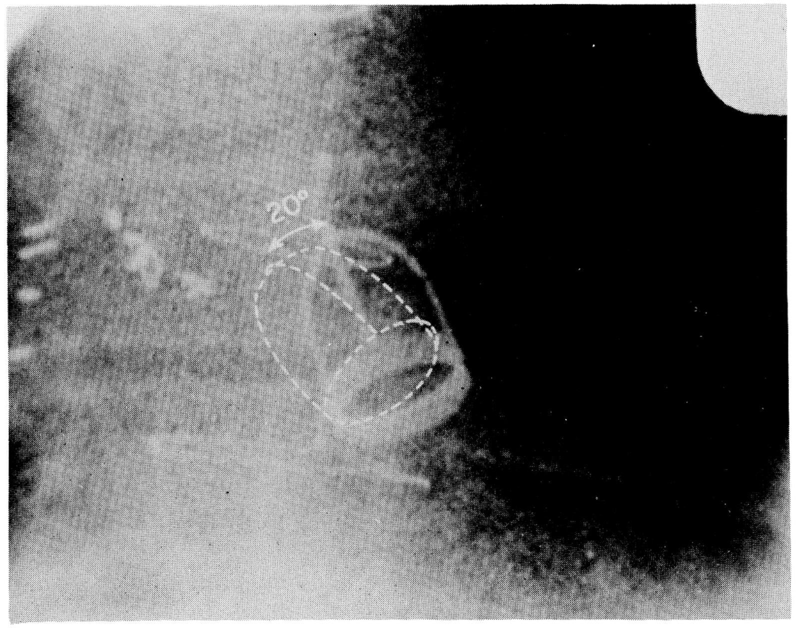
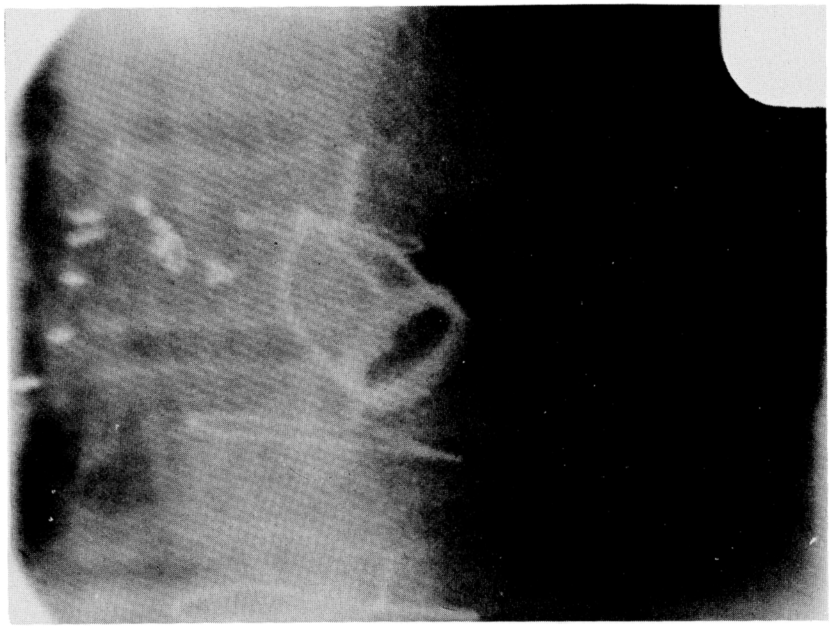
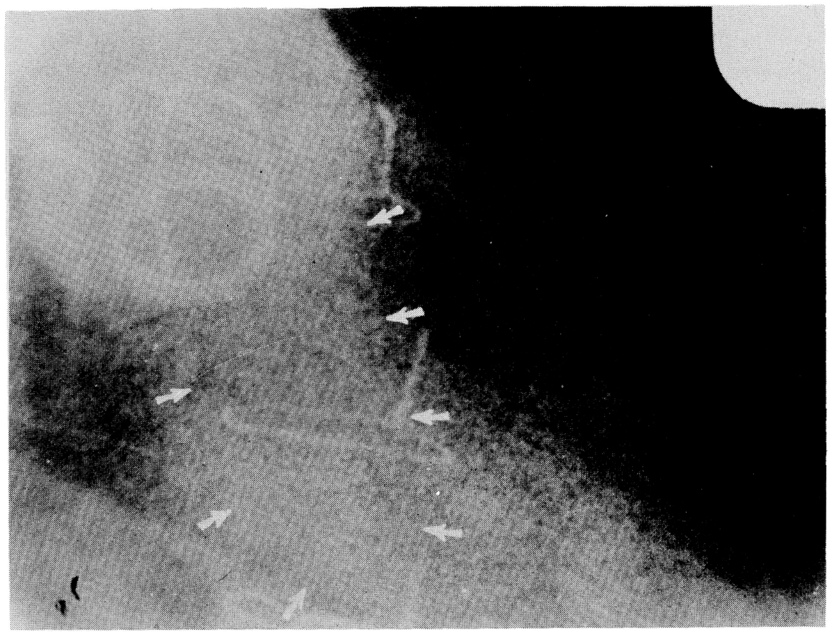


Figure 3

A 63-year-old female with double valve prosthesis. Only the aortic valve was studied. Upper left: Systole (RAO). Upper right: Diastole (RAO). The cage of the aortic prosthesis has tilted 4°. Lower left: Aortic root angiogram (RAO) shows no paravalvular leak. Lower right: Line drawing of aortic root angiogram.







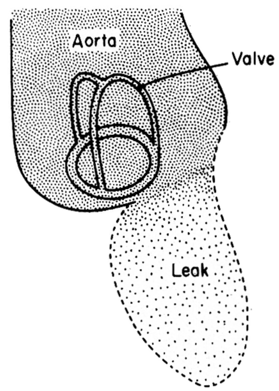


Figure 4

A 15-year-old male with prosthetic aortic valve. Upper left: Systole (AP). Upper right: Diastole. The valve has tilted 20° (AP). Lower left: Aortic root angiogram shows paravalvular leak (arrows). Confirmed at surgery. RAO projection was used for aortogram even though maximum tilt was in AP. Lower right: Line drawing of aortic root angiogram.

Table 1

Tilting Motion of Prosthetic Cardiac Valves

Patients	Age Sex	Severity	Maximum Tilt	Patients	Age-Sex	Maximum Tilt
	Aortic with Leak				*Aortic without Leak*	
RB	54–M	2+	4° in LAO	BF	43–F	4° in AP
MB	61–M	1+	5° in RAO	HM	63–F	4° in RAO
WC	63–M	1+	6° in AP	AP	55–M	6° in RAO & LAO
LC	66–F	1+	5° in RAO	SS	51–M	5° in RAO
SD	53–F	1+	4° in AP	JG	38–M	3° in LAO
LF	52–M	2+	2° in RAO	HS	59–M	3° in LAO
JH	37–F	1+	4° in RAO	HH	75–M	6° in AP
TH	15–M	3+	20° in AP	PE	46–M	2° in LAO
BL	61–M	1+	10° in LAO			
NL	67–M	2+	4° in LAO			
EM	50–M	1+	7° in RAO			
DM	49–M	3+	4° in AP			
MP	66–M	3+	7° in RAO			
MN	50–M	3+	11° in RAO			
RP	65–F	1+	6° in RAO			
SQ	66–F	1+	3° in AP			
HS	77–M	2+	7° in LAO			
IS–L	40–M	1+	15° in RAO			
RT	34–M	3+	24° in RAO			
GW	63–M	3+	7° in RAO			
YG	50–F	1+	3° in RAO			
	Mitral with Leak				*Mitral without Leak*	
EB	71–F	3+	13° in AP	B	50–F	8° in AP & LAO
JD	38–F	2+	18° in RAO	JD	58–M	21° in LAO
MK	52–M	3+	6° in LAO	LH	56–M	15° in RAO
HM	53–F	1+	5° in RAO	HJ	44–F	5° in RAO
JR	63–F	3+	12° in LAO	TK	76–M	10° in LAO
FW	54–F	3+	19° in LAO	PL	62–M	9° in LAO
YG	50–F	1+	23° in LAO	HL	65–F	7° in RAO
MF	67–F	3+	16° in LAO	TM	46–M	11° in LAO
RW	62–M	2+	21° in LAO	SS	51–M	6° in RAO
				JW	49–M	6° in RAO
				RS	59–M	10° in RAO
				VB	45–M	17° in LAO

24°. The range of tilt shown in the cineradiograms of eight patients with prosthetic aortic valves and no evidence of a paravalvular leak was 2° to 6° (fig. 5).

The valve tilt of eight patients with prosthetic mitral valves with evidence of paravalvular leakage by angiocardiography ranged between 5° and 23°. A range of 5° to 21° tiltage was shown in ten patients with prosthetic mitral valves and no evidence of paravalvular leakage (fig. 6).

Discussion

Some patients do not show the expected improvement in their cardiac status following prosthetic valve replacement. A few of these patients do poorly as a result of severe intrinsic myocardial disease.[3] Several complications may occur to the prosthetic valve itself. There can be mechanical damage to the ball, and actual extrusion of the ball has been reported.[6, 1] There may be thrombus formation on the outside of the cage; when thrombus occurs on the inside of the cage it can cause improper seating of the ball with a leak through the valve ring.

This paper deals with the development of paarvalvular leaks (i.e., leaks *around* the prosthetic valve ring) caused by the anchoring sutures ripping through the supporting structures.

A number of methods have been used to study prosthetic valves, including ultrasound,[2] phonocardiography, fluoroscopy with or without spot films[7] and cineradiography. Fluoroscopy without spot

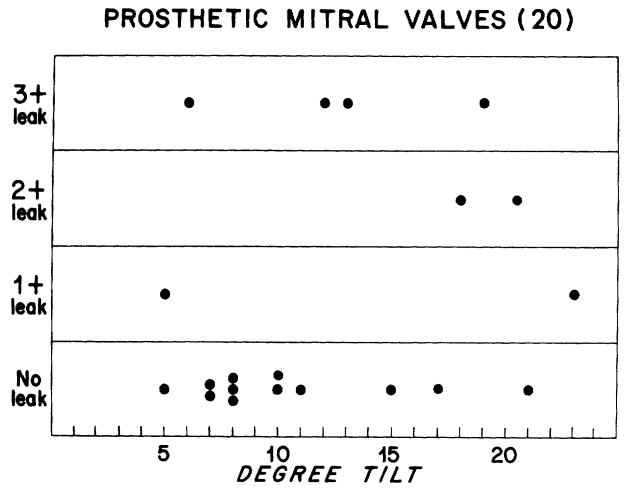


Figure 5

Scattergram of leaking and nonleaking prosthetic aortic valves.

films is a very subjective method and is unreliable. The rationale for cineradiographic study is that the degree of tilt will tend to be greater than normal if sutures have pulled through the supporting tissues, with the intact sutures acting as a pivot point. However, a paravalvular leak may occur in the presence of normal degree of tilt if there is a sufficient number of strategically placed intact sutures, without a pivot point.

We have found aortic valve prostheses (fig. 5) to be more stable than mitral prostheses with respect to their normal range of motion.

The greater range of tilting motion of the nonleaking prosthetic mitral valve is apparently due to at least two factors. First, the dynamic motion of the mitral annulus itself is greater than similar motion in the aortic root. Second, there is a greater variability in the amount of tissue left by the cardiac surgeon in the case of the mitral prosthesis than in the case of the aortic prosthesis.

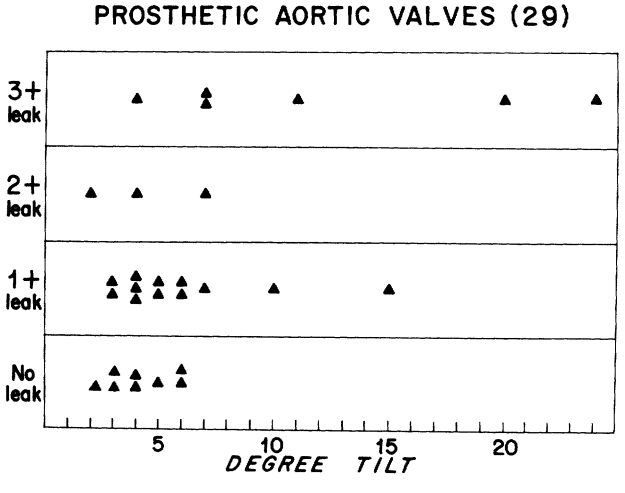


Figure 6

Scattergram of leaking and nonleaking prosthetic mitral valves.

The range of angle of tilt of the nonleaking mitral valves is about the same as for the leaking mitral valves (fig. 6). However, most of the nonleakers have a tilt of 11° or less. Six of the nine mitrals with a tilt of 12° or more had a paravalvular leak. When the mitral valve does leak, it is more consistently abnormal than in the case of the aortic valve (fig. 5, 6). Thus the range is approximately the same for leaking mitral valves and nonleaking mitral valves, and a tilting motion of more than 12° suggests a paravalvular leak may be present.

We recommend routine cineradiography after prosthetic valve replacement has been performed. Those patients who subsequently develop a murmur or unexplained congestive failure should have repeat cineradiography and the degree of tilting motion compared. A change in the tilt between the two examinations is more significant than the tilting motion on a single examination.

Our normal range for aortic valves (up to 6°) is in general agreement with previously published values of up to 4°[8] and up to 9°[5]. In the case of the mitral valve, however, we have found a broader normal range than previous authors[5] who reported up to 9° normal tilting motion. However, these previously reported normal values were often based on cases which clinically were felt not to be leaking. In view of the general agreement[1, 2, 3, 4] that paravalvular leaks are often difficult to detect clinically, we believe that our series of all angiographically confirmed cases provides a more accurate standard for the normal tilting motion of these valves.

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