Angiocardiographic Evaluation of Valvular Insufficiency

By Murray G. Baron, M.D.

SUMMARY
Incompetence of any of the cardiac valves can be easily evaluated by selective angiocardiography. Factitious insufficiency may result from faulty catheter placement or from ventricular extrasystoles caused by the pressure injection of the contrast agent. False negative results are almost nonexistent, and if no insufficiency is seen on a technically adequate angiogram, the valve can be considered to be competent.

Selective angiocardiography is a sensitive method for the evaluation of valvular competency and for grossly measuring the severity of valvular insufficiency. False negative results are rare, if they occur at all, and even minimal degrees of insufficiency can be demonstrated by a technically adequate angiographic study. On the other hand, it is possible to create the appearance of insufficiency where none is present or to magnify the degree of existing insufficiency by faulty catheter placement or simply as a result of the forceful injection of contrast material.

In order to study the competency of a cardiac valve, the contrast material should be injected selectively into the chamber or vessel on the downstream side of the valve, i.e., the one into which the valve opens. If the valve is incompetent, the regurgitant stream will then be visualized, and the chamber on the upstream side of the valve will become opacified (fig. 1).

When the contrast material is introduced into the heart at a point upstream to the valve in question, diagnosis of insufficiency will depend on the demonstration of an abnormally wide variation between the systolic and diastolic volumes of the chamber guarded by the valve, or by the presence of a regurgitant stream of radiolucent blood. This is a relatively insensitive technique and of little practical usefulness.

Ciné recording is better for the study of valve insufficiency than the use of a rapid film changer because of the ciné’s more rapid rate of film exposure, and because the eye is more sensitive to changes seen in motion than to changes in a series of still pictures. At 60 or more frames/sec, transient puffs of regurgitation are easily visualized, whereas they can be completely missed on large films made at the rate of 6/sec.

Aortic Valve
The aortic valve is the easiest of the cardiac valves to evaluate because there is little chance of producing factitious insufficiency. As long as the catheter tip is located above the valve cusps, it will not interfere with their closing. It is possible that the jet of contrast material from an end-hole catheter, positioned directly above the valve, may enter the left ventricle during end-systole before the cusps close. However, such regurgitation is transient and of a minor degree. An insignificant degree of aortic insufficiency, filling only the outflow portion of the left ventricle, can also be seen in patients without any other evidence of aortic valve disease (fig. 2). Whether or not this degree of incompetence indicates abnormality of the valve in all cases is uncertain.

Because of the rapid forward flow of blood in the aorta, it is important that the contrast material be injected in the immediate supravalvular region. If the injection is made too

From the Department of Radiology of The Mount Sinai School of Medicine of the City University of New York and The Mount Sinai Hospital, New York, New York 10029.
Mitral insufficiency, left ventricular angiocardiogram. (A) Lateral view. A prominent regurgitant stream of contrast material is seen pouring from the left ventricle (LV) backward into the left atrium (LA). (B) Frontal view. Despite the marked degree of insufficiency, the atrium (LA) is only moderately opacified because of the dilution of the contrast material.

Mitral Valve

Selective left ventricular angiocardiography is the procedure of choice for evaluating the competency of the mitral valve. As long as the ventricle is well opacified, any insufficiency of the valve will be easily visualized. The patient should be studied in the right anterior oblique projection because in this view the mitral valve is seen tangentially, separating the left atrium from the ventricle. The lateral projection is also satisfactory as the overlap of the two chambers is small.

In contrast, in the frontal view, a good portion of the left atrium is hidden by the opacified outflow tract of the left ventricle, and, in the left anterior oblique projection, the mitral valve is seen en face, and the body of the atrium is almost completely obscured. Because of the overlapping of the chambers, even a moderate degree of insufficiency can be missed in either of these views.

Factitious mitral insufficiency can result from faulty catheter placement or from ventricular extrasystoles. It is possible, in many cases, to manipulate a catheter within the left ventricle so that it passes retrograde through the mitral valve, and to inject contrast material directly into the left atrium. This can
originally assumed that incompetence.

If injection, the catheter promptly, atrium simply seen in the outflow tract of the left ventricle (arrow) indicating minimal incompetency of the aortic valve. At the time of surgery for mitral valve replacement, no insufficiency could be detected and the aortic valve was considered to be normal.

Also result by chance, from the whipping of the catheter that accompanies a high pressure injection, even though the catheter was originally positioned away from the valve (fig. 3.) Such “insufficiency” ends when the injection ceases. If the left atrium does not clear promptly, it is likely that the valve is truly incompetent.

Actually, a catheter is more likely to pass retrograde through the mitral valve if it is insufficient. Therefore, even if the catheter is seen to cross the mitral valve, it cannot be assumed that the resulting opacification of the atrium simply represents an artifact, and the angiocardiogram should be repeated after repositioning the catheter.

Because of the whipping of the catheter and the impinging of the jets of contrast material against the ventricular wall, a short run of extrasystoles commonly accompanies pressure injections into the left ventricle. This disrupts the orderly sequence of events in the cardiac cycle, and the premature ventricular contraction can force blood into the atrium before the mitral valve has a chance to close. Once the injection is ended and normal sinus rhythm is restored, the insufficiency ceases and the atrium clears rapidly.

Extrasystoles are most common when a J-shaped catheter is used to enter the left ventricle, especially if the curve of the “J” is so broad that the arms are sprung against the sides of the ventricle. A straight catheter with multiple side holes produces less functional disturbance because it tends to remain in the mid-ventricle and the force of the jets of contrast material is largely dissipated before it reaches the endocardium.

The severity of mitral insufficiency can be roughly gauged from the degree of opacification of the left atrium seen on a selective left ventricular angiogram. However, the size of the atrium must be taken into consideration. The larger the atrium, the greater the dilution of the regurgitated contrast material, and the atrial shadow may be of only moderate density even though there is wide open insufficiency (fig. 1). This evaluation can be made somewhat more objective if the density of the atrial shadow is compared with that of the aorta. In the presence of marked mitral insufficiency the two will be roughly equal, whereas with lesser degrees of regurgitation, opacification of the aorta will be relatively greater than that of the atrium.

In general, in the absence of significant mitral stenosis, the size of the left atrium is proportional to the degree of mitral insufficiency although this will vary with the length of time the insufficiency has been present and with the compliance of the atrial wall. With lesser degrees of insufficiency, the atrium may

Figure 2
Insignificant aortic insufficiency. Supraventricular aortogram, lateral view. A small amount of contrast material is present in the outflow tract of the left ventricle (arrow) indicating minimal incompetency of the aortic valve. At the time of surgery for mitral valve replacement, no insufficiency could be detected and the aortic valve was considered to be normal.

Circulation, Volume XLIII, April 1971
be normal in size. However, when the regurgitant stream is considerable, the atrium usually is enlarged.

Any disparity between the size of the atrium and the observed severity of the insufficiency must be explained. The most common causes of a normal-sized left atrium in the presence of marked mitral regurgitation are acute mitral insufficiency, including papillary muscle dysfunction or rupture, and rupture of the chordae tendineae, or artifactual insufficiency due to the angiocardiographic procedure (fig. 3).

If the left ventricle cannot be catheterized in a retrograde direction, through the aortic valve, it is still possible to evaluate the presence of mitral insufficiency. The ventricle can be entered by passing a venous catheter across the atrial septum, either through a patent foramen ovale or by transseptal puncture, and through the mitral valve. Even though the catheter lies across the valve, it rarely interferes with its closure, and insufficiency due to the catheter is rare.

**Tricuspid Valve**

Evaluation of the competency of the tricuspid valve is somewhat more uncertain than it is with the valves on the left side of the heart, because the catheter must traverse the valve to reach the right ventricle. In most cases, the catheter appears to lie in a commissure between two leaflets rather than directly across a leaflet, and it rarely interferes significantly with valve closure. Even when the right ventricular pressure is considerably

**Figure 3**

Artifactual mitral insufficiency, lateral view. (A) The catheter, originally positioned in the left ventricle (LV), has whipped backward from the force of the injection so that contrast material is deposited directly into the left atrium (LA). (B) A film made several cardiac cycles later shows complete clearing of the atrium while contrast material is still present in the ventricle (LV), indicating that there is no persistent mitral insufficiency.
RADIOLOGIC NOTES IN CARDIOLOGY

Figure 4

Tricuspid insufficiency. Right ventricular angiocardiogram, frontal view. The catheter tip (arrow) is well positioned in the right ventricle (RV). There is marked regurgitation of contrast material into the right atrium (RA), inferior vena cava (C) and the hepatic veins (H).

Figure 5

Right ventricular angiocardiogram, frontal projection. The right ventricle (RV) is dilated and extends to the right cardiac border. The atrium is displaced backward so that the tricuspid valve orifice (T) is rotated towards the frontal plane and is seen almost en face.

elevated, as in severe pulmonic stenosis, the valve usually appears competent on the angiocardiogram. A small regurgitant puff is occasionally seen but presents no problem because, even if it were not artifactual, it would be of no clinical importance.

In the presence of marked tricuspid insufficiency, contrast material injected into the right ventricle will opacify the right atrium and often regurgitate into the inferior vena cava and the hepatic veins (fig. 4). Usually there is no problem in identifying tricuspid insufficiency on a frontal view angiocardiogram because the right atrium forms the right border of the cardiac silhouette. However, when the right ventricle is dilated, it frequent-
ly extends to the right and displaces the atrium posteriorly. The tricuspid valve is rotated towards a coronal plane so that the anterior margin of the valve, corresponding to the atroventricular sulcus, is shifted laterally (fig. 5). The opacified right ventricle, during diastole, will extend almost to the right cardiac border and may be mistakenly interpreted as representing opacification of the atrium as well as the ventricle.

**Pulmonic Valve**

The problem in evaluating the competency of the pulmonic valve is much the same as with the tricuspid because the catheter must cross the valve if the contrast material is to be deposited in the pulmonary artery. Despite this, factitious insufficiency of the pulmonic valve is rarely seen. Actually, in many cases, because of the forward thrust of the blood in the pulmonary artery, the valve cusps are not visualized at all unless the catheter tip is positioned near the valve. However, when there is significant pulmonic insufficiency, there is sufficient ebb in the pulmonary arterial flow for the contrast material to wash

*Figure 6*

Pulmonary insufficiency. Pulmonary arteriogram, frontal view. Valvular incompetence following operation for pulmonic stenosis during infancy. The catheter tip (arrow) is positioned well into the right pulmonary artery (RP). Despite this, the contrast material regurgitates backward through the pulmonic valve and into the right ventricle (RV).
Pulmonary insufficiency. Right ventricular angiocardiogram, frontal view. (a) Systole. As the ventricle (RV) contracts, the main pulmonary artery (PA) is well opacified. (b) Diastole. On a film made 1/6 of a sec later, there is almost complete clearing of the pulmonary artery and over-distension of the right ventricle (RV), indicating valvular insufficiency.

backward to the valve and into the right ventricle (fig. 6). Although the catheter rarely affects the competency of a normal valve, slight degrees of insufficiency are not uncommonly seen in congenital pulmonic stenosis. Whether these valves are truly insufficient or whether this insufficiency is due to the catheter is not certain.

Pulmonic insufficiency of a significant degree can often be detected from a selective right ventricular angiocardiogram. During ventricular systole, the main pulmonary artery and its proximal branches fill with the contrast material ejected from the ventricle. During diastole, a good part of the contrast material regurgitates back into the right ventricle so that the pulmonary artery clears (fig. 7), to be refilled during the next systole. This is usually repeated over several cardiac cycles.

An accurate evaluation of pulmonary insufficiency without fear of artifact is possible in the presence of a patent ductus arteriosus. Contrast material injected into the aorta fills the pulmonary arteries, often down to the valve. Extrasystoles do not occur, and there is no catheter within the valve. Any contrast material seen in the right ventricle in this situation indicates incompetence of the valve.
Angiocardiographic Evaluation of Valvular Insufficiency
MURRAY G. BARON

_Circulation_. 1971;43:599-605
doi: 10.1161/01.CIR.43.4.599

_Circulation_ is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 1971 American Heart Association, Inc. All rights reserved.
Print ISSN: 0009-7322. Online ISSN: 1524-4539

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circ.ahajournals.org/content/43/4/599

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in _Circulation_ can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to _Circulation_ is online at:
http://circ.ahajournals.org//subscriptions/