Tricuspid insufficiency

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In the days when late cases of rheumatic valvular disease formed the bulk of the valvular abnormalities encountered, surgeons were commonly obliged to deal with functional tricuspid insufficiency, in which the tricuspid valve leaked during systole in the presence of structurally normal leaflets and chordae. Nowadays, the average North American surgeon encounters tricuspid insufficiency infrequently. The publication of an article on a method of measurement to aid in the performance of tricuspid annuloplasty serves as a stimulus to review some of the lessons that were learned in the past.

Repair for functional tricuspid insufficiency, in isolation or combined with left-sided valve surgery, carries a much higher risk for 30-day mortality and long-term survival than isolated mitral or aortic surgery. As such, it is a marker for late neglected valvular disease.¹

The lesson that gross tricuspid insufficiency cannot be ignored when performing left-sided valve surgery was learned long ago.² Despite correction of the left-sided pathologic condition, tricuspid insufficiency may persist or recur and produce persistent continued morbidity.³ Simon and associates,⁴ in an elegant study using right ventricular angiography before and 1 year after surgery, showed that impaired contraction of the atrioventricular orifice was the mechanism of the insufficiency and that this persisted in half the cases at 1 year, even in some patients in whom the right-sided pressures had returned substantially toward normal. The decision to repair all cases of gross functional tricuspid insufficiency is easy. (It does not even need special studies: the accessibility of jugular veins and the liver make detection of gross insufficiency easy at the bedside; it is, after all, systolic reversal of blood flow in the cavae that produces the signs and symptoms of gross insufficiency.)

What should the surgeon do when, at the time of surgery, the tricuspid insufficiency is only moderate, when it is not producing a V wave in the right atrium, when the area of the regurgitant jet does not occupy much of the atrium, or the width of the vena contracta does not indicate severe insufficiency?^{5,6} At one time, I would have left the tricuspid valve alone, but the problem is that functional tricuspid insufficiency is dynamic and does respond to medical therapy. It is possible to have gross insufficiency which, 3 weeks later, as the patient enters the operating room, has become mild. Late appearance of apparently new significant tricuspid insufficiency does occur, albeit rarely, after successful mitral surgery.⁷ At least some of these cases have had the warning sign of a previous episode of tricuspid insufficiency and some a dilated tricuspid anulus without gross insufficiency at the original operation. The message, then, is to be liberal in the indications for tricuspid annuloplasty and to regard any previous episode of significant insufficiency or a dilated tricuspid anulus⁵ as indications for repair. This means that the surgeon must know the patient's history, must positively look for insufficiency, and must use an approach that encourages opening of the right atrium. The alternative is to accept a number of patients who will need a reoperation for late tricuspid insufficiency with a high mortality and morbidity.

Anatomic Basis for Functional Tricuspid Insufficiency

Simon's work on the role of impaired right ventricular annular contraction has already been quoted. The classic autopsy measurements reported by Deloche and colleagues⁸ demonstrate chronic annular changes beautifully; their article is well worth revisiting.

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Differences and Similarities Compared with Functional Mitral Insufficiency

Both atrioventricular valves have a D-shaped anulus. The straight side of the mitral anulus is the fibrous atrioventricular membrane to which is attached the anterior leaflet. The straight side of the tricuspid valve runs across the interventricular septum from the central fibrous body to the meeting of the septum with the free wall of the right ventricle and gives attachment to the base of the septal leaflet.

In each case, when annular dilatation occurs, it is the mural part of the anulus that increases in length: the straight side retains its dimension.

There are two differences. The first is that, on the left side, the *single anterior leaflet* is the *deeper* part of the valve, is the part that moves the most, is the most important part functionally, and covers a disproportionately large area of the orifice in systole. On the right side, the *multiple leaflets and scallops of the mural part* of the valve are the *deeper* part of the valve, move the most, and cover a disproportionately large area of the orifice in closing.

The second difference is that the mitral papillary muscles arise from the middle of the free wall of the left ventricle, and their displacement by ventricular dimension changes is a more potent source of functional mitral insufficiency than annular dilatation. The tricuspid papillary attachments arise, in the case of the septal leaflet, directly from the upper septum and otherwise from extremely variable papillary muscles attached to the trabecular septum or sometimes from the free wall very close to the septum. As such, they are very little affected by dilatation of the free right ventricular wall, and lengthening of the mural anulus is by far the dominant mechanism of functional tricuspid insufficiency. For those interested in tricuspid valve anatomy, a series of articles was published in the *Journal of Heart Valve Disease* in 1994 (volume 3, number 1) and 1995 (volume 4, number 6).

Techniques of Annuloplasty

For a good many years there have been several basic types of tricuspid annuloplasty:

1. Methods that obliterate some of the mural leaflet tissue at the same time as they reduce the mural annular dimension taking one or more pleats along its length (Kay, Wooler)
2. Methods that fix the mural anulus to a partial ring, which may be completely rigid or pliable and reduce the annular dimension by using wide spacing of the sutures in the anulus and narrow spacing in the ring
3. Methods that incorporate a sliding plasty of the leaflets with annular reduction, done by means of a ring or the taking of pleats
4. Methods that shorten the anulus by a partial purse-string suture that is intertwined with the attachment of the mural leaflets to the atrium and ventricle, from the

central fibrous body around to the junction between the free wall and septum on the right (De Vega)

This last method is the simplest.

There is anecdotal opinion that method 1 is not as good as the others but scant hard evidence that there is much difference in results among the other three. In general, properly applied, they achieve their purpose well, although for all methods the skimpiness of the atrioventricular membrane on the right side makes secure narrowing of the anulus difficult, and many surgeons add biologic or synthetic bolsters to their techniques. However, what is really demanded is that the surgeon be particularly careful to pass the needle deep to the leaflet at the atrioventricular junction and back again to grasp what fibrous tissue there is, whether anchoring a ring or making a purse-string suture. Atrial sutures do not hold.

The other reason for anecdotal failures may well be related to difficulties of measurement.

Measurement

On the left side, the long-established measurement principle is to reduce the mural anulus to the size of the anterior leaflet: the straight base of the anterior leaflet and its more or less semicircular outline make this quite easy and, once achieved, ensure that there will be an extensive area of coaptation between the anterior and posterior leaflets in systole. On the right side, multiple leaflets and scallops on the curved base of the mural anulus do not lend themselves to any practical form of measurement. An alternative is presented in the article by Liang and associates⁹ in this issue. They take advantage of the relatively unchanged dimension of the base of the septal leaflet, using it as a guide to the length to which the mural anulus should be shortened so that it can be restored to normal. This theory is based on the mean ratio between the septal and mural parts of the normal anulus. The idea is reasonable, but the authors' measurements do not produce the same ratio as the measurements of Deloche and colleagues,⁸ possibly because of ethnic differences in the populations, but perhaps also related to the small number of subjects in both studies. In the authors' hands, the use of sizers and obturators based on the length of the septal leaflet base and shaped like the normal tricuspid anulus has worked well, both with the combination annular pleating and sliding leaflet plasty that they describe and with the regular De Vega annuloplasty.

In fact, other reliable methods of gauging the tightness of a tricuspid annuloplasty have been described. Sizers supplied with partial or nearly complete rings (method 2) are commonly used by lining up the straight side with the septal leaflet. For the suture methods, cylindrical valve sizers or Hegar dilators, while not ideal in shape, can be used effectively as obturators during the tying down of the sutures. Different units tend commonly to use one size for all cases: for example, I have seen diameters of 25, 26, and 30 mm

used in three institutions as well as “loose two fingers” in another. My prejudice is in favor of the narrower dimensions. The goal is to achieve an area of apposition, and I suspect that some failures of the suture techniques are due to operations that leave the leaflets in contact only at their edges. Recognize that the cross-sectional area of a 25-mm cylinder is 4.9 cm². The orifice area derived from hemodynamic measurements (the effective orifice area) is always less than the geometric orifice, but so long as the leaflet tissue is normal, significant obstruction to flow does not occur. In cases in which the 25-mm obturator is used, the derived orifice areas are generally 2.5 cm² or more and the inevitable gradients at normal cardiac indexes no more than 2 or 3 mm.

Finally, the anatomy of the right atrioventricular junction lends itself to an alternative functional method of deciding the extent and assessing the effectiveness of the De Vega annuloplasty. Instead of the two arms of the suture being tied at the right-hand margin of the septal leaflet, they are brought through the right atrial wall 10 to 15 mm from the anulus, passed through a pledget, and secured with a rubber shod clamp. It is then possible to adjust the tightness of the suture after good postbypass myocardial function has been established. When I first started using this method, I judged the effectiveness of the correction of gross insufficiency by a flow probe around the inferior vena cava or the injection of saline solution into the right ventricle, checking with an M-mode echocardiographic probe to be sure that the saline solution did not appear in the inferior vena cava. Cardiac outputs and transvalvular pressure drops would then be measured to be sure that tricuspid obstruction had not been produced. The mean effective orifice area achieved by this method was 2.25 cm² and the results were durable.¹⁰ With

modern intraoperative echocardiography, the procedure is much simplified.

Summary

Functional tricuspid insufficiency, left uncorrected, carries serious long-term consequences. It should be assiduously sought and aggressively treated. The particular method of annuloplasty is less important than familiarity with anatomy and function.

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