Rationale for remodelling annuloplasty to address functional tricuspid regurgitation during left-sided valve surgery

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INTRODUCTION

The surgical management of functional tricuspid regurgitation is controversial. Functional tricuspid regurgitation is common in patients with aortic and mitral valve disease, particularly in the presence of pulmonary hypertension. The high incidence and reversibility of functional tricuspid regurgitation are due to the unique anatomical relationship with the fibrous skeleton of the heart [2]. Long-standing functional regurgitation is the milieu from which secondary organic lesions—severe right ventricular dilatation, papillary muscle displacement and leaflet tethering—and irreversible dysfunction eventually result (Carpentier’s functional classification type IIIb) [3]. Annular dilatation is a common secondary lesion in this subset of patients.

MECHANISM OF FUNCTIONAL TRICUSPID REGURGITATION

Functional tricuspid regurgitation is characterized by annular dilatation in most patients, i.e. Carpentier’s functional classification type I [1]. The diameter of the anterior tricuspid annulus may increase by up to 40%, and the posterior annulus by up to 80%, whereas the septal annulus is relatively fixed because of its close anatomical relationship with the fibrous skeleton of the heart [2]. Long-standing functional regurgitation is the milieu from which secondary organic lesions—severe right ventricular dilatation, papillary muscle displacement and leaflet tethering—and irreversible dysfunction eventually result (Carpentier’s functional classification type IIIb) [3]. Annular dilatation is a common secondary lesion in this subset of patients.

DIAGNOSIS

Preoperative transthoracic echocardiography is the best diagnostic tool to determine presence and severity of functional tricuspid regurgitation, and specific focus should be directed towards evaluating the tricuspid valve in patients prior to mitral or aortic surgery. This is because tricuspid regurgitation is significantly down-graded by the conditions under which intraoperative transoesophageal echocardiography is performed. General anaesthesia induces systemic vasodilatation resulting in significant afterload reduction, a fall in preload as a result of venodilatation and fasting, and depression of right ventricular function. The absence of significant tricuspid regurgitation on intraoperative transoesophageal echocardiography is therefore an unreliable predictor of the absence of postoperative functional tricuspid regurgitation.

SURGICAL STRATEGY

The spectrum of surgical approaches to functional tricuspid regurgitation at the time of left-sided surgery extends from benign neglect to systematic tricuspid valve reconstruction whenever the annulus is dilated, even if regurgitation is minimal [4]. Historically, correction of left-sided valve disease was thought sufficient to reverse functional tricuspid regurgitation [5]. There is, however, a growing body of evidence that the regression of functional tricuspid regurgitation is unpredictable after surgical treatment of mitral and/or aortic valve diseases [6–8]. Left untreated, a significant minority of patients will develop severe symptomatic tricuspid regurgitation over time [7], associated with increased morbidity and mortality mainly due to end-stage heart failure. Most of these patients are not candidates for reintervention, because reoperative surgery for severe isolated tricuspid regurgitation carries high operative morbidity and mortality [9]. While only 16% of patients undergoing isolated mitral repair for mitral valve prolapse had moderate or greater tricuspid regurgitation at the time of their mitral repair, at 5-year follow-up the incidence of moderate or severe tricuspid regurgitation was 29% [7]; predictors of recurrent or residual tricuspid regurgitation include atrial fibrillation, pulmonary hypertension, right and left ventricular dysfunction, dilatation and papillary muscle displacement and tethering [4, 7, 8]. The persistence of mild-to-moderate tricuspid regurgitation has
**Figure 1:** Surgical algorithm for mild functional tricuspid regurgitation. Modified with permission from [3].

1. **Intra-operative inspection** (exclude organic lesions)
2. Measure surface area of anteroposterior leaflet with tricuspid annuloplasty sizer
3. Measure orifice area with sizer
   - **Leaflet tissue area < orifice area**
     - (e.g. 30 / 32)
     - Remodeling annuloplasty
   - **Leaflet tissue area = orifice area**
     - (e.g. 32 / 32)
     - No reconstruction

**Figure 2:** Intraoperative assessment of the tricuspid valve. (A) Surgical view of the tricuspid valve. (B) Using a sizer oriented along the septal annulus to assess the orifice area. (C) A nerve hook is used to expose the anterior and posterior leaflets. (D) The leaflet surface area is compared with the sizer. If the size of the orifice is greater than that of the leaflet area, remodelling annuloplasty is recommended. Figure reproduced with permission from [3].
been shown to have a negative impact on survival regardless of left ventricular function and pulmonary artery pressures [10]. Concomitant tricuspid remodelling annuloplasty can be performed reliably and reproducibly without incremental risk, with excellent durability in long-term follow-up [4, 6].

Our surgical group has therefore adopted a more liberal approach to correction of functional tricuspid regurgitation at the time of surgery for mitral or aortic valve disease. We recommend that all patients with moderate-to-severe tricuspid regurgitation (>2+) on preoperative or intraoperative echocardiography should undergo concomitant tricuspid valve reconstruction with a remodelling annuloplasty. In patients with lesser grades of regurgitation, and particularly in those with atrial fibrillation, increased pulmonary artery pressures or dysfunction of either ventricle, we recommend direct assessment of the tricuspid valve (Fig. 1). The amount of valvular tissue is assessed by measuring the anteroposterior leaflet surface area, which is then compared with the orifice area to determine whether remodelling annuloplasty is indicated (Fig. 2) [3]. If the sizer that covers the orifice area is larger than the sizer that covers the amount of leaflet tissue, significant annular dilatation is present and a remodelling annuloplasty is recommended. Echocardiographic measurement of the tricuspid annulus is a useful adjunct: several cut-offs have been proposed, and current consensus guidelines recommend concomitant tricuspid annuloplasty in patients with a tricuspid annulus diameter >40 mm on echocardiography (21 mm/m²) [6].

In summary, functional tricuspid regurgitation is common in patients with aortic or mitral valve disease. Correcting the left-sided lesion is insufficient in many patients, in whom progression of tricuspid regurgitation postoperatively is associated with decreased survival and functional status. Tricuspid remodelling annuloplasty is a safe, reproducible and reliable treatment for functional tricuspid regurgitation, and should be performed at the time of left-sided valve surgery in any patient with any history of moderate or severe tricuspid regurgitation, or significant annular dilatation.

**Conflict of interest:** Alain Carpentier is the inventor and holder of several patents for tricuspid annuloplasty rings.

**REFERENCES**