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CASE REPORT
Coronary intervention

Right coronary artery kinking after tricuspid valve annuloplasty: a case report

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Background Right coronary artery (RCA) injury is a rare complication of valvular surgery. However, complications should be considered, due to the significant clinical consequences. Identifying the coronary injury type and understanding the underlying pathophysiological mechanisms is essential to managing these complications.

Case summary The case of a 59-year-old man who underwent conservative mitral valve surgery with tricuspid valve annuloplasty is presented. The early post-operative period was complicated by acute coronary syndrome with inferior persistent ST-segment elevation. A coronary angiogram confirmed critical RCA hazy lesions, raising the suspicion of coronary kinking. To confirm the underlying mechanism for these lesions and determine the best treatment strategy, endocoronary imaging was performed, revealing coronary kinking of the RCA. Based on the persistent acute ischaemia, a long-lasting drug-eluting stent (DES) was implanted in the lower and upper knees of the RCA. After angioplasty, electrocardiography showed regression of the ST-segment elevation. Ten days later, coronary angiography and optical coherence tomography showed good results. The patient recovered from his myocardial infarction.

Discussion Only a few reports describe the use of endocoronary imaging for diagnosing coronary artery injury after tricuspid annuloplasty. The variety of lesion types that could underlie a single post-operative myocardial infarction makes endocoronary imaging a relevant technique to guide management strategy and optimize DES implantation.

Keywords Cardiac surgery • Tricuspid annuloplasty • Myocardial infarction • Coronary angiography • Optical coherence tomography • Coronary kinking • Case report

ESC curriculum 2.1 Imaging modalities • 3.1 Coronary artery disease • 3.2 Acute coronary syndrome • 3.4 Coronary angiography • 7.5 Cardiac surgery

Learning points

- After tricuspid valve annuloplasty, ECG for the screening of RCA injury should be systematically performed in the early postoperative period, even in the absence of haemodynamic instability or ventricular rhythm disturbance.
- Endocoronary imaging can be useful to determine the cause of coronary injury when there is angiographic ambiguity and to guide percutaneous coronary intervention.
- Percutaneous revascularization seems a feasible and safe approach for RCA kinking without complete coronary obstruction.

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Introduction

Annuloplasty is defined as valve repair, which various techniques have been described, including the ring annuloplasty as introduced by Carpentier, and the suture annuloplasty method, originally performed by De Vega.[1] According to the 2021 ESC/EACTS guidelines for the management of valvular heart disease, tricuspid valve repair performed during left-sided surgery in patients with secondary tricuspid regurgitation (TR) does not increase operative risk, and freedom from significant TR appears significantly greater compared to those undergoing isolated mitral surgery.[2] Recent long-term studies suggest that recurrence rate of significant tricuspid insufficiency after tricuspid annuloplasty is around 8–15%.[3] Moreover, direct injury of the right coronary artery (RCA) is a rare complication of tricuspid annuloplasty, but serious clinical consequences, such as cardiogenic shock, ventricular tachycardia, and inferior myocardial infarction, may occur due to the close anatomic link between the RCA and tricuspid annulus.[4] Herein, a case of right coronary kinking after tricuspid annuloplasty is presented.

Summary figure

Day 0:

Conservative mitral valve surgery with annuloplasty coupled with a tricuspid valve annuloplasty. No perioperative complications.

Immediate post-operative period in the intensive care unit:

Acute coronary syndrome with inferior ST-segment elevation. Transfer to the primary angioplasty room.

First hour in the Cathlab:

Angiography reveals a hazy lesion at the upper and lower knees of the right coronary artery.

Optical coherence tomography confirms the diagnosis of right coronary artery kinking.

Drug-eluting stent implantation in the lower and upper knees.

Day 10:

Angiography shows right coronary artery with a TIMI 3 flow.

The ostial hazy lesion is treated by angioplasty with implantation of a drug-eluting stent. Angiographic and optical coherence tomography results are good.

Day 14:

Hospital discharge. Left ventricular ejection fraction 25%. The patient is stable with standard treatment for heart failure.

Day 40:

Patient is asymptomatic and stable after cardiac rehabilitation. Left ventricular ejection fraction 35%.

Six-month follow-up:

Patient show excellent recovery and is asymptomatic. Left ventricular ejection fraction 30–35%.

No ischaemic recurrence.

Case presentation

A 59-year-old male was admitted to our emergency department with worsening dyspnoea and palpitations. Lung auscultation revealed pulmonary crackles. There was no sign of shock. He had no previous medical history or treatment on admission. After the clinical examination and chest X-ray, laboratory test showed NTproBNP at 2185 pg/mL, and troponin was negative. A diagnosis of pulmonary oedema was made, and an electrocardiogram (ECG) revealed atrial fibrillation (AF). The patient responded well to treatment with diuretics, vasodilators, and non-invasive ventilation. Atrial fibrillation was treated with anticoagulants and slowed as a rate control strategy. Five days after admission, the patient was stable and transthoracic echocardiogram (TTE) revealed severe mitral regurgitation (MR) caused by rupture of the posteromedial papillary muscle with complete prolapse associated with a myxoid degeneration aspect (see Supplementary material online, *Video S1*). The left ventricle was dilated, and the left ventricular ejection fraction (LVEF) was 40%. Right ventricular (RV) systolic function was preserved. The tricuspid annulus was dilated to 49 mm, and mild TR was detected. Coronary angiography showed normal left and right coronary arteries (*Figure 1A and B*). The patient was transferred to cardiac surgery after a normal preoperative workup.

Ten days after admission, the patient underwent conservative mitral valve surgery with a 32 mm mitral valve annuloplasty coupled with a 30 mm tricuspid valve annuloplasty. No perioperative complications occurred. The patient's haemodynamic status was stable, and amines or inotropes were not needed after removal of the cardiopulmonary bypass. Scope monitoring showed no changes in ECG. An immediate post-operative trans-oesophageal echocardiogram revealed severe biventricular dysfunction (LVEF 25%) and favourable functioning of the mitral and tricuspid valvuloplasties, without MR or TR.

The ECG performed on arrival at the intensive care unit showed an ST-segment elevation systematized in the inferior leads with an anterolateral mirror image (*Figure 2*). Due to the acute coronary syndrome with ST-segment elevation, the patient was treated with loading doses of aspirin and clopidogrel, and he was transferred to the cardiac catheterization laboratory to rule out a surgery-related coronary injury. Injection of the RCA revealed a hazy lesion extending from the upper to lower knee (*Figure 3A*, white arrows). Coronary kinking was suspected (*Figure 3A*, red arrow).

Intracoronary optical coherence tomography (OCT) showed the aspect of the coronary twist (*Figure 3B*, red arrow), supported by the OCT 3D image (*Figure 3C*, red arrow), confirming the diagnosis of right coronary kinking, which was probably secondary to the tricuspid annuloplasty (see Supplementary material online, *Videos S2 and S3*). The obstruction was partial, and it was possible to cross the lesion using the wire; therefore, percutaneous revascularization was feasible. Based on the signs of acute ischaemia, two long drug-eluting stents (DES) (both 4×38 mm) were placed in the lower knee and the upper knee of the RCA (see Supplementary material online, *Video S4*). A mild malposition of the second stent was corrected by post-dilatation with a 5 mm semi-compliant balloon (see Supplementary material online, *Video S5*). After percutaneous coronary intervention, the ECG showed a regression of the ST-segment elevation and inverted T waves in the inferior leads.

Ten days later, coronary angiography showed TIMI 3 flow in the RCA. An ostial hazy lesion was detected and treated with OCT-guided implantation of a 4.5×8 mm DES (see Supplementary material online, *Video S6*). The angiographic result was favourable (*Figure 4A*), and OCT showed loss of kinking at the sites of angioplasty (*Figure 4B and C*, red and white arrows).

Transthoracic echocardiogram at discharge showed a dilated left ventricle with severe left ventricular dysfunction (LVEF 25%). The right ventricle was dilated and hypokinetic without TR. He was transferred to the cardiovascular rehabilitation department with heart failure drugs combining bisoprolol, ramipril, spironolactone, and dapagliflozin. Due to AF, an association of clopidogrel and apixaban was given for 1 year. Cardiac and coronary computed tomography angiography (CCTA) was performed 3 months after angioplasty to check the permeability of the implanted stents and clarify the anatomical relationship between the right coronary injuries and the tricuspid annulus. The CCTA showed the proximity between the tricuspid annulus and

Figure 1 Preoperative coronary angiography. No significant lesion was detected on the right coronary artery (*A*) at 30° left anterior oblique and (*B*) at right anterior oblique with cranial angulation.

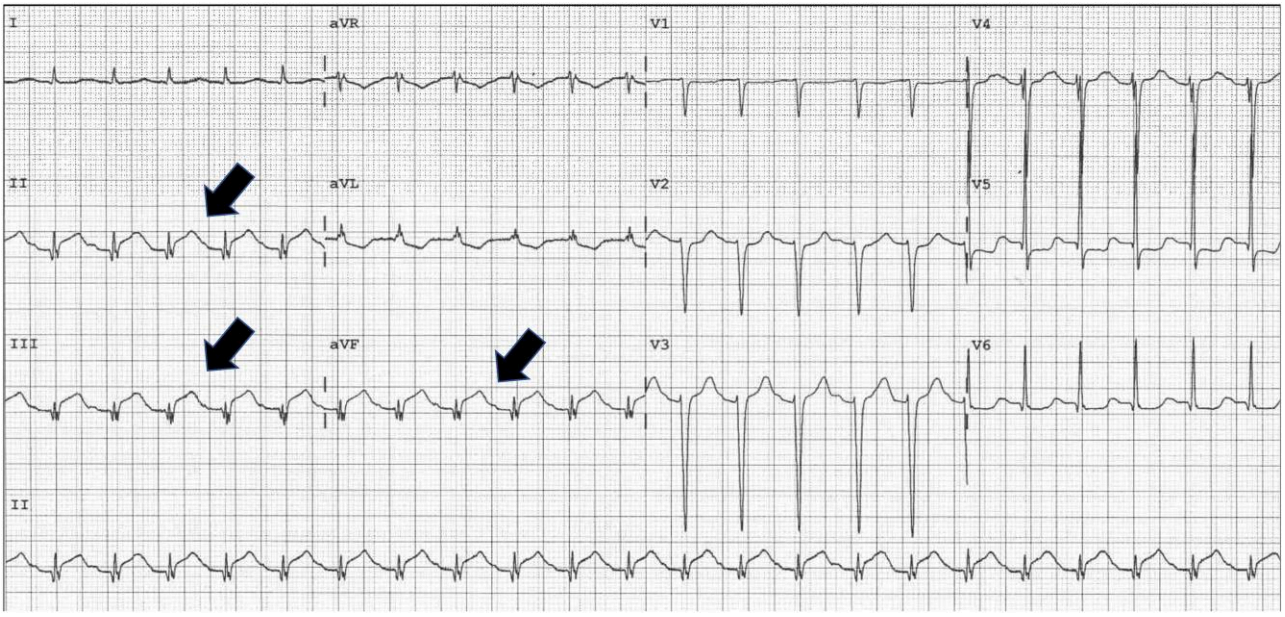

Figure 2 Postoperative electrocardiogram showing inferior ST elevation myocardial infarction with an anterolateral mirror image.

RCA, suggesting that the origin of the kinking was due to a traction mechanism (*Figure 5*, red arrow). At the 6-month follow-up, the patient showed excellent recovery and was asymptomatic, with an LVEF of 30–35%, and there had been no ischaemic recurrence.

Discussion

Secondary TR, which is often related to mitral valve disease, is the most common type of tricuspid valvulopathy and is associated with impaired survival and worsening heart failure.[5,6] The main mechanisms are RV dilatation due to pressure and/or volume overload and right atrial and tricuspid annulus dilatation due to chronic AF, which impairs proper leaflet coaptation.[7,8] Tricuspid valve repair is performed at the same time as the mitral valve surgery if severe TR or dilated annulus associated with mild to moderate TR exists.[9] Performing both procedures at once does not increase operative risk and improves RV function (possibly by promoting reverse remodelling),[10] functional status, and short- and long-term prognoses.[6,11] Most of the procedures are accomplished using surgical annuloplasty. However, despite

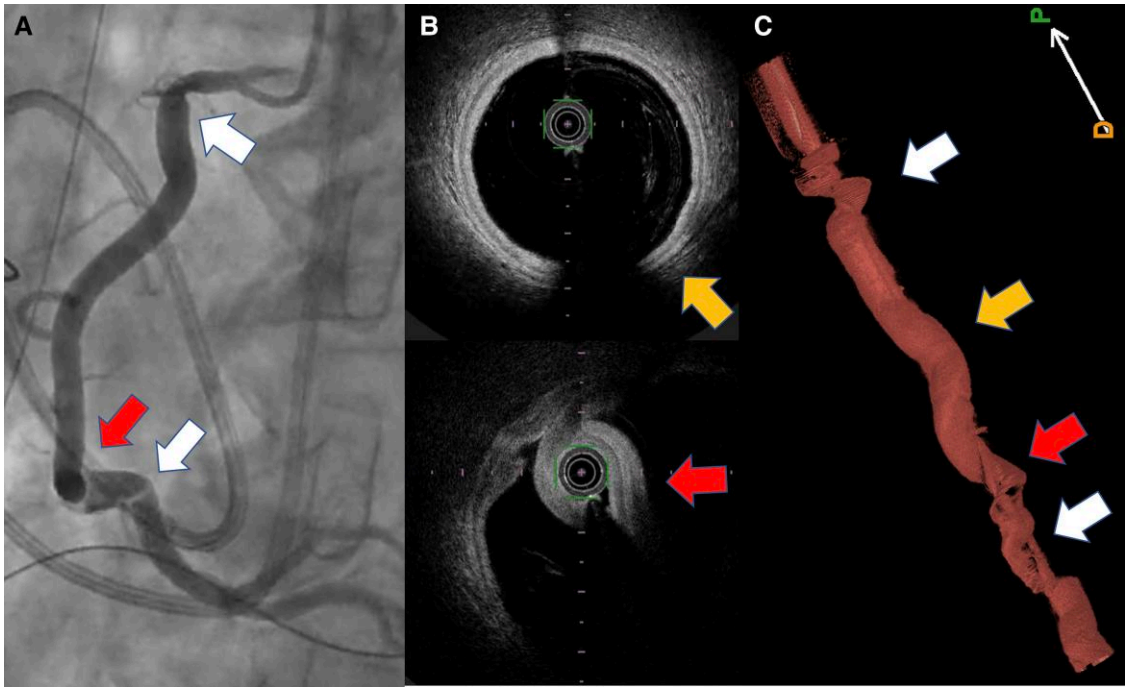

Figure 3 (*A*) Postoperative angiography. Hazy lesion of the upper knee and distal segment (upper/lower white arrows) and coronary twist aspect of the lower knee (red arrow). (*B*) Optical coherence tomography images. Coronary kinking (red arrow). Lesion-free area (yellow arrow). (*C*) Optical coherence tomography 3D image.

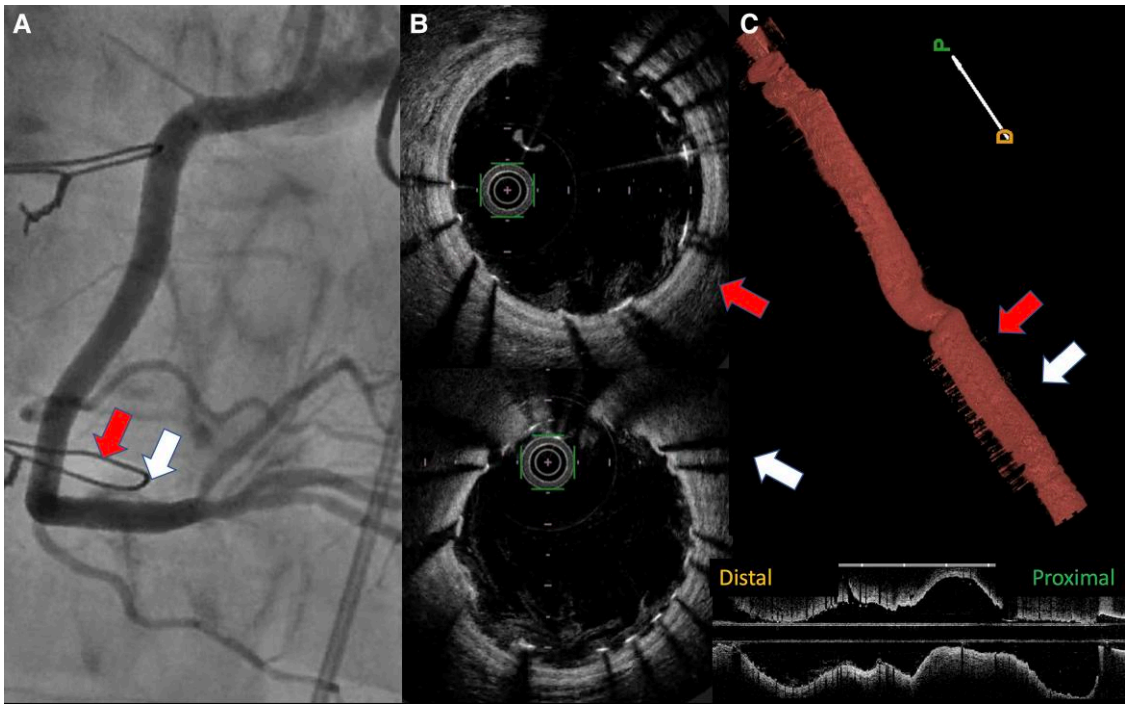

Figure 4 (*A*) Good angiographic control results associated with (*B*) an optical coherence tomography showing loss of kinking (red and white arrows). (*C*) 3D optical coherence tomography showing incomplete kinking upstream of the stenting.

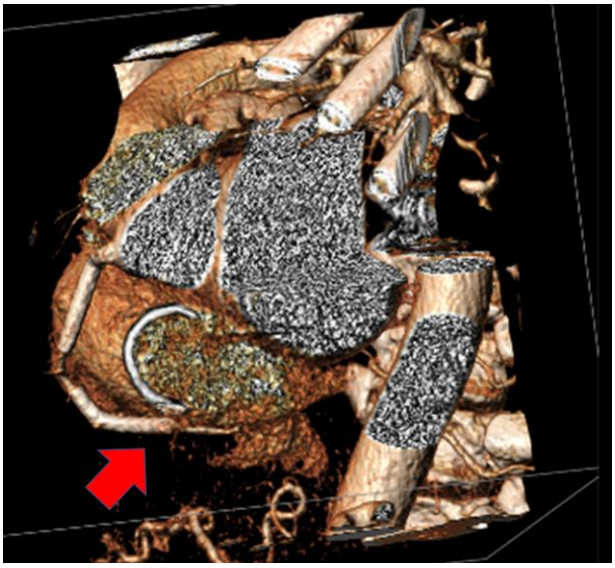

Figure 5 Cardiac computed tomography showing the very close relationship between the right coronary artery and the tricuspid annuloplasty at the kinking site visualized by angiography (red arrow).

improvements in surgical techniques and enhanced experiences of surgical teams, serious complications may appear. Right coronary artery injury is one of the main adverse events, often leading to substantial clinical consequences, such as cardiogenic shock, ventricular tachycardia, inferior ischaemia, or acute post-operative RV dysfunction.[12] The trans-catheter tricuspid valve replacement or interventions for repair are novel and less invasive alternatives to surgery and have shown early promising results.[13] Endovascular repair using the Cardioband system has been employed recently in patients with moderate to severe tricuspid insufficiencies who are symptomatic and have high or prohibitive surgical risk. In the recent prospective TRI-REPAIR study assessing this approach, no intra- or post-procedural myocardial infarctions occurred during follow-up. The absence of infarctions was related to a careful selection of patients and the use of coronary angiographic control during the procedure.[14]

Although circumflex artery injuries related to mitral annuloplasty have been reported many times,[15] RCA injuries are rarely described. To date, only 19 cases of injury to the RCA related to TR surgery have been described in the literature. In these cases, two main types of lesions were described: direct obstruction and kinking of the coronary artery.[4]

The mechanism of obstruction was based on the anatomical proximity of the RCA to the tricuspid annulus.[16] A portion of the RCA may be caught in a suture because of the location in the right atrioventricular sulcus between the right marginal artery and the crux of the heart where the RCA is the most vulnerable. The diagnosis and clinical manifestations may be delayed depending on the degree of stenosis caused by the suture. When percutaneous revascularization is attempted, the procedure is often unsuccessful because passing the wire through the suture or achieving sufficient balloon dilatation of the surgical stenosis is difficult. In this case, returning to the operating room to remove the sutures or performing an RCA bypass is indicated.[17] However, coronary kinking is a dynamic process. Dilatation of the annulus distorts the normal course of the RCA, and narrowing the tricuspid annulus during the annuloplasty may cause significant shape changes, leading to coronary kinking. Due to the absence of complete obstruction, percutaneous revascularization is technically easier due to the possibility to cross the lesion with the wire.[18]

By understanding the close anatomical relationship between the tricuspid valve annulus and the RCA, surgical outcomes can be optimized to reduce the risk of coronary injury during surgery. Deep sutures should be avoided because of the thin atrial myocardium, and placement of fewer superficial sutures, especially at the anteroposterior commissure, significantly reduces the likelihood of injury. In addition, RCA kinking can be avoided using semi-rigid rings, as previously described.[4]

In RCA lesion cases where coronary angiography is performed, only a few cases have reported the use of OCT or intravascular ultrasound.[16,18] As indicated by this case, these techniques may help clarify ambiguity on the angiogram and discriminate between an obstruction and coronary kinking. Thus, OCT may be a useful tool for determining the revascularization strategy and optimizing the DES deployment, resulting in a reduced risk of stent thrombosis and restenosis.[19] In our case, the decision to return to the operating room may have been made due to the immediate post-operative occurrence. However, the first procedure had already been long, and after a discussion with the surgery team, a percutaneous angioplasty was performed using long stents to avoid the risk of shifting the artery kink proximal and distal to the angioplasty sites.

Conclusion

We presented a case of RCA kinking causing myocardial infarction as an early complication of tricuspid valve annuloplasty. Right coronary artery occlusion should be systematically screened in the early post-operative period, even in the absence of haemodynamic instability or ventricular rhythm disturbance. For RCA kinking without complete coronary obstruction, percutaneous revascularization guided by endocoronary imaging seems a feasible and safe approach.

Lead author biography

Jeremy Florence is a fourth-year resident in cardiology. Currently he is in the University Hospital of Clermont-Ferrand in France, and he is specializing in cardiac multi-modality imaging.

Supplementary material

Supplementary material is available at *European Heart Journal – Case Reports* online.

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Data availability

The data underlying this article are available in the article and in its online Supplementary Material.

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