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Mini Review

Intracavitary Coronary Course: A Silent Anatomical Variant with Potential Risks during Cardiac Interventions

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ABSTRACT

Intracavitary coronary course is a rare anatomical variant that is characterized by passage of a coronary arterial segment inside the cardiac chamber through penetration into the myocardium. The condition has been more frequently noticed in the past years owing to the widespread utility of coronary computed tomography. It typically has an asymptomatic clinical course with only a theoretical risk of ischemia in cases of severe pulmonary hypertension. Invasive cardiac procedures involving the right atrium and ventricle carry a high risk of arterial injury with subsequent myocardial ischemia and coronary-cameral fistula. Further research is still required to better understand the pathophysiology, clinical consequences and proper management of the condition.

Keywords: Intracavitary coronary course; Myocardial bridge; Intracavitary right coronary artery; Intracavitary left anterior descending artery

INTRODUCTION

Coronary arteries normally run in the epicardial space. Abnormal variant courses are classified into Intramural (IM), Intracavitary (IC) or less commonly aerial course above the epicardium. The main two described IC variants are Left Anterior Descending artery (LAD) course into the Right Ventricle (RV) cavity and Right Coronary Artery (RCA) course into the Right Atrium (RA) cavity, with no reported cases for IC left circumflex or ramus arteries.

The silent nature of the condition has always masked the true prevalence, being only accidentally identified intra-operatively or in the Coronary Computed Tomography Angiography (CCTA) studies. Despite the recent increase of reporting Intracavitary Coronary Arteries (ICCA) in literature, we still know a little about their pathophysiology and clinical implications.

LITERATURE REVIEW

Epidemiology of intracavitary coronary course

IC coronary course was first reported in 1975 by McAlpine who was able to identify IC segments for postmortem autopsies in 4 out of 1000 normal hearts [1]. Afterwards, the condition was more recognized, particularly in the surgical community, being accidentally discovered intraoperatively during coronary artery bypass grafting procedures.

The condition's prevalence varied among studies from 0.054% to 0.36% [2,3]. Data were first derived from postmortem specimens and intraoperative findings, however the recent widespread use of CCTA has largely lead to more awareness of the condition, with a reported prevalence that could reach up to 1.73% [4]. In a CCTA study on 5,050 patients, the prevalence of IC coronaries was 0.33%, with IC RCA more frequently identified than LAD (0.29% *vs.* 0.04%) [5]. While other studies mentioned higher frequency of IC LAD.

Intra-atrial RCA is further classified into three types according to the anatomical course [6]. Whereas, the LAD IC course is typically beneath the interventricular groove, within trabeculae carneae of the RV. Most of the studies reported no sex predilection for the condition with both genders equally affected [7]. IC course is usually confined to a single arterial segment, yet only one case reported two IC arteries in the same patient [8]. Mid to distal segments are commonly involved, sparing the proximal segments. The RCA IC course tends to be longer with a mean length of 35.8 mm.

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Difference from myocardial bridge

It is believed that coronary myocardial bridge and Intracavitary Coronary Arteries (ICCA) belong to the same disease spectrum. Due to an increased prevalence more than previously thought, these conditions are currently considered as anatomical variants rather than congenital anomalies. While myocardial bridge is commonly found in hypertrophic cardiomyopathy, IC course has been reported in cases of RV hypertrophy [9]. It's possible that wall hypertrophy and fiber disarray push an already superficial IM artery into a deeper position. That is why an IC course may be considered as a variant of the IM course.

It was found that myocardial bridge is usually protected against development of atherosclerosis. This is explained by the shear stress caused by myocardial contraction on the arterial wall, as well as the different intimal histological structure with less cell proliferation and collagen deposition. On the contrary, development of atherosclerotic plaques is more frequent in the segment just proximal to the myocardial bridge [10]. Whether these findings are consistent in cases of ICCA is still debatable. Krishnan B, et al. reported luminal stenosis in intra-atrial RCA segments, yet lesions were non-significant.

DISCUSSION

Clinical course and potential hazards

The clinical course of ICCA is relatively benign, with absent symptoms and normal prognosis. Reported cases that underwent surgical intervention were symptomatic due to significant atherosclerotic lesions, with the IC course discovered accidentally in a pre-operative CCTA or during surgery.

Nevertheless, an IC segment is subjected to a high risk of injury during right-side cardiac interventions. It is essential that all the medical personnel working in the fields of cardiac imaging, intervention and surgery be aware of the condition in order to avoid complications. Accidental diagnosis of an ICCA before cardiac invasive procedures prompts specific precautions and may even lead to cancellation of the procedure if deemed risky.

In atrial fibrillation ablation procedures, contact with the ablation catheter tip may cause thermal damage. While in right heart catheterization, inter-atrial septal puncture or device implantation, excessive catheter or lead manipulation may cause arterial entanglement and injury. Intra-atrial RCA injury has been particularly linked to cavo-tricuspid isthmus ablation and tricuspid valve surger [11]. Atrial, septal and even lateral radiofrequency ablation may increase the risk of injury or lead to late coronary stenosis. Vessel injury usually results in myocardial ischemia or infarction in the supplied territory distal to injury. In severe cases, a coronary-cameral fistula leads to left-to-right shunting with subsequent volume overload and heart failure. Unlike epicardial coronaries, injury of an ICCA does not cause blood extravasation or cardiac tamponade.

Role of coronary angiography and cardiac imaging in diagnosis

Demonstration of an ICCA is not usually feasible during invasive Coronary Angiography (CA). Unlike myocardial bridge, systolic milking of an IC segment is absent. This is explained by the intracavitary pressure of the right heart chambers that is too low to cause coronary compression. In rare scenarios, an abnormally elevated right ventricular systolic pressure may exceed the coronary artery pressure exerting a milking effect that can be easily detected in CA. However, this cannot be differentiated from an IM myocardial bridge.

Some findings have been proposed to suspect an ICCA while performing CA; a sharp angulation at the inlet or exit of the LAD segment towards the ventricular cavity, which is best seen in the lateral view, may be a clue for IC course. In addition, a significant separation between the LAD and great cardiac vein in the right anterior oblique view can also suggest an IC LAD course [12].

An ICCA is confirmed in the CCTA when a segment is seen completely surrounded by IC contrast in all phases of the cardiac cycle. The increase in temporal and spatial resolution for different scanners can even lead to more diagnosis of ICCA.

Management of intracavitary coronary artery

While the mainstay treatment of myocardial bridge is medical therapy using beta-blockers or calcium channel blockers, there is no evidence that medical treatment is beneficial for ICCA given the intra-cameral position and absence of mechanical compression by the heart muscle.

An atherosclerotic ICCA can be managed according to the general recommendations for coronary artery disease, with the same indications for surgical intervention. However, there is lack of consensus about stenting of the IC portion in particular. This may be explained by the low incidence of atherosclerosis in the IC segment due to possible protective mechanisms that were previously mentioned.

Surgical intervention for intracavitary coronary artery

Grafting a diseased ICCA is a complex intervention that necessitates opening into the involved cardiac chamber. The three major challenging steps are IC segment identification, performing anastomosis and safe closure of the involved chamber [13]. Potential intra-operative complications include air introduction into the venous lines, massive bleeding, inadequate arterial exposure due to deep position and most importantly compromising the coronary flow during closure of the myotomy.

Many techniques can aid in the tracing of an IC LAD; following a distal segment or a diagonal branch retrogradely, dissection to the right of the great cardiac vein, use of epicardial ultrasound or placement of an intraluminal probe after distal arteriotomy to provide visual and tactile feedback [14].

Over the past decades, several options have been proposed to anastomose an ICCA. The location and length of the

intracavitary portion of the artery determined the surgical management. The techniques employed were moving the artery into an aerial position; preforming anastomosis inside the cavity with closure around the graft; or selecting an alternative more distal epicardial site for anastomosis.

The most commonly described approach for RV closure is using buttressed mattress sutures to approximate the ventricular free edges beneath the LAD leaving the artery into a more aerial position; however, this might cause injury to the diagonal branches and septal perforators, thus favoring horizontal mattress sutures [15].

In patients who require dissection over a long IC segment, a pericardial patch can be used to close the myotomy, through which the graft traverses to the deep-lying LAD. Suzer, et al. described a more expeditious approach by performing a voluntary right ventriculotomy upon failure to detect the LAD in the apical half of the septal wall, followed by exteriorization of the LAD and suturing a glutaraldehyde-treated pericardial patch beneath the LAD to close the ventriculotomy [16].

CONCLUSION

ICCA is a rare anatomical variant that is still under-recognized by the cardiac surgeons and interventionists. Either LAD or RCA can be involved, with the affected IC segment hanging inside the cavity of one of the right heart chambers. Pre-procedural CCTA before intra-cardiac interventions may be helpful for identification of an abnormal ICCA course and for proper planning to avoid arterial injury. Surgical intervention for ICCA is a challenging procedure that requires skillful hands and wide experience to reduce the risk of operative complications.

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