The Role of Atrial Vessels in Aortic Root and Mitral Valve Operations

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Background. **For the last 90 years, several authors have focused on studying the blood supply to the conduction system in the human heart. However, an important gap has been maintained between this topic and cardiac surgical procedures when they should have been closely matched. This paper is aimed at clarifying the morphology of the conduction system and its blood supply and assessing its role in cardiac surgical procedures.**

Methods. **Twenty human hearts were dissected after antegrade and retrograde injection. After dissection, different surgical procedures were simulated. Finally, we assessed the damage that these procedures might have caused either to the conduction system or to the vessels supplying it.**

Results. **Kügel's artery, the right superior descending artery, and the sinoatrial node artery were found to be harmed by the surgical procedures performed. In all these cases, these vessels were supplying part of the conduction system.**

Conclusions. **All the vascular structures described in the paper play a very important role in the blood supply to the conduction system, and they become vulnerable during aortic root and mitral valve surgical procedures.**

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By the end of 20th century, surgeons are likely to change their surgical techniques if they are convinced, with strong statistical correlation, of new procedures having better results. Probably, purely anatomic findings themselves are not enough to persuade a surgeon. But if they have clear surgical significance, they may invite the surgeon to be more accurate and elegant while performing the same operations.

The origin of the blood supply to the atrioventricular (AV) node has been widely studied. Two new arterial conduits supplying the conduction system were previously described by us [1]. These are the right superior descending artery and Kügel's artery. Their role in cardiac surgical procedures had been suggested by indirect studies, but it had never been objectively proved. In this paper, real surgical procedures were simulated on previously dissected hearts to show clear evidence of the significance they have in certain operations involving the aortic root and the mitral valve.

Material and Methods

For the present study, 20 hearts were removed from the cadavers of subjects with and without coronary disease, who had ranged in age from 15 to 65 years at the time of death. They were injected in an antegrade and retrograde manner with a new technique followed by dissection, as described previously [1]. Once the hearts were dissected, they were placed and fixed on a board in surgical position. After that, different surgical procedures were simulated in separate hearts, trying to resemble the real situation in as much as possible. In five of them, a Bentall procedure was performed, whereas six hearts underwent a Yacoub procedure, and a Guiraudon approach was simulated in five different pieces [2–4]. On finishing the simulations, we checked the integrity of the vessels dissected. We considered that a vessel had been damaged only in the cases that we found it either caught by the suture or completely cut because of traction of the coronary pedicles during the procedure. Lesion of the vessels after any movement apart from the ones strictly necessary in the procedure was not taken into account. Photographs were taken before and after the simulations.

Results

In all the hearts in which a Bentall procedure was performed, the right superior descending artery was cut when pulling from the coronary pedicles for their attachment (Fig 1). Kügel's artery was caught in all the samples of the Yacoub procedure at the time of suturing the graft to the aortic root at the level of the noncoronary cusp (Fig 2). After simulating a Guiraudon approach, we observed that the sinoatrial node artery, as well as small branches of Kügel's artery, was damaged in all cases (Fig 3). The right superior descending artery artery supplied the AV node in 14 of the 20 dissected hearts (70%), whereas

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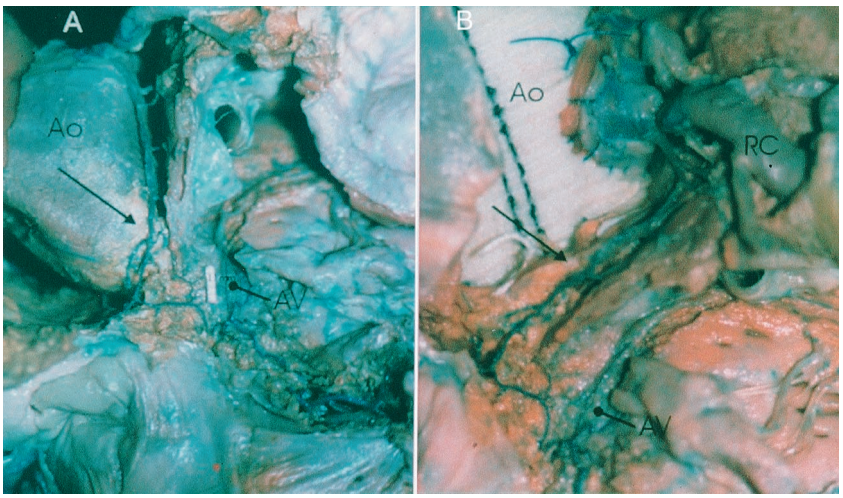

Fig 1. Bentall procedure. (A) The right superior descending artery (arrow) *surrounding the aortic root. (B) Simulation of Bentall procedure with aortic root replacement and attachment of the coronary pedicles.* (Ao = *aorta;* AV = *atrioventricular node;* RC = *right coronary artery.)*

Kügel's artery supplied blood to the conduction system in 8 of the 20 hearts (40%).

Comment

The blood supply to the conduction system was a main subject of study during the 1960s and 1970s owing to the advent of coronary angiography and myocardial revascularization procedures. At the same time, an increase was evident in the frequency of surgical procedures involving the aortic root with the attachment of the coronary ostia. In this last type of operation, arrhythmias are more frequent when stopping the cardiopulmonary bypass and during the first few hours of the postoperative course [5–8]. Most of these alterations are transitory, with most patients regaining sinus rhythm soon after. One of the causes of these nonpermanent rhythm disturbances was thought to be the postsurgical edema of the conduction system. However, some authors stated that stunning of the conduction system was the main problem. We believe that direct harm of the blood supply to the AV node during the operation should be acknowledged as one of the main causes of postoperative arrhythmias. A cardiac surgeon should, then, be aware of the anatomy of the blood supply that nourishes the conduction system, as well as which procedures threaten its integrity.

Anatomy

The classic anatomic concept included the AV node artery, or rami septi fibrosi, and the first septal artery branch of the anterior descending coronary artery as the

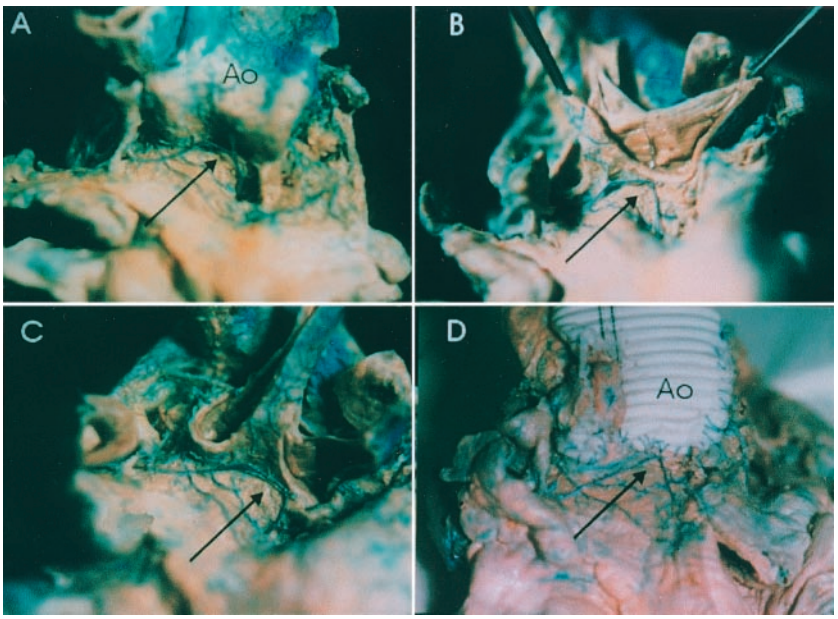

Fig 2. Yacoub procedure. (A) Kügel's artery (arrow) *lying over the interatrial septum behind the aortic root before the simulation. (B) The aortic root was removed, preserving the native valve. (C) The aortic valve and the coronary pedicles ready for the grafting. (D) Placement of the aortic graft and attachment of the coronary pedicles. See how the suture "captures" Kügel's artery* (arrow). (Ao = *aorta.)*

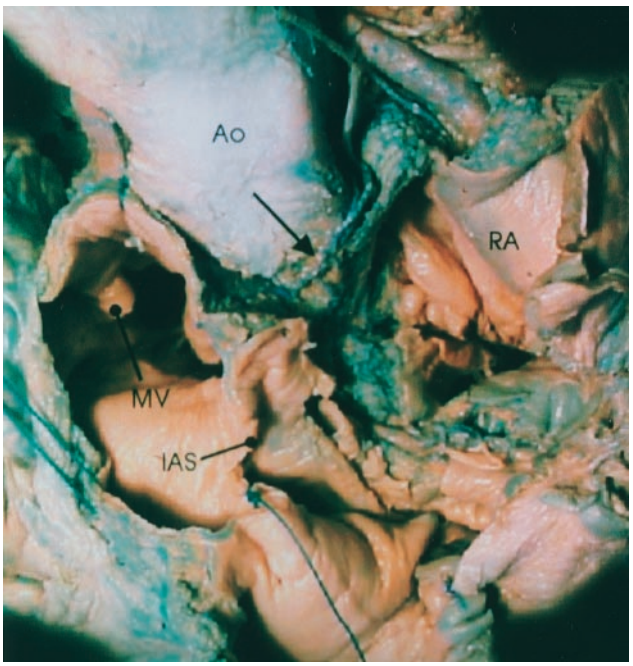

Fig 3. Guiraudon approach. Kügel's artery (arrow) *is surrounding the aortic root, passing near the surgical incision.* (Ao = *aorta;* IAS = *interatrial septum;* MV = *mitral valve [posterior leaflet];* RA = *right atrium.)*

main conduits supplying the AV node [9–11]. As described by us previously, Kügel's artery and the right superior descending artery are an important source of perfusion for the conduction system [1].

Some authors doubted the existence of Kügel's artery (arteria anastomotica auricularis magna) [10], whereas others suggested that it could be related to the blood supply of the AV node but that its small caliber deterred them from the attempt of proving it [11]. Added to the clear pictorial demonstration of this vessel nourishing the AV node, we inferred that the genetic information for this artery might be present in the genetic code of all mammals as we were able to dissect it in the heart of a Minke whale (*Balaenoptera acutorostrata*) [12].

Surgical Procedures

Regarding the anatomic evidence shown in this paper, direct injury to the atrial vessels should be taken into account when considering the factors causing postoperative arrhythmias, especially after procedures like Bentall, Yacoub, or even a classic aortic valve replacement when the technique modality implies placing the suture across the aortic wall. We believe that one way of reducing the risk of lesion of these vessels is by giving the least possible movement to the coronary pedicles, thus preventing pulling from them as they originate at the very beginning of the coronary artery. However, if the possibility of kinking or tension in the line of suture exists, this last consideration should be disregarded as any complication at that moment would lead to a much worse outcome than a perioperative arrhythmia.

In the case of a Guiraudon approach for mitral valve replacement, the risk of injuring the atrial arteries is quite high because of obvious anatomic relations. Furthermore, the incidence of supraventricular arrhythmias is increased in this kind of approach [13–16]. The cutting of the sinoatrial node artery with posterior nodal ischemia was previously thought to be the cause. However, there is evidence that supraventricular arrhythmias persist even when section of the sinoatrial node artery does not involve nodal ischemia [17]. To avoid this problem, performing a lateral approach to the mitral valve is advisable. Several surgical maneuvers, such as mobilizing both venae cavae, using Pacífico cannulas, dissecting the interatrial sulcus, or placing a gauze on the apex of the left ventricle and moving it toward the mitral annulus, allow improvement in the approach, thus avoiding lesion of the blood supply to the conduction system. If a Guiraudon approach is still considered, incision of the atrium should be as far as possible from its insertion in the aorta.

Again, we encourage a full comprehension of these anatomic findings to give elegance and accuracy to every surgical procedure.

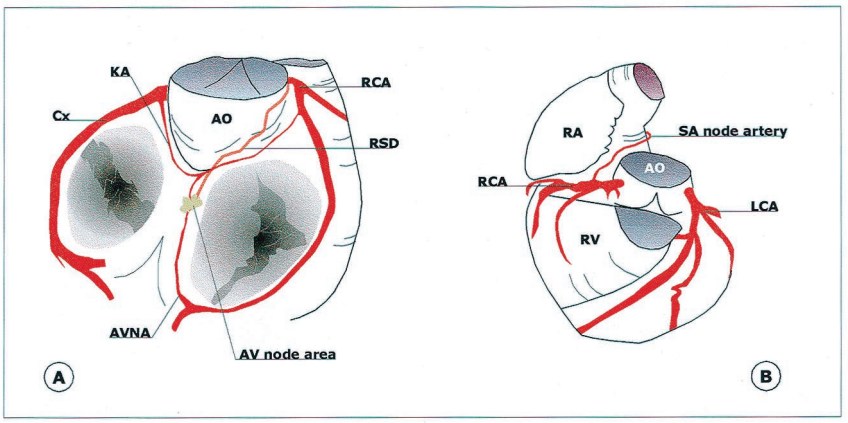

Fig 4. Atrial vessels supplying the atrioventricular (AV) *node. (A) Kügel's artery* (KA) *and right superior descending* (RSD) *in a posterior view of the heart. (B) Sinoatrial* (SA) *node artery supplying the sinoatrial node area in an anterior view of the heart.* (AO = *aorta;* AVNA = *AV node artery;* Cx = *circumflex artery;* LCA = *left coronary artery;* RA = *right atrium;* RCA = *right coronary artery;* RV = *right ventricle.)*

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