

Clinical Anatomy of the Atrioventricular Node Artery

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Background and aim of the study: The study aim was to describe the topographical relationship of the atrioventricular (AV) node artery and mitral valve annulus fibrosus with regard to AV node dysfunction following mitral valve replacement or ring annuloplasty.

Methods: The anatomy of the AV node artery was analyzed in 55 human hearts without previous pathological alterations. Selective coronary angiograms were performed to identify the AV node origin. Run-off of the AV node artery and its topographical relationship to the mitral valve attachment was analyzed in dry-dissected hearts. The position of the AV node was verified by histological sectioning.

Results: The AV node artery originated from the right coronary artery in 73% of examined cases, and from

the left coronary artery in 27% of cases. The left AV node artery was closely related to the mitral valve attachment, especially at the area of the left proximal part of the posterior leaflet.

Conclusion: These morphological data were compared to clinical reports emphasizing the postoperative incidence of AV block after mitral valve implantation and ring annuloplasty. The occurrence of early postoperative AV node block ranged from 20% to 37%. By comparing the present data with available literature, it can be stated that there is a high risk of intraoperative damage to the left AV node artery during manipulation of the mitral valve annulus fibrosus.

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The atrioventricular (AV) node artery forms a functional part of the AV node, which plays an important role in the heart's conduction system. In classical anatomical reports, the artery is described as a branch of the left or right coronary artery, with its run-off on the posterior superior process of the left ventricle (1). However, no data exist which refer to the relationship between the artery and annulus fibrosus of the mitral valve.

AV node dysfunction is a frequent complication during the early postoperative period following implantation of a mitral prosthesis, or after mitral valve ring annuloplasty. The major rhythm disturbances have been referred to as AV blocks of different grades. The occurrence of postoperative rhythm disturbance may

reach 37% among investigated cases (2,3). The observed rhythm disturbances were presumed to be caused by damage of the AV node artery (4), but due to a lack of morphological evidence correlating the course of the AV node artery and the operating area, this presumption has not yet been confirmed. In order to clarify the anatomic possibility of AV node artery damage, the course of the artery and its relationship to the mitral valve annulus fibrosus were studied.

Materials and methods

A total of 55 human hearts obtained from the cadavers of patients aged between 20 to 70 years was analyzed. The left and right coronary orifices were separately cannulated, and 30 ml of radiopaque material was injected into the coronary arteries. A 70% density suspension of barium sulfate was used as contrast material. Coronary angiographs were recorded on Gevaert Structurix D2 plates from a distance of 80 cm, with the exposure time adjusted to 3.2 mAs and kV set at 40. The origin of the AV artery was determined by selective coronary angiography (Fig. 1A and B). Subsequently, the injected hearts were placed into 4%

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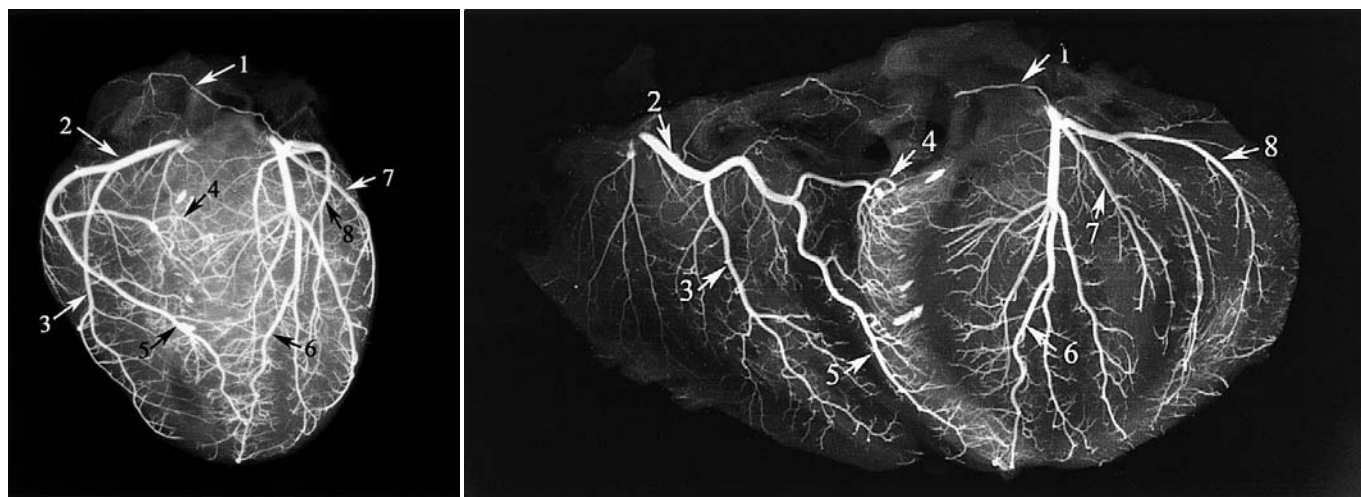


Figure 1: Coronary angiogram showing the right type of AV node blood supply. The origin of the AV node artery is just superior to the crux (A). For better interpretation of the course, the left and right ventricles were transected, the left ventricular wall on its basal aspect just near the septum and the right ventricle on its anterior aspect. Consequently, the hearts were folded as a book in one plane. On these angiograms (B) the relationship of the AV node artery and mitral valve was easy to identify. In the presented case the artery runs in the middle of the space between the mitral and tricuspid valve. 1: Sinus node artery; 2: Right coronary artery; 3: Marginal branch; 4: AV node artery; 5: Right posterolateral branch; 6: Anterior interventricular branch; 7: Diagonal branch; 8: Left posterolateral branch.

formalin solution for one month. This was followed by immersion in a solution consisting of 25% isopropyl alcohol, 20% propylene glycol, 0.5% glutaraldehyde and 5% benzyl alconium chloride. Dry dissection of the AV node artery was performed following the preservation procedure (Fig. 3). The course of the AV node artery was dissected from its origin up to the AV node. By using histological methods, the exact position of the AV node was determined.

Results

Anatomy of the AV artery

In 42 (76.4%) of the heart specimens, the AV node was vascularized by the right AV node artery (Figs. 1, 2B and C), while in 13 (23.6%) of specimens vascularization was provided by the left AV node artery (Figs. 2A and 3). There was no direct connection between the dominance and the origin of the artery. The AV node artery originated from the left coronary artery in nine cases of left dominance (Fig. 3), in three cases of right dominance, and in one case of the intermediate vascularization type. The right AV node artery originated in 37 cases from the right dominant coronary artery, in three cases from the left dominant artery, and two cases were of the intermediate vascularization type (Table I). From its origin, which in most cases is at the level of the crux, the artery ascends onto the superior process of the left ventricle toward the AV node and bundle of His (Fig. 3). With regard to its topography to the mitral and tricuspid annulus fibrosus, the follow-

ing morphological variants were determined. In the first subtype, there were 13 cases (23%), where the artery passed along the left lateral margin of the superior process. After reaching the proximal part of the annulus fibrosus of the posterior leaflet, the artery passed just lateral to the posteromedial commissure (Figs. 2A and 3). The second subtype consisted of 27 cases (40%); here, the artery ran in the middle of the space between the mitral and tricuspid valve (Fig. 2B). The third subtype comprised 15 cases (18%), with the artery passing just adjacent to, but not in contact with, the annulus of the septal leaflet of the tricuspid valve (Fig. 2C).

AV node anatomy

On the dry-dissected hearts, the position of the AV node was found at the attachment of the membranous

Table I: Percentage distribution of the right and left AV node arteries on 55 analyzed hearts.

Condition	Left AV node artery (n = 42)	Right AV node artery (n = 13)
Right coronary dominance	37	3
Left coronary dominance	3	9
Intermediate blood supply	2	1

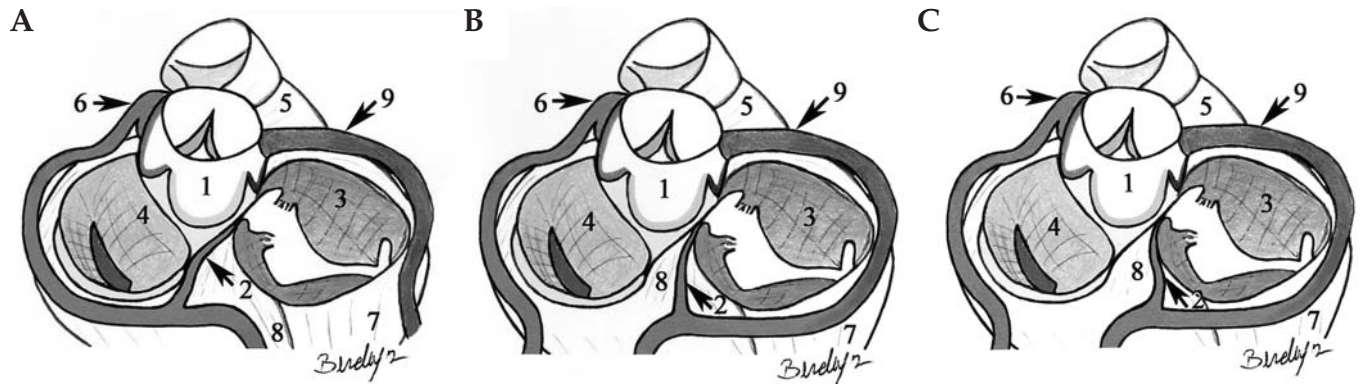


Figure 2: Schematic description of the three main types of AV node artery. A) The artery runs close to the mitral valve. B) The artery is in middle of the space between the mitral and tricuspid valves. C) The artery is close to the tricuspid leaflet. 1: Aorta; 2: AV node artery; 3: Tricuspid leaflet; 4: Mitral valve; 5: Pulmonary trunk; 6: Left coronary artery; 7: Right ventricle; 8: Superior posterior process of the left ventricle; 9: Right coronary artery.

septum to the ostium of the left ventricle (Fig. 4). The position of the AV node, as observed by dry dissection, was confirmed by histological investigation of the area of the central fibrous body.

Discussion

The risk of developing heart conduction disturbances following open-heart surgery has been well established, and leads to permanent pacemaker implantation in about 2-3% of patients undergoing this type of surgery (5,6). The incidence of AV node dys-

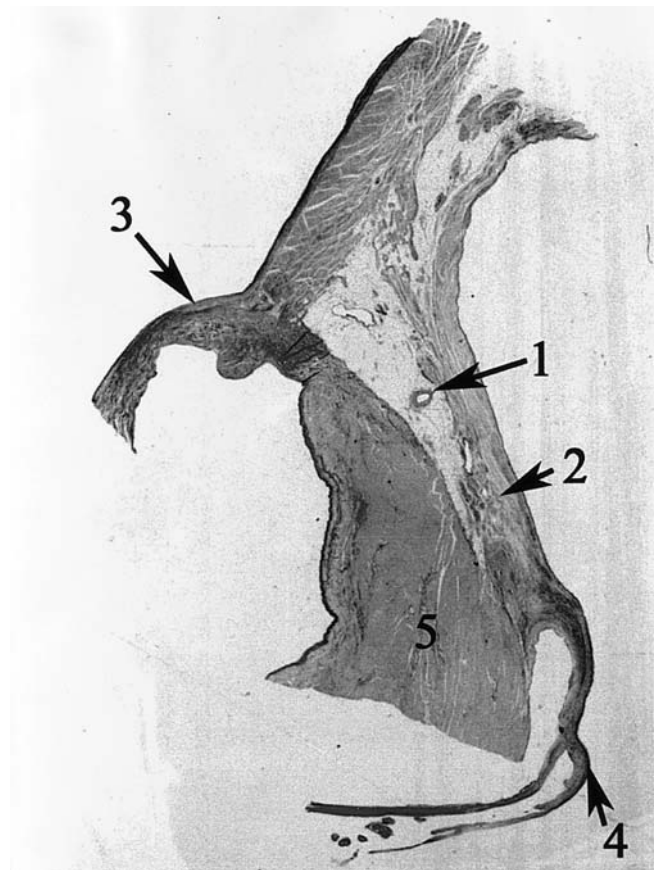


Figure 4: Histological specimen of the AV node. The AV node is positioned just superior to the tricuspid valve. The AV node artery runs between the annulus fibrosus of the mitral and tricuspid valves. In this case, intraoperative damage to the AV node artery is less frequent than in cases where the artery runs close to the mitral valve annulus. 1: AV node artery; 2: AV node; 3: Mitral valve; 4: Tricuspid valve; 5: Interventricular septum.

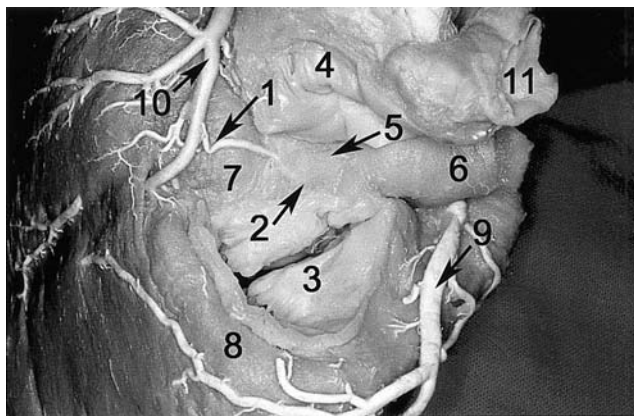


Figure 3: Dry-dissected specimen of the AV node artery. Note that the right atrium was removed. The presented vascularization type is of left dominance; note that the AV node artery arises from the left coronary artery. On reaching the crux, the artery runs close to the mitral valve annulus. 1: AV node artery; 2: AV node; 3: Tricuspid valve; 4: Interatrial septum; 5: Right fibrous trigone; 6: Aorta; 7: Superior posterior process of the left ventricle; 8: Right ventricle; 9: Right coronary artery; 10: Left coronary artery; 11: Superior vena cava.

function in patients undergoing mitral valve procedures ranges from 23% to 37% (7,8). Recently, mitral valve reconstruction has become the technique of choice in the treatment of mitral valve regurgitation (9-11). It is clear that the mitral valve apparatus is related topographically to the atrioventricular conducting structures, especially the proximal part of the posterior leaflet and the posterior medial commissure. Nevertheless, to date no morphological evidence has been provided of conduction disturbances following manipulation of the annulus fibrosus. The present study examined the morphological predictors of postoperative AV block following mitral valve surgery.

Interest in the blood supply of the heart conducting system is not new, with Hadziselimovic having previously studied the blood supply of the AV node and bundle of His (12). The AV node artery was seen to arise from the right coronary artery in 83% of cases, and from the left coronary artery in 17% of cases. Further interest in the AV node blood supply and the course of the AV node artery intensified the evaluation of open-heart procedures on the mitral valve (13-15). The major complications detected during the early postoperative days were AV conduction blocks of different grade. The rhythm disturbances during the early postoperative period were considered to reflect damage to the AV node artery.

The major rhythm disturbances following mitral valve replacement or reconstruction are atrioventricular blocks (AVB) of different grades (2,3). These complications are considered primarily as damage to the AV node artery (4). With regard to the above-mentioned complication, Meimoun et al. (2) studied the incidence and predictors of AVB after mitral valve repair, and reported the incidence to be 23%.

In the present morphological study, the topography of the AV node artery and its relationship to the mitral valve was described. The data presented herein concerning the origin of the artery are similar to findings published previously, with the AV node artery in some cases being seen to approach the annulus fibrosus of the mitral valve. Independently of the dominance or origin in 13 cases (23%), the AV node artery approached the P3 section of the posterior leaflet.

The present morphological data show that the AV node artery frequently passes close to the posterolateral part of the mitral valve annulus. Therefore, damage to the AV node's blood supply would become very likely during mitral valve ring annuloplasty or prosthesis implantation. The present morphological assumptions on potential damage of the AV node artery are supported by the findings of two independent, but similar, clinical studies. Meimoun et al. (2) and Moran et al. (3) each studied the incidence of AVB that might follow mitral valve surgery and reported respec-

tively that, during early postoperative electrocardiographic monitoring, 23% (2) and 35% (3) of those patients in sinus rhythm before surgery exhibited AVB postoperatively.

It is the opinion of the present authors that intraoperative damage of the AV node artery can be avoided if surgeons identify the artery and its origin on the coronary angiogram, which is performed preoperatively. Based on the identification of the artery and its origin, the probable course of the vessel and its position relative to the annulus fibrosus can then be determined.

In all of those cases where the AV node artery originates from the left coronary artery, the artery run-off might be close to the mitral valve annulus. Consequently, the placement of deep sutures during mitral valve manipulations must be avoided. It should also be recalled that the major trunk of the coronary artery may follow the run-off of the superior posterior process, and that occlusion of these branches may result in infarction of large areas of the left ventricle.

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