

The Atrio-Ventricular Node Artery in the Human Heart

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Abstract

The atrioventricular node artery is a major contributor to the arterial supply of the atrioventricular conducting pathway and is an important vessel in the pathogenesis of heart block. The terminal ramifications of this artery were studied in detail by serial sectioning techniques in 50 human infant hearts. The artery provided branches to the posterior interventricular septum in all hearts (100%) and to the interatrial septum in 22 hearts (44%). The vessel supplied the atrioventricular node in 45 hearts (90%) but it terminated before reaching the node in five (10%). It supplied the penetrating bundle in 32 hearts (64%). Alternative sources of arterial supply to the atrioventricular conducting pathway include: the first septal branch of the left anterior descending coronary artery; the descending septal artery; and anterior atrial branches. Although the arterial supply to this region of the heart is variable, it is possible to make hypothetical predictions of conducting tissue involvement in myocardial infarction of various types.

Introduction

Patients with coronary heart disease can develop heart block as a consequence of ischaemia or infarction of the atrio-ventricular conducting pathway. This continuous pathway, which carries the cardiac impulse from the atria to the ventricles, has three anatomically recognised divisions; the atrio-ventricular node, atrio-ventricular bundle and the bundle branches. There are several small arterial twigs supplying each division and the anatomy of these arterial twigs determines how and to what extent atrio-ventricular conduction will be impaired when a major coronary artery is diseased. Despite the obvious clinical importance of these small arteries a definitive account of their exact anatomy is lacking. One reason for this is that the arteries are too small to be

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traced by gross dissection where they actually make contact with the conducting tissue. Another is that this general region of the heart is traversed by a maze of penetrating vessels which are difficult to trace and individually isolate by injection or histological techniques. We have attempted to overcome these difficulties by concentrating our attention on a single vessel, the atrio-ventricular node artery, which we studied by serial sections in infant hearts. The atrio-ventricular node artery is a branch of either the distal right coronary artery (90% of hearts) or the distal left circumflex coronary artery (10% of hearts).^{1,2} The purpose of our study was to determine exactly its role in providing arterial blood supply to the atrioventricular conducting tissue.

Materials and Methods

The study was performed on anatomically normal hearts from fifty infants less than 1 year of age. In all hearts, a tissue block, incorporating the posterior two thirds of the ventricular and atrial septa and adjacent posterior wall of the heart, was excised. This block was carefully embedded and serial sectioned on a rotary microtome set at 10 μ . Every 25th section was mounted and stained with the Masson trichrome method. In smaller hearts every 10th section was prepared. The remaining sections were retained and prepared if required. The atrio-ventricular node artery was identified at the most posterior aspect of the block then followed anteriorly to its termination. Attention was paid to its size as it passed various landmarks and to the destination of its major branches.

Results

There was considerable variation in the size of the artery and the extent of its penetration into the heart. The extent to which it reached the components of the conducting tissue is shown in Figure 1.

Atrio-ventricular Node

The artery reached to and supplied the node in 45 of the 50 hearts. In the remaining five hearts, the artery was very small and terminated in the cardiac septum posterior to the node. In these latter hearts the node appeared to receive an alternative arterial supply from small vessels descending in the inter-atrial septum.

Atrio-ventricular Bundle (Bundle of His)

The artery reached the bundle in 32 of the 50 hearts. In 20 of these, the artery terminated in a splay of branches before reaching the bifurcation of the bundle. In the remaining twelve hearts the main artery supplied the entire length of the bundle, continued past the bifurcation and ran for a variable distance with either left or right bundle branch.

Inter-ventricular Septum

In all hearts the atrio-ventricular node artery provided branches to the

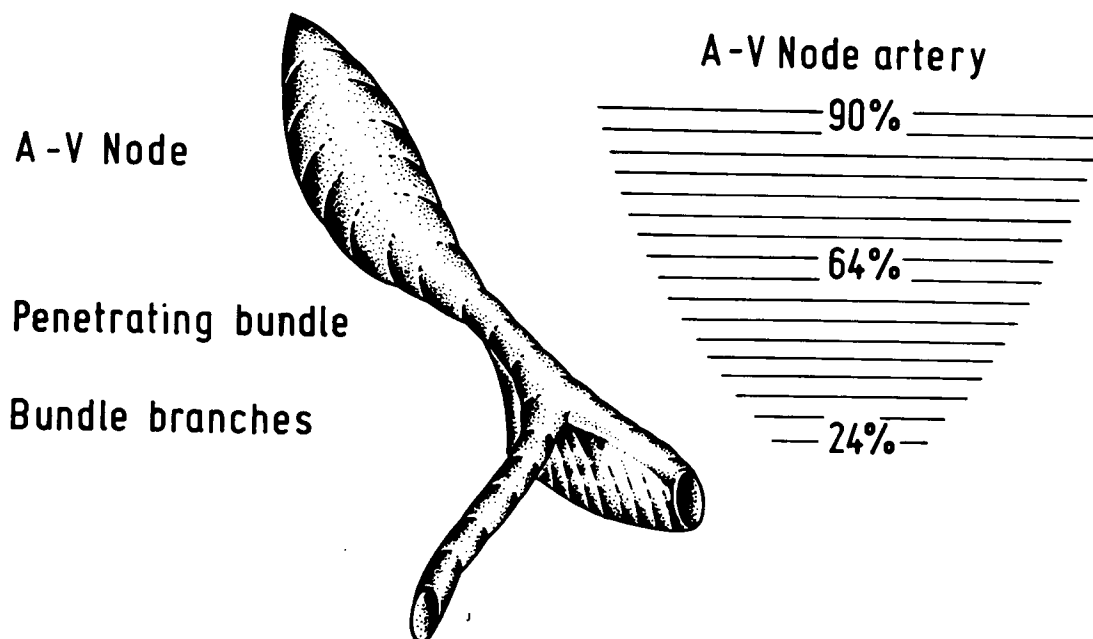


FIG. 1. The bar graph on the right indicates the percentage of hearts in which the atrio-ventricular node artery reached to the corresponding level on the adjacent diagram of the conducting tissue. (A-V, atrio-ventricular).

posterior interventricular septum (Figure 2). In 15 of these cases the branches were very small. In 32 hearts an additional branch descended through the central fibrous body, from the node to the upper ventricular septum. In 13 hearts, this descending artery demonstrated a curious histological variation, characterised by a loss of the muscular media, as it penetrated the central fibrous body.

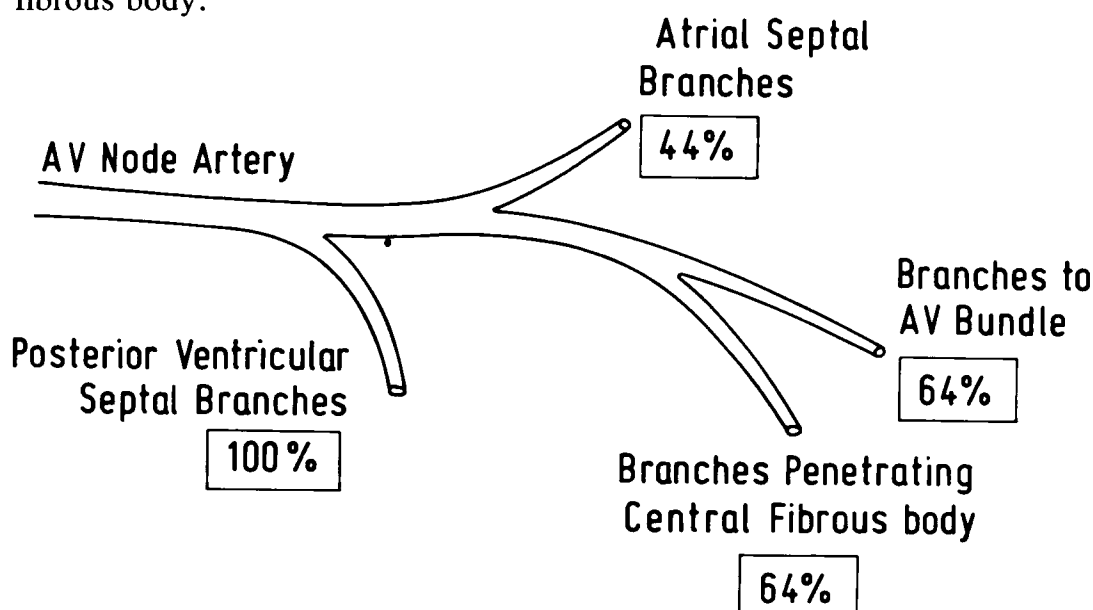


FIG. 2. The percentage frequency observed of major branches of the atrio-ventricular node artery.

Inter-atrial Septum

The artery gave branches to the inter-atrial septum in 22 of the 50 hearts although in some cases these branches were very small (Figure 2).

Discussion

The atrioventricular node artery arises from the epicardial coronary artery providing the major supply to the back of the heart. This is the right coronary artery in 80% to 90% of human hearts, and the left circumflex artery in the remainder.^{1,2} From its origin at the crux of the heart, the atrioventricular node artery penetrates the cardiac septum for a short distance to reach the node and bundle. This study demonstrates considerable variation in the size and branching pattern of the artery, and also variation in the extent to which the artery supplies the atrioventricular node and bundle; in 18 of the 50 hearts (36%) the artery did not reach the penetrating bundle, and in five of the 50 (10%) it failed to even reach the node (Figure 1).

In hearts in which the atrioventricular node artery is diminutive there are several alternative sources of supply to the conducting tissue (Figure 3). The first septal branch of the left anterior descending coronary artery is a major supplier of the atrioventricular penetrating bundle and proximal bundle branches. The terminal twigs of this septal perforating vessel ramify with the terminal twigs of the atrioventricular node artery in and around the penetrating bundle.^{3,4} Taylor⁵ points out that the descending septal artery, an often overlooked branch of the right coronary artery, also offers an alternative supply to the region. Surprisingly, despite its multiple sources of arterial supply, the area of the atrio-ventricular bundle has been described as an "arteriolar no-man's land" because of the paucity of vessels seen in histological sections.³

The atrio-ventricular node's major alternative supply is from small arteries which descend in the inter-atrial septum. These are derived from anterior atrial branches originating from the proximal segment of either the right coronary or circumflex coronary arteries. The most prominent anterior atrial artery is the most superior one; the sinus node artery. Another named branch is Kugel's artery⁶ which is an inferiorly located anterior atrial vessel.

There has been disagreement about the presence or absence of collateral vessels linking the arterial twigs around the atrioventricular junctional conducting tissue. Some authors,⁴ using injection techniques were able to demonstrate rich anastomoses in the region where as others³ using similar techniques found collaterals in only a minority of cases. We did not observe collaterals in the infant hearts we studied, but the methods used were not specifically designed to assess collaterals. It is our impression that anastomoses between cardiac arteries are infrequent in infants, but increase with age, and are almost ubiquitous in patients with established coronary atherosclerosis. This may

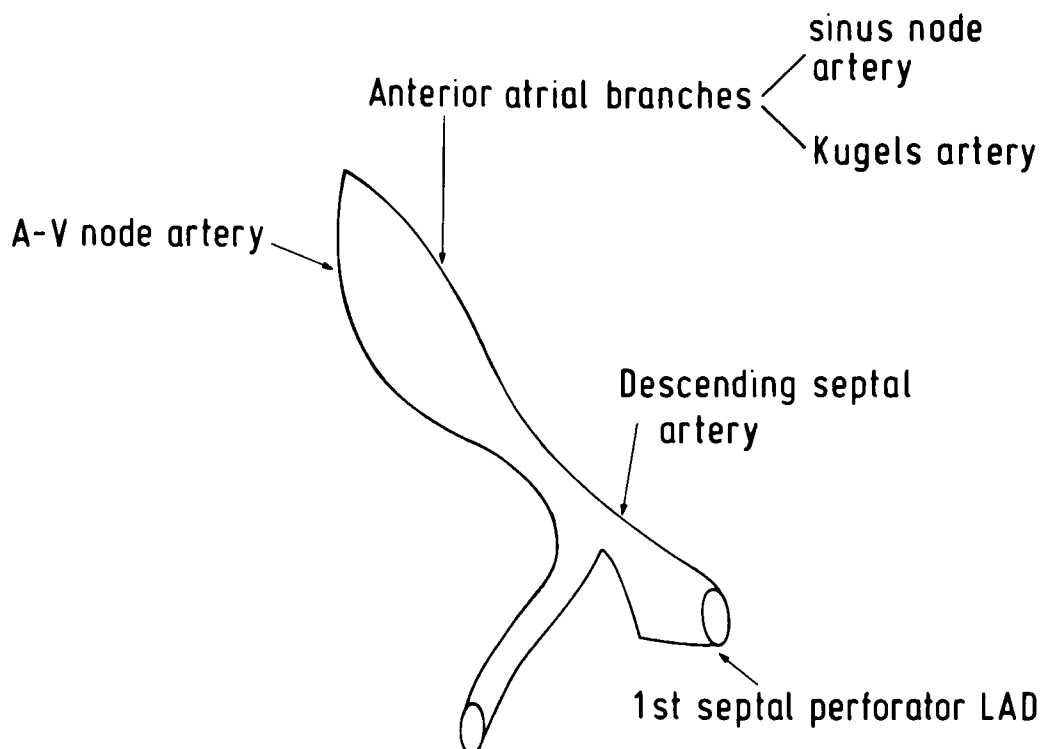


FIG. 3. A summary of the major alternative arteries which may contribute to the supply of the atrio-ventricular conducting tissue (LAD, left anterior descending).

explain the variable success other workers have had in identifying collateral vessels.

It is known that heart block complicating anteroseptal myocardial infarction carries a worse prognosis than heart block complicating posterior myocardial infarction.⁷ It would be useful to be able to relate atrioventricular conduction abnormalities, complicating myocardial infarction, more precisely to the

TABLE I
*Hypothetical involvement of A-V conducting tissue
in coronary occlusion*

Vessel Occluded	Conducting Tissue Affected		
	A-V node	A-V bundle	Bundle branches
RCA (ostium)	87%	58%	22%
RCA (distal)	81%	58%	22%
Left main stem	13%	42%	78%
LAD (proximal)	0%	36%	76%
Circumflex (proximal)	13%	6%	2%
Circumflex (distal)	9%	6%	2%

Note: RCA, right coronary artery; LAD, left anterior descending; A-V, atrio-ventricular.

This table is derived from Rombilt et al,¹ James,² Van der Hauwaert et al,³ Taylor⁵ and our own observations.

site of coronary artery occlusion or to the site of myocardial infarction. With this information it could be possible to identify patients at risk of developing atrioventricular conduction abnormalities. Although complicated, because of the number of arteries supplying the region and the variation in size of these vessels, it is hypothetically possible to make such predictions (Table I). However such a predictive chart is unlikely to be of much value in patients with established coronary disease, because in these patients collateral vessels provide arterial supply from unpredictable sources. This may to a greater or lesser extent negate the value of the chart.

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