A Retrospective Look at A-V Nodal Rhythms

Many important cardiac electrophysiological observations have been made by investigators who did not have sophisticated electronic equipment. However, some of the "classic" older studies produced data which were difficult to verify or interpret, although conclusions from them continue to exert powerful influence on electropharadiography today. One set of such studies conducted by Zahn led to the concept of upper, middle, and lower A-V (atrioventricular) nodal rhythms. A brief summary of the experiments upon which this concept was based will place it in more useful perspective.

A specially designed thermode was inserted through the appendage of the actively beating, blood-filled right atrium and was said to have been placed at selected sites in the region of the A-V junction. These sites were at the coronary sinus orifice, labeled the upper A-V node; at a point on the atrium along the septal insertion of the tricuspid valve, labeled middle A-V node; and at a point "hinunter," i.e., below the latter point which Zahn himself thought was very likely on the His bundle, but labeled lower A-V node. By warming the thermode, Zahn claimed to have produced special rhythms during which the atrial and ventricular contractions were mechanically recorded and the A-V intervals thereby produced were measured. It should be noted that no records were made of the electrical activity of the heart. When the "upper AV node" was warmed, the A-V interval was zero or barely positive; and, when the lower A-V node was warmed a negative A-V interval was produced. The thermode was also used to cool these same regions of the heart during a rhythm, said to be A-V nodal and created by extirpating the sinus node. During these latter studies, the A-V intervals were affected in an analogous way to the above, and were interpreted as further support for the concept of upper, middle, and lower A-V nodal rhythms.

It is difficult to know why Zahn's conclusions were apparently accepted so readily and uncritically, particularly since his data were obtained with crudely estimated placement of devices onto tiny structures in a beating, blood-filled heart. Perhaps, as summarized by Scherf and Cohen, it was because earlier reports by others concluded that the A-V node was a seat of impulse formation, or perhaps, as they also suggested, because the division into "upper," "middle," and "lower" A-V nodal rhythms was so easily understandable and seemed logical. There was some contemporary criticism of these studies but unfortunately it only served to perpetuate the concept. For example, Lewis's statement about Zahn's work speaks for itself: "Zahn's statement that he [affected] particular and known regions of the [A-V] node is scarcely convincing, but there seems no reason to doubt the more general conclusions."

Meek and Eyster clearly recognized the need for more careful electrical studies to examine Zahn's concept. They attempted to determine initial negativity during "A-V nodal" rhythms induced by several interventions in the canine heart. Single electrodes were placed at five regions of the right atrium, and bipolar electrograms were recorded by sequentially pairing the several electrodes during the induced "A-V nodal" rhythms. One of the electrodes was placed at "... the coronary sulcus as near as possible to the ventral margin of the coronary sinus, ..." an area they called an auricular portion of the A-V node. Another of the electrodes was placed "... on the auricular septum just above the middle cusp of the tricuspid valve, ..." an area they called the ventricular portion of the A-V node. The other electrodes were placed in the region of the sinus node, on the superior vena cava 10 mm from the sinus electrode, and on the free wall of the right atrium. It is clear that while Meek and Eyster may have been able to determine initial negativity when comparing one atrial electrode site with another, they clearly did not determine primary negativity during any of the rhythms they created, simply because they did not explore a sufficient number of sites on the atrium. Furthermore, based on more recent studies it is also clear that they recorded electrograms from atrial muscle, not from the A-V node. While Meek and Eyster did record local electrical activity, they did not record surface electrocardiograms, which is where the question of the clinical diagnosis of A-V nodal rhythms actually lies. Nevertheless, they

Address for reprints: Albert L. Waldo, M.D., Cardiovascular Research and Training Center, University of Alabama School of Medicine, University Station, Birmingham, Alabama 35294.
concluded that “two types of auriculoventricular rhythm were distinguished accordingly as the impulse arose in the ventricular part of the auriculoventricular node or in the extension of the node around the coronary sinus.” Although they concluded that “the work of Zahn has thus been confirmed by electrical methods,” this certainly was not so. Lewis also criticized the evidence provided by Meek and Eyster: “…the exact location of events in a small and buried structure appears to me [Lewis] precarious…,” but then inexplicably stated that because “…the conclusion that the rhythm arises in the A-V node is not only supported by these observations [of Meek and Eyster] but it is in harmony with so many other conclusions, that it is scarcely to be questioned.”

It is a sobering thought to consider how extensively the conclusions based on these studies have influenced modern clinical electrocardiography. The site of impulse formation during the rhythms produced (whatever they were) in these studies was never established. Yet, based on analysis of the P wave polarity (negative in ECG leads II, III, and aVF) and the relationship of the P wave to the QRS complex, clinical equivalents of upper, middle, and lower A-V nodal rhythms were generally thought to exist. Furthermore, a P-R interval of 0.12 sec became the clinically accepted upper limit for A-V nodal rhythms although we have not been able to determine how or why. At a later time and largely based on interpretation of the P-R interval, a controversy arose regarding the separation of “upper A-V nodal rhythm” from “coronary sinus rhythm.” even though Zahn and Meek and Eyster seemed to make no distinction between the “upper A-V node,” the “auricular portion of the A-V node,” or the region of the coronary sinus ostium.

Both the clinical controversy and the “rules” about P-wave polarity and the P-R interval in these rhythms were poorly grounded. Careful review of the original studies demonstrates that the entire original basis for the concept of upper, middle, and lower nodal rhythm is almost entirely hypothetical and based on debatably valid experimental observations. Furthermore, it is today quite clear that neither P-wave polarity nor the P-R interval serves as a reliable guide to the localization of the site of origin of impulse formation.

Sixty years after Zahn’s experiments, we are still at the beginning of an understanding of A-V junctional rhythms. In retrospect, probably the best thing to be learned from Zahn’s work is that the temptation to accept a simple concept because it is logical must be tempered with more careful analysis of the evidence which is offered in its support.

Albert L. Waldo
Thomas N. James

References

4. Meek WJ, Eyster JAE: Experiments on the origin and propagation of the impulse on the heart: III. The effect of vagal stimulation on the location of the pacemaker in auriculo-ventricular rhythm, and the effect of vagal stimulation on this rhythm. Heart 5: 227, 1913
5. Lewis T: The Mechanism and Graphic Registration of the Heart Beat. New York, Paul B. Hoeber, 1921
12. Brumlak JV: The sinoatrial node, the atrioventricular node, and atrial dysrhythmias. In Advances in Electrocardiography, edited by Kossman CK. New

16. JAMES TN, SHERF L: Specialized tissues and preferential conduction in the atria of the heart. Amer J Cardiol 28: 414, 1971

17. WEDD AM, STRoud WD: The spread of the excitation wave related to the standard electrocardiogram in the dog's heart. Heart 9: 15, 1921


A Retrospective Look at A-V Nodal Rhythms
ALBERT L. WALDO and THOMAS N. JAMES

Circulation. 1973;47:222-224
doi: 10.1161/01.CIR.47.2.222

Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 1973 American Heart Association, Inc. All rights reserved.
Print ISSN: 0009-7322. Online ISSN: 1524-4539

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circ.ahajournals.org/content/47/2/222.citation

An erratum has been published regarding this article. Please see the attached page for:
/content/47/3/464.full.pdf

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Circulation can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Circulation is online at:
http://circ.ahajournals.org//subscriptions/
34. Research Committee to the Medical Research Council: Controlled trial of soya bean oil in myocardial infarction. Lancet 2: 693, 1966
42. Roberts WC: Coronary arteries in fatal acute myocardial infarction. Circulation 45: 215, 1972
43. Gensini GG, Buonanno C: Coronary arteriography: A study of 100 cases with angiographically proved coronary artery disease. Dis Chest 54: 10, 1968
44. Tekson M: The hemodynamic concept of atherosclerosis. Amer J Cardiol 5: 291, 1960
46. Blumgart HL, Schlesinger MJ, Davis P: Studies on the relation of the clinical manifestations of angina pectoris, coronary thrombosis, and myocardial infarction to the pathologic findings with particular reference to the significance of the collateral circulation. Amer Heart J 19: 1, 1940

Correction
Waldo AL, James TN: Circulation 47: 222, 1973. On page 222, line 30 should read: "When the 'upper A-V node' was warmed, the A-V interval was shorter than during normal rhythms; when the 'middle A-V node' was warmed, the A-V interval was zero or barely positive; and, when the 'lower A-V node' was warmed, a negative A-V interval was produced."