Association of idiopathic RVOT VT and AVNRT: anything else than chance?

In the current issue of the journal, Kautzner et al.\(^1\) report a surprising and to date unrecognized high incidence (15%) of concomitant atrioventricular nodal reentrant tachycardia (AVNRT) in patients referred to the electrophysiology laboratory for catheter ablation of symptomatic right ventricular outflow tract tachycardia (RVOT VT). Although association of these two arrhythmias had not been clinically documented before ablation, they were beyond any doubt sequentially inducible in the same heart. Before concluding that this is mere chance, several potential common factors such as mechanisms, substrates, triggers, or sympathovagal status for initiation, which may contribute to the coexistence of these two different arrhythmias in the same patient, should be analysed.

### Arrhythmia substrate

By definition, idiopathic VT refers to ventricular arrhythmias that originate in hearts without structural disease.\(^2\) Although several magnetic resonance imaging studies have reported absence of structural ventricular defects in these patients, others have shown RVOT abnormalities including focal wall thinning and abnormal regional systolic wall motion. However, the causal relationship between the anatomic abnormalities and the site of tachycardia origin remains controversial.\(^3,4\) Results of studies of right ventricular biopsy sample are heterogeneous. Pathological findings range from normal myocardium, interstitial fibrosis, myocardial cell hypertrophy to myocarditis.\(^5,6\) Therefore, the implication of these histologic findings in the pathophysiology of RVOT VT remains unclear. Many studies have implied that the so-called fast and slow pathways involved in the genesis of AVNRT were anatomically distinct structures. However, analysis of the anatomy of the atrioventricular nodal region of patients with and without AVNRT has never clearly shown evidence of specialized pathways in the human heart.\(^7\) The AVNRT reentry circuit is therefore most likely functionally determined. Then, no particular anatomical substrates are required for the development of AVNRT or RVOT VT.

### Arrhythmia mechanisms

Several forms of idiopathic VT have been identified and classified depending on their site of origin in the ventricles, response to pharmacological agents, catecholamine dependence and clinical features. Irrespective of the phenotypic forms (non sustained repetitive monomorphic, or exercise-induced sustained), most of the idiopathic VT originating from the RVOT are adenosine sensitive. It is accepted that their mechanism is catecholamine-mediated delayed after depolarizations and triggered activity. Conversely, the mechanism of AVNRT is reentry. Moe et al. were the first to postulate that supraventricular tachycardia could be produced by longitudinal dissociation of the atrioventricular node.\(^8\) Development of AVNRT requires dual AV nodal physiology, because of the spatial coexistence of a fast conducting pathway with a long refractory period and a slower conducting pathway with a shorter refractory period. The exact mechanism leading to reentry remains a subject of discussion. The atrioventricular node is a complex structure with posterior and left atrial extensions that are engaged by transitional cells. The anatomical characteristics of this region strongly promote non-uniform anisotropic conduction that can potentially lead to sustained reentry in response to premature stimuli.\(^9\) More recently, based on optical mapping data and microelectrode recordings of the atrioventricular junction, it has been proposed that the electrical heterogeneity across the asymmetric transitional zone of the AV node rather than local structural uncoupling or anisotropy was the mechanism underlying the development of AVNRT.\(^10\)
any case, the mechanisms of RVOT VT and AVNRT are clearly different.

**Arrhythmia initiation**

In the electrophysiology laboratory, both AVNRT and RVOT VT can be induced using the same techniques (programmed stimulation, or rapid atrial and ventricular pacing). Theoretically any of the two arrhythmias can also initiate the other. Interestingly, cycle length dependence can be observed during induction manoeuvres of RVOT VT and this is a recognized marker of triggered activity. In this case, VT is induced only within a window of ventricular cycle lengths. Therefore, either a common trigger or the predominant arrhythmia may favour the coexistence of RVOT VT and AVNRT in the same patient.

**The role of the autonomic nervous system**

Another variable that is common to AVNRT and RVOT VT is that their induction is facilitated by isoprenaline infusion. This suggests a prominent role of the autonomic nervous system in the genesis of these arrhythmias. A regional sympathetic denervation has been found in up to half of the patients suffering from RVOT VT using Thallium and 123 I-MIBG scintigraphy. Due to the inability of visualizing the right ventricle using these techniques, these focal defects have been documented in the left ventricle only, which renders the causal relationship between these findings and RVOT VT questionable[11]. A significant shortening of the RR intervals preceding doublets or runs of VT, without parasympathetic withdrawal has been found in patients with RVOT VT. This suggests that the sympathovagal imbalance preceding tachycardia is preferentially related to an increase in the sympathetic tone[12]. Using positron emission tomography, Schaffers et al.[13] have shown that both presynaptic catecholamine reuptake and postsynaptic beta-adrenoceptor density are reduced in patients with RVOT VT. These findings suggest locally increased sympathetic activity, most likely due to increased local catecholamine levels in the synaptic cleft. In patients with AVNRT, Wen et al. have also demonstrated that vagal activity was impaired and that sympathetic efferent activity evaluated by isoprenaline sensitivity test and treadmill exercise test was more active compared with normal volunteers[14]. Therefore, autonomic dysfunction seems to be a common property of both RVOT and AVNRT patient populations, and may explain the high incidence AVNRT in patients with symptomatic RVOT VT.

**Morphogenesis of the atrioventricular junction**

It is interesting to note that the atrioventricular node and the RVOT are two areas anatomically very close. In the present manuscript, the authors propose the implication of more abundant specialized tissue in these regions, secondary embryonic heart development, in the occurrence of both AVNRT and RVOT VT in adults. Many years ago[15], it has also been suggested that persistent foetal dispersion of either the atrioventricular node or His bundle throughout the adjacent central fibrous body may play a role in the development of reentrant arrhythmias as well as parasystolic rhythms. Within the first few years, the normal morphogenetic process transforms the relatively large and irregular atrioventricular node and His bundle of the newborn into the sharply circumscribed and clearly delineated structures of the adult heart. However, this process may fail, leaving too much of the tissue normally present in the foetus to persist into adult life. Two types of persistent foetal dispersion of the atrioventricular node and His bundle are of interest. Loop connections from one point of the atrioventricular to another, mostly composed of transitional cells, and shielded in their midpoint by collagen, have been suggested as anatomical substrate to reentry. Conversely, supra-septal nests of similar cells, disconnected from the conducting system, potentially active sites of automaticity, have been thought to be involved in parasystolic rhythms.

**Should we necessarily ablate both arrhythmias?**

Another question raised by this study is the relevance of performing catheter ablation of both arrhythmias in the same session. There is little doubt about the need for performing slow pathway ablation in case of incessant induction of AVNRT, interfering with mapping and ablation of VT. Apart from this situation, the rationale of performing concomitant RVOT VT and AVNRT ablation remains questionable. In the present study, only one patient experienced symptomatic AVNRT recurrence following RVOT VT ablation. At this point in time it seems that further studies are required before advising systematic additional slow pathway ablation in these patients.

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