Vulnerability in Regionally Ischemic Human Heart. Effect of the Extracellular Potassium Concentration

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ABSTRACT

When dealing with the pathological heart, ventricular tachycardia and fibrillation are known to be two types of cardiac arrhythmias that usually take place during acute ischemia, and frequently lead to sudden death [1]. Even though these arrhythmias arise from different conditions, ischemia is the most important perpetrator among them. During ischemia, the delivery of nutrients to the myocardium diminishes, causing metabolic changes, which result in a progressive deterioration of the electric activity in the injured region [2]. These metabolic changes are mainly hypoxia, increased concentrations of the extracellular potassium [K+]o (hyperkalemia), decrease of intracellular ATP (hypoxia), and acidosis [3]. From an electrophysiological point of view, these metabolic changes imply alterations in the action potential (AP), excitability, conduction velocity (CV), and effective refractive period (ERP) among others, creating a substrate for arrhythmias and fibrillation [3,4]. In addition, the impact of ischemia in the myocardium is characterized by a high degree of heterogeneity both intramurally and transmurally. In the tissue affected by acute ischemia, two zones can be distinguis- hed: i) the central ischemic zone (CIZ) corresponding to the core of the tissue suffering from the lack of blood, and ii) a border zone (BZ) which comprises changes in electrophysiological properties between the healthy and ischemic regions [5]. Pro-arrhythmic mechanisms of acute ischemia have been extensively investigated, although often in animal models rather than in human ventricles. Seminal studies by Janse et al. [4,6] in pig and dog hearts highlight the complexity of the pro- arrhythmic and spatio-temporally dynamic substrate in acute ischemia. Heterogeneity in excitability and repolarization properties across the border zone leads to the establishment of reentry around the ischemic region following ectopic excitation [4,7]. The same studies also showed intramural reentry in certain cases (highlighting the potential variability in th
e mechanisms). However, the mechanisms that determine reentry formation and intramural patterns in acute ischemia in the three-dimensional human heart remain unclear, due to low resolution of intramural recordings. In this work, we have studied the different propagation patterns and determined the vulnerable window in a human heart during acute ischemia.

REFERENCES

[1] Rubart M, Zipes DP. J Clin Invest 2005; 115(9):2305-2315.
[2] Katz A. Physiology of the Heart. Lippincott Williams and Wilkins 2001.
[3] Carmeliet E. Physiol Rev 1999; 79: 917-1017.
[4] Janse MJ, Kleber AG. Circ Res 1981; 49(5): 1069-1081.
[5] Coronel R. Cardiovasc. Res. 1994; 28(6):770-777.
[6] Janse MJ, et al. Circ Res 1980; 47(2): 151-165.
[7] Wilensky RL, et al. Circulation 1986; 74: 1137-1146.