



High Altitude and Intracardiac Devices (Pacemaker and Intracardiac Defibrillator and Cardiac Resynchronisation Therapy)

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ABSTRACT

Cardiovascular system responds to high altitude short after exposure. Hypoxia induces increase in heart rate, myocardial contractility, and cardiac output. This may have clinical implications in patients with underlying heart disease such as coronary artery disease, heart failure and rhythm disorders. Past studies have showed that patients may experience altitude-induced arrhythmias. However, there are conflicting data for patients with cardiac devices such as permanent pacemaker, intracardiac defibrillators (ICDs) and cardiac resynchronisation therapies (CRTs). Limited studies demonstrate that patients with pacemakers can be safely exposed to high altitudes with no impact on ventricular stimulation thresholds, however effects of altitude on ICDs or CRTs are still unknown at the present time requiring further research.

Key Words: High altitude; intracardiac device

Yüksek İrtifa ve İtrakardiyak Cihazlar (Pacemaker ve İtrakardiyak Defibrilatör ve Kardiyak Resenkronizasyon Tedavisi)

ÖZET

Kardiyovasküler sistem yüksek irtifa maruziyetine kısa sürede cevap verir. Hipoksi kalp hızını, miyokard kasılmasını ve kardiyak debiyi artırır. Bu özellikle kalp yetersizliği, ritm bozukluğu ve koroner arter hastalığı gibi altta yatan kalp hastalığı olduğu durumlarda klinik önem arz edebilir. Geçmişte yapılmış çalışmalarda yüksek irtifaya bağlı ritm bozuklukları bazı hastalarda gözlenmiştir. Fakat kalıcı pil, intrakardiyak defibrilatör (IKD) ve kardiyak resenkronizasyon terapisi (KRT) gibi kalp cihazlarıyla ilgili çelişkili sonuçlar mevcuttur. Kısıtlı sayıda yapılan çalışmalarda yüksek irtifaya maruz kalmış kalp pili olan hastalarda yüksekliğin ventriküler stimülasyon eşiği üzerinde etkisinin olmadığı ve bu durumun güvenilir olduğu gösterilmiştir; fakat günümüzde yüksek irtifanın IKD ve KRT cihazları üzerindeki etkisi halen net olarak bilinmemektedir ve daha fazla çalışmaya ihtiyaç vardır.

Anahtar Kelimeler: Yüksek irtifa; intrakardiyak cihazlar

EFFECT of HIGH ALTITUDE on CARDIOVASCULAR SYSTEM

When exposed to high altitude, several changes occur in cardiovascular system. High altitude may cause hypobaric hypoxia and may impair physiologic functions of the heart. Acute hypoxia induces increase in heart rate and myocardial contractility^(1,2). Healthy individuals usually tolerate well; most patients with cardiovascular disease are at risk of complications^(3,4).

Atmospheric pressure, oxygen pressure and temperature decrease when moving from sea level to high altitude⁽⁵⁾. The content of oxygen and inspired partial oxygen pressure decreases at high altitudes in both normal population and patients with cardiovascular disease⁽¹⁾. Oxygen-poor air-related tissue hypoxia results in the compensatory

physiological changes at rest and exercise at higher altitudes. As altitude increases, cardiac output increases to maintain the same oxygen delivery to the body⁽⁶⁾.

In normal people several changes are observed at rest when exposed to high altitude. The heart rate increases, ST-T waves may flatten, QRS axis may shift rightward, QT interval may prolonge and P-wave amplitude may increase in lead 2⁽⁷⁾.

In a report by Saurenmann et al.⁽⁸⁾, 3 of 12 patients developed a new right bundle branch block and three others showed changes consistent with right ventricular hypertrophy at the most extreme altitude.

HIGH ALTITUDE and ARRHYTHMIA

The incidence of arrhythmias at high altitude is variable and depends upon the patient characteristics. In normal population

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arrhythmias are exceedingly rare at high altitude and even at extreme altitude the ECG shows only the changes of pulmonary hypertension⁽⁹⁾. Sympathetic activity increases and so may aggravate the incidence of supraventricular and ventricular arrhythmias, especially in patients with known heart disease^(10,11). Age is a potential risk factor for development of arrhythmia. Eight healthy young men who were observed during exercise at simulated altitudes up to the equivalent of the summit of Mount Everest had no arrhythmias, due to a study reported by Malconian et al.⁽¹²⁾. On the other hand, older patients may have altitude-induced arrhythmias. In a Holter monitoring study of healthy middle-aged men, the incidence of both supraventricular and ventricular extrasystoles was nearly doubled at an altitude of 1350 meters as compared to 200 meters. At higher altitude (2632 meters), the incidence of ectopy was increased six- to sevenfold⁽¹³⁾. This shows that increased altitude may aggravate arrhythmias. The increase in ectopic beats was probably due to early release of catecholamines and beta adrenergic stimulation at the higher altitude^(13,14).

ALTITUDE and INTRACARDIAC DEVICES (PACEMAKER and INTRACARDIAC DEFIBRILLATOR (ICD) and CARDIAC RESYNCHRONISATION THERAPY (CRT))

The majority of cardiac devices are conventional pacemakers, but there are an increasing number of CRT pacemakers and ICDs, with or without CRT capability in the last decade. The safety of pacemaker at high altitude and the possibility of alterations in stimulation thresholds are not certain since data are conflicting.

More than 40 years ago, Westerholm CJ⁽¹⁵⁾ reported a threshold research about transvenous cardiac pacemaker implantation. By simulating altitude with inhalation of 10 percent oxygen, a significant but reversible increase in stimulation thresholds was observed. In another phase of threshold testing, mechanic hyperventilation-induced hypocapnia led to a decrease in pacing stimulation thresholds. In a more recent contemporary report, stepwise simulated hypobaric chamber ascent from 450 meters to 4000 meters produced no change in stimulation thresholds despite the significant fall of PaO₂⁽¹⁶⁾. How can this dilemma be explained? This is due to the balance between hypoxia and hypocapnia, which push the pacing stimulation threshold in different directions⁽¹⁷⁾. Due to some previous reports, pacing thresholds can remain unchanged at the moderate altitudes during aeroplane travel. The safety of pacemakers at the extreme altitudes is not known⁽¹⁸⁾.

Aeroplane travel for patients with pacemakers and ICDs may require serious attention in certain circumstances. The insertion of pacemaker-related guidewires usually includes puncture of subclavian vein and pneumothorax may occur. Passengers with a pneumothorax should not travel by aeroplane due the risk of gaseous expansion at high altitude which may impair respiratory function. Possible development of tension pneumothorax may become inevitable. Travel should be deferred for 2 weeks after full radiographic resolution if the procedure has been complicated by pneumothorax⁽¹⁸⁾. Patients with intracardiac devices often have significant cardiac disease such as previous ischemic

heart disease and left ventricular systolic dysfunction. When evaluating the patient's fly convenience, the clinical stability of these underlying problems necessitate careful consideration⁽¹⁹⁾.

Although most of the patients with an cardiac device may travel safely by aeroplane, there are a few specific topics that should be evaluated. Patients who are dependent on pacemaker are especially at increased risk for developing adverse effects in case of an electromagnetic interference (EMI)^(19,20). The duration of the interference and the extent to which the patient is pacemaker-dependent are important factors that may have clinical implications^(19,21). More than 20 years ago, some researchers evaluated the effect of the environment in different types of aeroplane on the function of explanted pacemakers which either showed no effects or little effects such as one or two missed pacing pulses⁽²²⁾. In study reported by De Rotte et al.⁽²³⁾ no effect of interference could be detected in any of the pacemakers on holter recordings. In a patient with ICD, interferences may be falsely interpreted as tachyarrhythmia which may result in inappropriate pacing or shocks. Feed-through capacitors have been recently incorporated into the most of the pacemakers and ICDs and interference protection has improved significantly^(19,24). The risk of clinically significant interference affecting intracardiac devices in the aeroplane environment is minimal⁽¹⁹⁾.

Consequently, patients with pacemakers can be safely exposed to high altitudes without any alteration on ventricular stimulation thresholds; however effects of altitude on ICDs or CRTs are still unknown at present time requiring further studies.

CONFLICT of INTEREST

The authors reported no conflict of interest related to this article.

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