EVALUATION OF OPPORTUNITY FOR AIR TRAVELING OF PATIENTS WITH CARDIAC ARRHYTHMIAS

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The increasing use of air transport by people with cardiovascular diseases, prone to problems associated with air travel, and require more attention during the entire journey. Considerations for preventing the worsening of the condition of patients during air travel based on the available data are summarised, algorithms for preliminary risk assessment and preparation of patients with cardiac arrhythmias are given.

Key words: aviation environment; air travel; arrhythmias; tachyarrhythmias; bradyarrhythmias; cardiac implantable electronic devices

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Nowadays, more and more people suffering from cardiovascular diseases use air travel. This is partly due to the greater availability of air travel, and partly to advances in cardiology and medicine in general. Progress in the diagnosis and treatment of cardiac arrhythmias is evident, and, accordingly, a significant proportion of patients with cardiac arrhythmias can be found among the passengers of modern commercial airlines. These patients tend to have problems with air travel and may need more attention during travel. Nevertheless, there are few studies that can provide recommendations for patients with cardiac arrhythmias who wish to travel on commercial airlines. In this review, we have attempted to summarise considerations for preventing deterioration in quality of life during air travel based on the available evidence and to provide (as far as possible) reasonable algorithms for the pretesting and preparation of patients with cardiac arrhythmias.

FACTORS AFFECTING THE PATIENT WITH ARRHYTHMIA DURING AIR TRAVEL

Even for a large proportion of modern people, flying aboard an airplane is not part of the routine of life, and some people even tend to perceive it as something extreme, because the conditions to which a person is exposed during an air journey are different from the conditions in which he lives on a daily basis and for the life he is designed to lead. When considering the effects of the flight environment on the cardiovascular system, the changes in the atmosphere during the flight (physiological factors) are of course primarily taken into account, but one must not ignore the influences that occur before take-off and after landing. These include, for example, the change of time zones or the experience of waiting for a flight or being delayed, i.e. psychological and physical stress factors [1, 2], as well as failures to take medication [3].

Effect of cabin atmosphere

There are few direct clinical studies on the pathophysiological effects of flight conditions on patients with pre-existing cardiovascular disease. Concerns about possible adverse effects are based on extrapolating what is known about the physics of gases at different altitudes, cardiovascular physiology and studies that attempt to simulate flight conditions, either by studying patients adapting to life on land at high altitude or by studying the effects of hypoxia in artificially created conditions [4-6].

First and foremost among the findings from the physics of gases is Dalton's law, or rather one of the two Dalton's laws that interest us, namely the «law of the total pressure of a gas mixture», which is formulated as follows: The pressure of a mixture of chemically non-interacting ideal gases is equal to the sum of their partial pressures. Accordingly, as altitude increases and atmospheric pressure drops, the partial pressure of oxygen drops simultaneously. Hypobaric hypoxia, which is associated with a drop in partial pressure of oxygen, can be a definite health risk in patients with cardiovascular disease [7]. Although pressurisation of aircraft cabins results in the barometric altitude in the cabin being much lower than the altitude at which normal commercial flights take place (between 6000 and 13500 m), there is still a drop in the partial pressure of oxygen, but not beyond the «barometric altitude limit». Aviation regulations dictate that cabin pressure must not exceed 2438 m (8000 ft) at the aircraft's maximum operating altitude [8], which most aircraft have been shown to be able to maintain at all times [9]. This barometric altitude limit, depends on the type of aircraft. For example, for the Airbus A320 family it is 2438 meters and for the A340-200/300 it is 2240 meters. According to the standard oxygen dissociation curve of a healthy person, at a barometric altitude of 2438 m in the cabin, if the partial pressure of oxygen in the cabin is 118 mmHg, oxygen saturation is maintained at 90-93%. [10].

To be fair, it should be noted that hypoxia under flight conditions does not cause extreme changes in resting circulatory parameters [4-8], and circulatory changes are limited to a slight (probably transient) increase in heart rate, a slight decrease in total peripheral resistance, which may lead to an increase in minute volume and some increase in coronary blood flow. That said, an oxygen saturation of 80% at barometric altitudes of 2438 m is unlikely in commercial aircraft. Nevertheless, a number of aspects of hypobaric hypoxia that cause the development of cardiovascular changes are still not fully understood, including ischaemia [11], heart failure [12] and thrombosis [13].

There are very few well-designed studies assessing arrhythmia risks in humans in hypobaric environments, and most of the studies suggesting an increased arrhythmia risk at high altitudes have generally been conducted at much higher barometric altitudes (e.g. extreme mountaineering) than in commercial aircraft cabins or in animals, making extrapolation of their results to passengers somewhat difficult [14]. Cardiac arrhythmias are thought to be caused by activation of the sympathetic nervous system in susceptible passengers, especially those with underlying heart disease, and there are many factors (hypoxia, tachycardia, hyperventilation, psychological stress, omitted medication, etc.) for this activation during air travel [15].

Most interesting are studies in which healthy volunteers, while continuously recording ECGs, ascended (and then descended) by cable car to the second highest peak of the High Tatras, Lomnický Štítít, in Slovakia. The altitude to which the volunteers climbed was 2632 m; there was also a transfer point along the way with an altitude of 1764 m [16, 17]. The researchers noted a linear correlation between the increase in height and the frequency of extrasystoles, both ventricular and supraventricular. These results did not extend to sustained or hemodynamically significant ventricular arrhythmias.

It can therefore be assumed that passengers with cardiomyopathies, especially those over 50 years of age, are more susceptible to cardiac arrhythmias during air travel, even though the absolute increase in risk is probably only small.

Electric and magnetic fields

One of the factors one is exposed to when travelling by air, both in the cockpit and at airports, is exposure to electric and magnetic fields. Of interest are the effects on the cardiovascular system in patients with cardiac implantable electronic devices (CIEDs), including pacemakers, defibrillators and ECG loop recorders. Large-scale studies on the interaction of the CIED with the environment in the aircraft cabin are currently few. It seems likely that such studies will be done in the future, as the number of people with CIEDs is progressively increasing year by year.

Concerns that draw attention to the issue of operating CIEDs under flight conditions relate to the operation of electronic equipment on board (such as radars, rangefinders, etc.) that generate electromagnetic radiation in the cockpit of a passenger aircraft that is higher and/or of a different nature than in everyday life. Non-cardiac signals, either from the body or from external electrical devices, can potentially mimic arrhythmias that may result in inappropriate cardiac pacing or unwarranted defibrillator activation.

The above concerns stem from two studies that examined the effects of being surrounded by a single-engine aircraft. The choice of such an aircraft is due to the fact that its passenger seats are closer to the on-board radio electronics than in a large multi-engine commercial aircraft. To assess the electromagnetic interference of pacemakers [18] or cardioverter defibrillators [19], the performance of these devices placed in an artificial chest was evaluated before, during and after the test flight. The devices were working normally. Although the study tested only a few devices and only on one aircraft, it is assumed that the results are transferable to other types of CIEDs as well as to other aircraft.

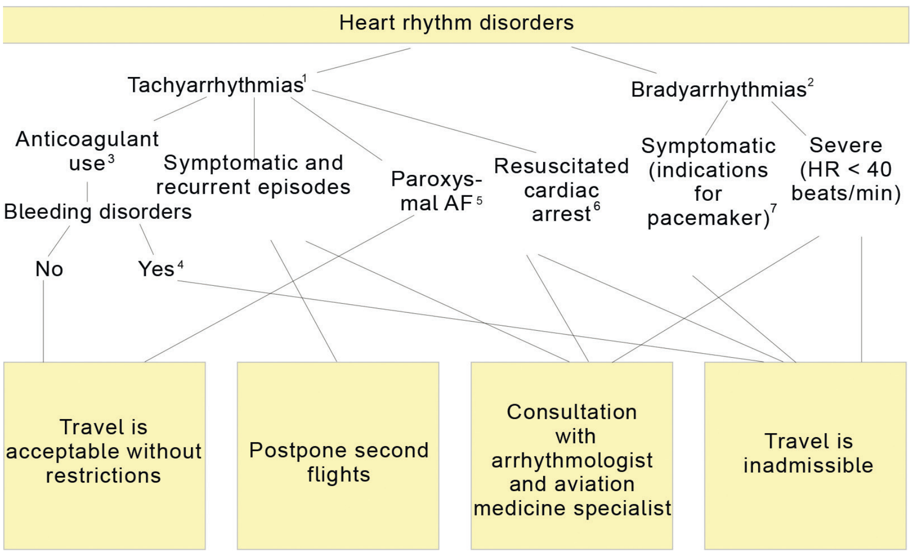

Fig. 1. Algorithm for evaluation of the patient with arrhythmia on air travel, where [1] - atrial fibrillation with rapid ventricular rhythm, atrial tachycardia, supraventricular tachycardia; [2] - sick sinus syndrome, high degree atrioventricular block; [3] - both direct-acting oral anticoagulants and vitamin K antagonists; in the latter case, check the international normalized ratio (INR) 24-48 hours before the flight, also consider skipping the next 1-2 doses and rechecking the INR upon arrival at the destination; [4] - INR >4; [5] - medication must be carried in a pocket on board and within easy reach; [6] - due to arrhythmic syncope (ventricular tachycardia / ventricular fibrillation / torsades de pointes) without implanted cardioverter-defibrillator and with left ventricular ejection fraction < 35% or without reversible / correctable cause; [7] - travel inadmissible before pacemaker implantation.

More important are the issues of CIED's interaction with security systems that work with electromagnetic fields and are widely used at airports. Walk-through or hand-held metal detectors are used for safety purposes to detect disturbances in electromagnetic fields. Curved metal detectors operate in continuous wave (5-10 kHz) or pulse mode (200-400 Hz) and provide a much higher magnetic field strength compared to portable metal detectors which operate in a much stronger continuous wave mode (80-130 kHz).

The effects of curved (stationary) metal detectors at airports on implanted pacemakers have been studied for almost two decades. In the observed patients, as expected, the metal detection signal was always activated when they passed without interruption through such metal detectors set to maximum sensitivity, but the behaviour of the pacemaker system was not affected in any of the patients. In particular, none of the devices were set to «noise reversal mode» or asynchronous (fixed speed) operation. However, the devices could be inhibited by 1 heartbeat [20]. Distance from the device and duration of exposure are important risk factors when assessing the interaction between CIEDs and safety systems [21]. For example, wearable metal detectors with magnets have a greater potential to interact with the implanted device.

Therefore, the effects of such electromagnetic interference on CIEDs are usually short-lived and passengers with such devices should be warned to inform security personnel about their implants to avoid prolonged contact with security devices and to avoid unnecessary stress from inadvertently triggering alarms when such devices are detected [6].

CONTRAINDICATIONS TO AIR TRAVEL FOR PEOPLE WITH HEART RHYTHM DISORDERS

Russian legislation is quite complicated when it comes to the exclusion from air travel of people who show signs of decompensation of a disease, including cardiovascular disease. Moreover, according to cl. 108 of the Order of the Ministry of Transport No. 82 «On Approval of Federal Aviation Rules «General Rules for Air Transportation of Passengers, Baggage, Cargo and Requirements for Servicing Passengers, Shippers, Consignees» of June 28, 2007, «a passenger is obliged to independently determine the possibility of using air transportation, based on the state of his/her health», which is problematic even for a medical worker, let alone a person who does not have such com-

Table 1.

General considerations for evaluating and preparing for air travel in the patient with arrhythmias

Aeromedical assessment	Determining suitability for traveling alone, accompanied or medically accompanied. Determining the need for consultation with an attending cardiologist and/or aviation medicine specialist in special and complex cases.
Clinical assessment	Anamnesis. Pulse oximeter measurement of baseline SpO2 at rest and, in some cases, in a stress test. Standard ECG in 12 leads. Chest radiography (after implantation of CIED). INR while taking warfarin (no earlier than 24-48 hours before departure). Prior consultation with a cardiologist about the interaction of cardiovascular drugs with prophylactic drugs against infectious diseases, if such drugs are required at the destination (e.g. antimalarials, etc.), is necessary.
Patient education	Prepare and carry the appropriate documents for relocation and admission through airport security control. Ensure that a device or equipment card is on hand. Carry a copy or printout of the most recent device test report and copies of a 12-lead ECG with and without a pacemaker. Provide advance communication with a qualified clinic and, in some cases, a manufacturer's representative at the destination. Advise security personnel not to place movable detectors over the device. Minimise the time spent near metal detectors. Provide assistance in advance (usually 3 days in advance) at the airport and during the flight with luggage, especially stowing and unloading..
In-flight measures (patient education)	Inform the flight attendant of your condition. Have your most recent doctor's orders (with information on drug allergies) on hand (in your hand luggage). Carry in your hand luggage an adequate supply of medication for the duration of the flight plus 3-5 days thereafter (in case of traveling to destinations with poor medical care, lost luggage, etc.). Carry emergency medications (e.g., antiarrhythmic drugs for paroxysmal atrial fibrillation) in your carry-on baggage. In neurocardiogenic syncope: inform flight attendant, rest in seat (recline if possible), cross legs, drink. For paroxysmal supraventricular tachycardia: inform flight attendant, Valsalva maneuver.

Notes: SpO_2 - oxygen saturation, ECG - electrocardiography, CIED - cardiac implantable electronic devices, INR - international normalized ratio.

petencies. In a number of cases, the medical staff of the health centre and the crew members of an aircraft are confronted by some passengers with a blatant disregard for the seriousness of their own condition. In such situations, one should be guided by Article 107 of Federal Law No. 60- FZ «Air Transport Code of the Russian Federation» of March 05, 1997 (with amendments and modifications), which states that «the air carrier may unilaterally terminate the contract for carriage of a passenger <...> if a passenger's state of health requires special conditions of air carriage or endangers the safety of the passenger or other persons, as confirmed by medical documents, as well as causes disorder and irreparable inconvenience to other passengers and the passenger's health and safety.

In many respects, the above position is in line with the International Air Transport Association, which establishes the following general criteria [22] for airlines to ensure that a passenger receives the necessary medical clearance for the flight if he/she:
1. suffers from any disease that is considered contagious and infectious;
2. may pose a danger or cause discomfort to other passengers due to a physical or behavioral condition;
3. is a potential risk to the safety or punctuality of the flight, including the possibility of diversion or unscheduled landing;
4. can't take care of himself/herself and requires special assistance;
5. has a medical condition that may be adversely affected by flight conditions.

In general, passengers with cardiac rhythm disorders, acute or chronic, fall into the categories described in paragraphs 4 and 5 above, and grounds for refusal to fly on board a civil aircraft may include:
• shock states (if cardiogenic shock is included);
• acute heart rhythm disturbance;
• cardiovascular diseases in decompensation stage (stage 3).

This list can be expanded and the wording replaced with more up-to-date formulations by selecting absolute cardiovascular contraindications for patients with cardiac rhythm disorders from various international guidelines and consensus documents [4-6, 8, 23, 24]. They are as follows:
• Uncontrolled ventricular or supraventricular arrhythmias;
• Resuscitated cardiac arrest caused by arrhythmic collapse, without an implantable cardioverter-defibrillator and with a left ventricular ejection fraction <35% or no reversible/correctable cause within 6 months.

The above documents usually add that this list is not exhaustive and physicians, in determining fitness to fly, must assess passengers on an individual basis. If a passenger is diagnosed with any of the above contraindications, air travel should initially be postponed and the existing clinical condition should be treated in a timely manner.

ASSESSMENT OF FITNESS FOR AIR TRAVEL IN TACHY A ND BRADYARRHYTHMIAS

As a rule, recommendations for active arrhythmias include brief notes on flight tolerance if they are «stable» or «uncomplicated» This is currently insufficient as a wide range of clinical scenarios and severities may occur in different patients. Therefore, a more comprehensive algorithm is needed to help the treating physician make a more appropriate decision during counselling.

One aspect of determining in-flight risks is related to the propensity for increased thrombogenicity [8, 13, 25, 26], but the number of passengers taking anticoagulants, particularly vitamin K antagonists, to prevent thromboembolism in atrial fibrillation or flutter has increased quite substantially recently. As a result, bleeding rather than thrombogenicity has become an urgent concern, and there is little research on the safety of air travel in relation to the risk of bleeding when taking anticoagulants. Consequently, for the time being, all recommendations for the acceptability of air travel must be derived from ground-based studies on this risk.

There are several publications suggesting that it is probably possible to set a safety limit for taking vitamin K antagonists at an International Normalized Ratio of 4 [6, 23, 27]. In this case, assessing the presence or absence of ongoing bleeding is of paramount importance when examining a patient, especially in patients taking oral direct-act-

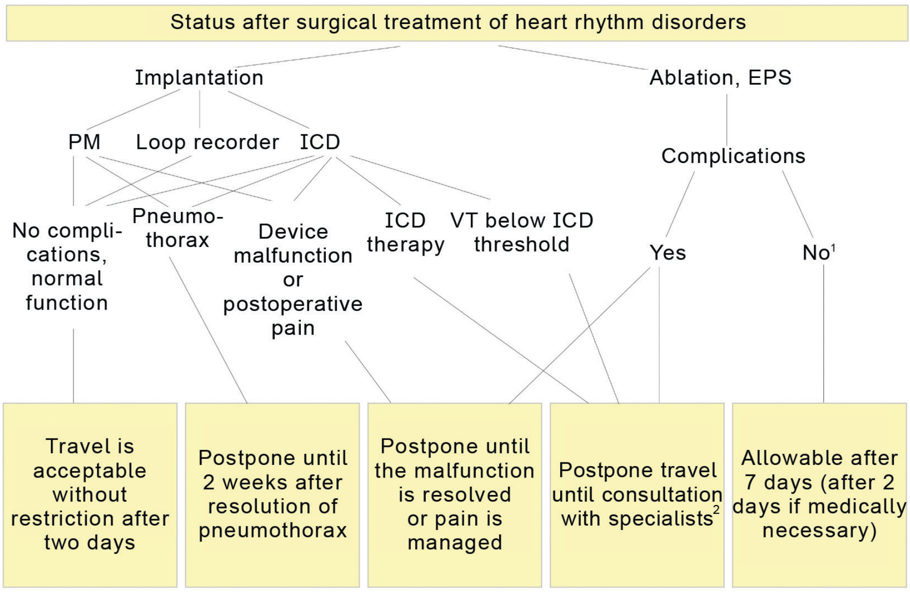

Fig. 2. Algorithm for evaluating a patient after surgical treatment of arrhythmias for airway, where [1] - no access site bleeding or hematoma, pericardial effusion, stroke, thromboembolism, valve or myocardial damage, etc. to minimize the risk of thromboembolism, antithrombotic agents are needed for left-sided ablation; [2] - consult a cardiac surgeon-arrhythmologist and aviation medicine specialist; ICD - implantable cardioverter-defibrillator, PM – pacemaker, EPS - electrophysiological study, VT - ventricular tachycardia.

ing anticoagulants (dabigatran, rivaroxaban, apixaban, etc.) whose activity is more difficult to monitor [28].

Fig. 1 shows the algorithm we have developed for the assessment of patients with arrhythmias based on the summary of expert opinions [6, 8, 9, 22, 23, 27, 28], which also refer to aspects other than bleeding. Table 1 is supplementing the figure.

ASSESSMENT AFTER SURGICAL TREATMENT OF ARRHYTHMIAS

Implantation of pacemakers and cardioverter defibrillators requires access to the central veins, and pneumothorax is a common complication of their puncture. The incidence of ipsilateral pneumothorax due to needle injury to the pleura while searching the subclavian vein averages 2%. Risk factors for pneumothorax are: female gender, body mass index < 20, age > 80 years, chronic obstructive pulmonary disease, bullous emphysema, corticosteroid treatment, anticoagulant therapy, antiplatelet therapy, emergency surgery, anxious and uncooperative patient and inexperience of the surgeon. In addition, the risk is increased in patients with congenital venous or thoracic anomalies, previous procedures, surgery, trauma or radiotherapy to the affected area, a history of clavicle deformities and fractures, the use of an oversized catheter or two electrodes, more than two puncture attempts / long duration of the procedure and revision of the electrode [29].

In some cases pneumothorax may be asymptomatic, in others it may cause pain, dyspnoea, tachypnoea and tachycardia. More severe symptoms such as hypoxia (oxygen saturation < 90%), arterial hypotension, swollen neck veins, tracheal shift and decreased or absent breath sounds clearly indicate a tension pneumothorax and can be life-threatening. Whenever a patient presents with classic signs and symptoms associated with pneumothorax within a few hours of CIED implantation, it should be assumed that the patient develops a pneumothorax until proven otherwise. The usual routine examination after CIED implantation is a review chest radiograph, and specialists evaluating this examination should be alert for pneumothorax, even a small one.

The more severe manifestation of pneumothorax is due to the inherent property of gas expansion at altitude according to the Boyle-Marriott law, which can impair respiratory function or, in rare cases, even lead to tension pneumothorax. Any pneumothorax is a contraindication for air travel. However, there is consensus among guidelines and professional organizations that passenger air travel is safe 2 weeks after resolution of pneumothorax [4, 6, 8, 30].

Other aspects of surgery for cardiac arrhythmias include invasive electrophysiological investigations and/or ablation. In a typical procedure, 4-5 introducers are placed in the femoral veins through which catheters are inserted into the heart. If necessary, the left ventricles are accessed by septal puncture or by retrograde access to the left ventricle via the femoral artery. The period of immobility during and after the procedure is usually up to six hours and represents an additional thrombotic risk factor. The incidence of asymptomatic deep vein thrombosis in these conditions ranges from 5 to 18%; the clinical incidence is much lower (0.4-2%) [31].

In particular, patients undergoing left-sided procedures are a higher risk group, as any potential thrombi that form either from catheters or from endocardial lesions after ablation can cause systemic embolism [32], with the first week after the procedure being the most dangerous window for thrombus formation. Therefore, patients should be advised to postpone non-urgent air travel during this period [6, 8].

Fig. 2 shows our algorithm for assessing patients who wish to travel by air after surgical treatment for cardiac arrhythmias, based on the general opinion of experts and international recommendations [4, 6, 8, 27, 29-33]. See also Table 1.

CONCLUSION

Thus, after reviewing the current literature covering various aspects related to air travel of passengers with cardiac arrhythmias, one can conclude that such patients should be appropriately assessed and prepared based on their travel intentions. Both the attending physician and the flight medics should know both the contraindications for flight and the correct procedure (algorithms) for a preliminary risk assessment in these individuals.

REFERENCES

1. Praskurnichiy E.A. Medical and aeromedical flight safety risks. Moscow 2021: 192 p. (In Russ.) ISBN 978-5-6046269-8-6.
2. Vaccarino V, Almuwaqqat Z, Kim JH, et al. Association of Mental Stress-Induced Myocardial Ischemia With Cardiovascular Events in Patients With Coronary Heart Disease. *JAMA*. 2021;*326*(18): 1818-28. https://doi.org/10.1001/jama.2021.17649
3. Chellappa SL, Vujovic N, Williams JS, et al. Impact of circadian disruption on cardiovascular function and disease. *Trends in endocrinology and metabolism*. 2019;30(10): 767-779. https://doi.org/10.1016/j.tem.2019.07.008.
4. Gill GV, Redmond S. Insulin treatment, time-zones and air travel: a survey of current advice from British diabetic clinics. *Diabetic Medicine: A Journal of the British Diabetic Association*. 1993;10(8): 764-767. https://doi.org/10.1111/j.1464-5491.1993.tb00161.x.
5. Thibeault C, Evans AD, Dowdall NP. AsMA Medical Guidelines for Air Travel: Fitness to Fly and Medical Clearances. *Aerospace Medicine and Human Performance*. 2015;86(7): 656. https://doi.org/10.3357/AMHP.4222.2015.
6. Meyer MJ, Mordukhovich I, Coull BA, et al. Impact of simulated flight conditions on supraventricular and ventricular ectopy. *Scientific Reports*. 2023;13(1): 481. https://doi.org/10.1038/s41598-022-27113-x.
7. Koh CH. Commercial Air Travel for Passengers With Cardiovascular Disease: Recommendations for Less Common Conditions, Considerations for Venous Thromboembolism, and General Guidance. *Current Problems in Cardiology*. 2021;46(4): 100782. https://doi.org/10.1016/j.cpcardiol.2020.100782.
8. Nishi S. Effects of altitude-related hypoxia on aircrews in aircraft with unpressurized cabins. *Military*

Medicine. 2011;176(1): 79-83. https://doi.org/10.7205/milmed-d-09-00213.
9. Smith D, Toff W, Joy M, et al. Fitness to fly for passengers with cardiovascular disease. *Heart (British Cardiac Society)*. 2010;96 Suppl 2: ii1-16. https://doi.org/10.1136/hrt.2010.203091.
10. Aerospace Medical Association; Aviation Safety Committee; Civil Aviation Subcommittee. Cabin cruising altitudes for regular transport aircraft. *Aviat Space Environ Med*. 2008; 79(4): 433-9. https://doi.org/10.3357/asem.2272.2008.
11. Cottrell JJ, Lebovitz BL, Fennell RG, et al. Inflight arterial saturation: continuous monitoring by pulse oximetry. *Aviation, Space, and Environmental Medicine*. 1995;66(2): 126-130.
12. Parati G, Agostoni P, Basnyat B, et al. Clinical recommendations for high altitude exposure of individuals with pre-existing cardiovascular conditions: A joint statement by the European Society of Cardiology, the Council on Hypertension of the European Society of Cardiology, the European Society of Hypertension, the International Society of Mountain Medicine, the Italian Society of Hypertension and the Italian Society of Mountain Medicine. *European Heart Journal*. 2018;39(17): 1546-1554. https://doi.org/10.1093/eurheartj/ehx720.
13. Erdem G. Is heart failure an obstacle to air travel? *Anatolian Journal of Cardiology*. 2021;25(Suppl 1): S10-S12. https://doi.org/10.5152/AnatolJCardiol.2021.S105.
14. McKerrow Johnson I, Shatzel J, Olson S, et al. Travel-Associated Venous Thromboembolism. *Wilderness & Environmental Medicine*. 2022;33(2): 169-178. https://doi.org/10.1016/j.wem.2022.02.004.
15. Woods DR, Boos C, Roberts PR. Cardiac arrhythmias at high altitude. *Journal of the Royal Army Medical Corps*. 2011;157(1): 59-62. https://doi.org/10.1136/jramc-157-01-10.
16. von Haehling S, Birner C, Dworatzek E, et al. Travelling with heart failure: risk assessment and practical recommendations. *Nature Reviews. Cardiology*. 2022;19(5): 302-313. https://doi.org/10.1038/s41569-021-00643-z.
17. Kujaník S, Snincák M, Vokál' J, et al. Periodicity of arrhythmias in healthy elderly men at the moderate altitude. *Physiological Research*. 2000;49(2): 285-287.
18. Kujaník S, Snincák M, Galajdová, K et al. Cardiovascular changes during sudden ascent in a cable cabin to the moderate altitude. *Physiological Research*. 2000;49(6): 729-731.
19. De Rotte AA, Van Der Kemp P. Electromagnetic interference in pacemakers in single-engine fixed-wing aircraft: a European perspective. *Aviation, Space, and Environmental Medicine*. 2002;73(3): 179-183.
20. De Rotte AA, van der Kemp P, Mundy PA, et al. Electromagnetic Interference in Implantable Defibrillators in Single-Engine Fixed-Wing Aircraft. *Aerospace Medicine and Human Performance*. 2017;88(1): 52-55. https://doi.org/10.3357/AMHP.4623.2017.
21. Yerra L, Reddy PC. Effects of electromagnetic interference on implanted cardiac devices and their management. *Cardiology in Review*. 2007;15(6): 304-309. https://doi.org/10.1097/CRD.0b013e31813e0ba9.
22. Misiri J, Kusumoto F, Goldschlager N. Electromagnetic interference and implanted cardiac devices: the nonmedical environment (part I). *Clinical Cardiology*. 2012;35(5): 276-280. https://doi.org/10.1002/clc.21998.
23. Erkan AF. Is air travel safe for patients with cardiac implantable electronic devices? *Anatolian Journal of Cardiology*. 2021;25(Suppl 1): S26-S28. https://doi.org/10.5152/AnatolJCardiol.2021.S110.
24. International Air Transport Association (IATA). International Air Transport Association Medical Manual. Montreal, QC: International Air Transport Association; 2020 12th ed.
25. Koh CH. Commercial Air Travel for Passengers With Cardiovascular Disease: Recommendations for Less Common Conditions, Considerations for Venous Thromboembolism, and General Guidance. *Current Problems in Cardiology*. 2021;46(4): 100782. https://doi.org/10.1016/j.cpcardiol.2020.100782.
26. Poredos P, Kozak M, Antignani PL, et al. From varicose veins to venous thromboembolic events. *International Angiology: A Journal of the International Union of Angiology*. 2023;42(3): 254-259. https://doi.org/10.23736/S0392-9590.23.04948-9.
27. Kupchak BR. Exercise and Air-Travel-Induced Alterations in Blood Hemostasis. *Seminars in Thrombosis and Hemostasis*. 2018;44(8): 756-764. https://doi.org/10.1055/s-0038-1670640.
28. Makris M, van Veen JJ, Maclean R. Warfarin anticoagulation reversal: management of the asymptomatic and bleeding patient. *Journal of Thrombosis and Thrombolysis*. 2010;29(2): 171-181. https://doi.org/10.1007/s11239-009-0412-5.
29. Baron TH, Kamath PS, McBane RD. Management of antithrombotic therapy in patients undergoing invasive procedures. *The New England Journal of Medicine*. 2013;368(22): 2113-2124. https://doi.org/10.1056/NEJMra1206531.
30. Olesen LL. Bilateral Pneumothorax Complicating Pacemaker Implantation, due to Puncture of the Left Subclavian Vein and Electrode Perforation of the Right Atrium. *Cureus*. 2020;12(11): e11302. https://doi.org/10.7759/cureus.11302.
31. Tam A, Singh P, Ensor JE, et al. Air travel after biopsy-related pneumothorax: is it safe to fly? *Journal of vascular and interventional radiology : JVIR*. 2011;22(5). https://doi.org/10.1016/j.jvir.2011.01.436.
32. Saunderson C, Hickman S, Wilkinson E, et al. Current Venous Thromboembolism Prevention Practices Following Endovascular Electrophysiological Procedures in the UK: A retrospective study. *Sultan Qaboos University Medical Journal*. 2018;18(3): e374-e378. https://doi.org/10.18295/squmj.2018.18.03.018.
33. Sticherling C, Marin F, Birnie D, et al. Antithrombotic management in patients undergoing electrophysiological procedures: a European Heart Rhythm Association (EHRA) position document endorsed by the ESC Working Group Thrombosis, Heart Rhythm Society (HRS), and Asia Pacific Heart Rhythm Society (APHRS). *Europace*. 2015;17(8): 1197-1214. https://doi.org/10.1093/europace/euv190.