



Arrhythmias Present Pilots With Range of Risks

Some irregular heart rhythms are harmless, but others are associated with loss of consciousness or sudden death. Thorough medical evaluation often is required to determine the severity of a pilot's arrhythmia and whether the ailment might affect the safety of flight operations.

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FSF Editorial Staff

An arrhythmia (also called a dysrhythmia or an irregular heartbeat) is a change in the regular beating of the heart that, in most people, presents no risk. In some people, however, the arrhythmia may be associated with heart disease or may constitute a serious health problem that can result in loss of consciousness or death.

For pilots, arrhythmias typically require further evaluation by medical specialists to determine whether the condition prohibits medical certification.

The International Civil Aviation Organization (ICAO) *Manual of Civil Aviation Medicine* says that medical certification generally should not be granted if a pilot's arrhythmia is a result of heart disease, if recurrence of the arrhythmia cannot be predicted or if other elements of the pilot's condition could present a risk to safe flight operations.¹

Annette Ruge, M.D., Ph.D., medical coordinator for the European Joint Aviation Authorities (JAA), said that JAA is reviewing its requirements for the evaluation of pilots with arrhythmias and that those requirements may be changed in late 2003 or early 2004. Current requirements are that all but



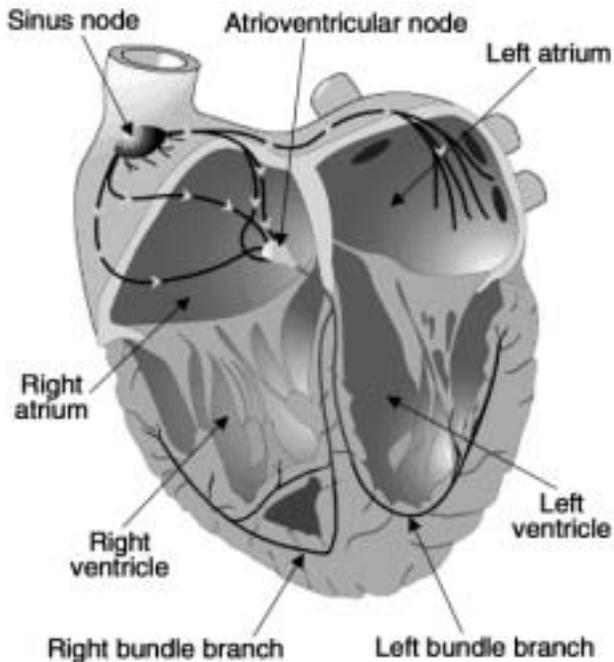
the most minor arrhythmias require further medical evaluation.²

Warren Silberman, D.O., M.P.H., manager of the U.S. Federal Aviation Administration (FAA) Civil Aerospace Medical Institute Aerospace Medical Certification Division, said that arrhythmias are "one of the more common things that we deal with." In many cases, after medical authorities are satisfied that the arrhythmia does not present a risk to the pilot's safe operation of an aircraft, he or she is issued a medical certificate; in cases involving more serious arrhythmias, medical certification is denied.³

Electrical Impulses Determine Heart Rate and Rhythm

The heart is a muscular pump, divided into four chambers (Figure 1, page 2). The two upper chambers are the left atrium and the right atrium; the two lower chambers are the left ventricle and the right ventricle. The right atrium contains the heart's sinus node (sinoatrial node), a natural pacemaker that

Heart's Electrical-conduction System



Source: Stanley R. Mohler, M.D.

Figure 1

transmits an electrical impulse through the heart, causing it to contract (beat).

For the heart to pump blood properly, the electrical impulse must follow a path that begins in the right atrium and spreads through the atria to the atrioventricular node, an area between the atria that connects to fibers that carry the impulse to the ventricles. The impulse causes the heart to contract — the atria contract first, pumping blood to the ventricles. When the ventricles contract a fraction of a second later, blood is pumped out of the heart. Normally, when the electrical impulse is transmitted properly, these contractions occur about 60 times to 100 times per minute in a person at rest (more often during periods of exercise, pain or anger), and the heart beats at a regular rate. (Aerobically trained athletes, however, may have normal resting heart rates below 50 beats per minute; resting heart rates of more than 90 beats per minute are unlikely in healthy adults.)

If the impulse is not transmitted properly, however, an arrhythmia may result. There are many types of arrhythmias; they occur when the heartbeat is inappropriately fast or more than 100 beats per minute (tachycardia), inappropriately slow or less than 60 beats per minute (bradycardia), or when the electrical impulse travels on an abnormal path and the heartbeat is irregular.^{4,5}

Irregular heartbeats often are either premature heartbeats, which occur when the regular beating of the heart is interrupted

by an early beat, or fibrillations, which occur when a chamber of the heart experiences a spasm and does not pump.

Arrhythmias are identified according to the part of the heart in which they originate and the effect they produce on the heart rhythm (see “Arrhythmias Classified According to Location, Effect,” page 4). For example, in atrial fibrillation — the most common type of arrhythmia — the atria undergo rapid, uncoordinated contractions. (The ICAO *Manual of Civil Aviation Medicine* says that atrial fibrillation “may cause pilot incapacitation” and that pilots with atrial fibrillation often should be denied medical certification; some pilots who have experienced single episodes of atrial fibrillation, however, “may be considered for restricted flight crew duties, subject to [further evaluation].”) In ventricular tachycardia, an accelerated heart rate begins in the ventricles. (ICAO says that pilots with this condition, which typically is associated with heart disease, usually “are medically unfit for licensing.”)⁶

Heart Disease Is Most Common Cause of Arrhythmia

The causes of arrhythmias sometimes are not apparent. Most are a result of heart disease, especially coronary artery disease (in which the flow of blood through the arteries is obstructed by an accumulation of fatty deposits on the artery walls), heart failure (in which the heart fails to pump enough blood to satisfy the body’s requirements) and heart-valve function (in which the heart valves either leak or fail to open fully).⁷

Arrhythmias also can be caused by some diseases and medications. For example, hypothyroidism (low thyroid activity) and some blood-pressure medications are among the causes of bradycardias. Tachycardias can result from use of medications such as decongestants, diet pills and thyroid medication; exercise; and diseases such as adrenal tumors, hyperthyroidism (elevated thyroid activity), lung disease, imbalances in blood electrolytes, dehydration and anemia.

Minor arrhythmias can result from stress or excessive consumption of alcohol or tobacco.

Also among the risk factors for arrhythmia are advancing age; a family history of heart disease; a high-fat, high-cholesterol diet; and obesity.

Symptoms Include Palpitations, Chest Pain

People with arrhythmia may experience a number of symptoms — or they may have no symptoms. The most frequent symptoms include the following:⁸

- Palpitations can be felt as a pounding or racing of the heart or a fluttering sensation in the chest. Sometimes, the heart

seems to skip a beat. (In reality, this is an extra heartbeat that comes earlier than normal.) The sensation may be over in seconds or may continue for several minutes or hours;

- Lightheadedness may occur as a result of the reduction in blood supplied to the brain as a result of a heart rate that is too fast or too slow. If the abnormal heart rate persists for longer than six seconds, loss of consciousness may occur;
- Chest pains may result from tachycardias. The increased beating of the heart causes an increase in the heart's oxygen requirements; when the increased oxygen cannot be provided, chest pains occur;
- Shortness of breath sometimes is a symptom of a rapid heart rate that hinders the ability of the heart to fill with blood and results in a back-up of blood into the lungs; and,
- Fatigue — although usually associated with a cause unrelated to the heart — sometimes is a symptom of arrhythmia. A heart rate that is either too slow or too fast can cause tiredness.

ECG Aids in Diagnosis

Diagnosis of an arrhythmia usually requires an electrocardiogram (ECG; also known as EKG) to measure the electrical current that travels through the heart when the heart beats and to provide information needed to analyze the heart's rhythm and rate. To administer an ECG, small patches containing metal contacts (electrodes) are placed on the skin to measure the electric currents emitted by the heart; the information is recorded on paper or in a computer.

The record shows three major waves of electrical impulses: the P wave, which measures the electrical activity of the atria; the QRS wave, which measures the electrical activity of the ventricles; and the T wave, which measures the heart's electrical repolarization and its return to the resting state. The shape and size of the waves and the time between the waves can be analyzed for information about how long electrical impulses take to travel through the atria, the atrioventricular conduction system and the ventricles.⁹

In addition to identifying abnormal heart rhythms, ECGs can help identify inadequate blood supply to the heart, thickening of heart muscle (sometimes a result of high blood pressure) and a thinning or absence of heart muscle (often a result of a heart attack). ECGs are either "resting" ECGs, conducted while the person is lying down, or "exercise" ECGs, conducted while the person pedals a stationary bicycle or walks on a treadmill. The results of exercise ECGs can show whether exercise causes an arrhythmia or makes it worse and whether blood flow to the heart may be inadequate.

Other diagnostic tests include a 24-hour ECG documented by a portable ECG recorder (Holter monitor). Electrodes are placed on the patient's chest, with the electrode wires connected to the battery-powered recorder. The monitor operates while the patient continues his or her normal activities. Afterward, the data collected by the portable ECG are analyzed using computer software that identifies abnormalities in the heart's rhythm and helps determine whether the abnormalities are a result of the patient's activity level.

For monitoring arrhythmias that occur less often than once a day, the patient wears a portable ECG "event monitor." After the patient feels an arrhythmia, he or she transmits the ECG by telephone to specialists who analyze the resulting data.

Other diagnostic tools also may be used, including the following:^{10,11}

- Echocardiography uses sound waves to observe the size, structure and motion of the heart;
- Electrophysiologic testing can be used to collect information on infrequent arrhythmias or suspected arrhythmias. After a local anesthetic is administered, temporary electrode catheters are placed in the atria, the ventricles and along the electrical-conduction system to record electrical impulses and determine how they spread with each heartbeat. The process shows where in the system a heart block is located and where tachycardia originates;
- Esophageal electrophysiologic procedures are used to diagnose and/or treat tachycardias. A thin, flexible tube is inserted through a nostril into the esophagus (the tube connecting the mouth and the stomach), where — because of the location near the atria — an ECG recording can provide more precise information than a regular ECG. During the procedure, specialists may use an electrical stimulator to restart an arrhythmia for diagnosis, and they may test different medications to find the most effective one;
- Intracardiac electrophysiologic procedure (cardiac catheterization) involves inserting a thin, flexible tube through a large blood vessel in the legs or arms into the heart to record the heart's electrical impulses. This procedure can provide more precise information than a regular ECG;
- Radionuclide ventriculography (first-pass technique or multiple-gated acquisition scanning) is a nuclear-medicine test to measure the heart's pumping ability. The test involves the injection of a radioactive isotope into a vein. Cameras or other equipment are used to observe the radioactive isotope as it travels through the heart; and,¹²

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Arrhythmias Classified According to Location, Effect

Different types of arrhythmias are identified according to the part of the heart where they originate and the effect that they have on the heart's rhythm.^{1,2,3}

Types of arrhythmias originating in the atria include the following:

- Atrial fibrillation occurs when muscles of the atria emit uncoordinated electrical impulses. The atria attempt to pump too fast (about five times to seven times faster than normal) and unevenly and do not contract completely. Because not all of the atria's electrical impulses affect the ventricles, the ventricles continue to pump blood, but the ventricular rate may be uneven. Atrial fibrillation can be associated with various arrhythmias, congestive heart failure and stroke; people with atrial fibrillation are about five times more likely to suffer strokes than people without atrial fibrillation. Atrial fibrillation is the most common of all serious arrhythmias;
- Atrial flutter occurs when rapid electrical impulses cause the atria to contract quickly, as many as 200 contractions to 320 contractions per minute. The result is a fast heartbeat;
- Premature atrial contraction occurs when premature heartbeats or extra heartbeats cause irregularity in heart rhythms. Premature atrial contraction produces the sensation that the heart has skipped a beat; in reality, there is no skipped beat but rather an extra beat that comes earlier than normal. Most people have premature heartbeats at some time in their lives. Usually no treatment is required, and the premature beats may eventually cease. Sometimes, because premature heartbeats can be a result of illness or injury, further medical evaluation may be required;
- Sick sinus syndrome occurs when the sinus node (the primary pacemaker, located in the upper right atrium) does not send electrical impulses properly and the heart rate slows. In some cases, the heart rate may be alternately too slow and too fast;
- Sinus arrhythmia occurs when the heart rate slows when an individual inhales and speeds up when the individual exhales. Sinus arrhythmia is normal;
- Sinus tachycardia occurs when the sinus node transmits signals faster than usual and the heart rate increases (above 100 beats per minute). This arrhythmia can accompany fever, excitement and exercise; in these cases, treatment is not required. Rarely, diseases such as anemia (low blood count) or hyperthyroidism (increased thyroid activity) cause sinus tachycardia; in these cases, treatment of the disease eliminates the arrhythmia;

- Supraventricular tachycardia (also called paroxysmal atrial tachycardia or paroxysmal supraventricular tachycardia) occurs when a series of early beats in the atria cause the heart rate to increase (to 160 beats to 190 beats per minute). Treatment often is not required; and,
- Wolff-Parkinson-White syndrome occurs when the pathways between the atria and the ventricles are abnormal, and as a result, the electrical impulse arrives too soon to the ventricles. The result can be bursts of accelerated heart rates.

Types of arrhythmias originating in the ventricles include the following:

- Premature ventricular contraction occurs when a premature contraction or extra contractions result in irregular heart rhythms. In this type of arrhythmia, the premature contractions begin in the ventricles, and, as with premature atrial contraction, premature ventricular contraction produces the sensation that the heart has skipped a beat. Usually no treatment is required, and the premature beats may eventually cease. Sometimes, because premature heartbeats can be a result of illness or injury; further medical evaluation may be required;
- Ventricular fibrillation occurs when disorganized electrical impulses within the ventricular muscle result in rapid and uncoordinated contraction of the ventricles, causing the heart to pump little or no blood. Without immediate medical treatment, this arrhythmia can result in collapse and sudden death within four minutes. Treatment includes electric shock to restore normal heart rhythm. Subsequent treatment may include medication or surgical implantation of an electronic defibrillator; and,
- Ventricular tachycardia occurs when an accelerated heart rate begins in the ventricles. This arrhythmia may be a result of heart disease and usually requires prompt treatment in the form of medication, ablation (the nonsurgical elimination of heart tissue or electrical pathways that cause arrhythmia) or surgery.

Other types of arrhythmias include those caused by obstructions of other pathways traveled by the electrical impulses that are generated by the sinus node. These arrhythmias include:

- Adams-Stokes disease occurs when the normal heartbeat between the atria and the ventricles is interrupted, causing a heart block (improper transmission of the electrical impulse from the atria to the ventricles), a decrease in heart rate, an inadequate supply of blood to the brain and fainting;

- Bundle branch block occurs when there is a block in one of the two pathways (the right bundle branch or the left bundle branch) that are followed by electrical impulses as they travel through the heart. The block forces the electrical impulses to follow a longer, alternate path; the slowdown means that the ventricle on that side contracts more slowly than the other ventricle;
- Heart block occurs in the following three forms:
 - First-degree heart block, in which the heart rate and rhythm remain normal, occurs when the electrical impulse moves more slowly than normal through the atrioventricular node;
 - Second-degree heart block occurs when some signals from the atria do not reach the ventricles; and,
 - Third-degree heart block (complete heart block) occurs when none of the electrical impulses from the atria reach the ventricles. This can cause the heart to beat too slowly. In these cases, secondary pacemaker cells in the ventricles deliver electrical impulses to contract the ventricles, but the contractions occur at a slower rate than would be directed by the atrioventricular node; and,

- Long Q-T syndrome is a relatively rare hereditary disorder in the heart's electrical-conduction system in which a longer-than-normal time is required for the electrical system to recharge after each heartbeat. The syndrome, which usually affects children and young adults, can result in a fast abnormal heart rhythm that prevents blood from being pumped out of the heart and can lead to sudden cardiac arrest.♦

— FSF Editorial Staff

Notes

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- Tilt tests may be used to diagnose the cause of recurrent fainting spells. The tests are conducted using tables that can be tilted to specific angles while the patient's heart rhythm and blood pressure are monitored through plastic tubes inserted into the blood vessels.

Civil aviation authorities use several of these diagnostic tests when conducting further evaluation of pilots with arrhythmias. For example, Ruge said that if, during a routine ECG, a pilot is found to have one of the most minor arrhythmias, the aviation medical examiner enters a notation in the pilot's medical records. JAA requirements specify that pilots with most other arrhythmias undergo resting ECGs, exercise ECGs, 24-hour monitoring with a portable ECG and echocardiograms. Some pilots also may require either electrophysiological testing or coronary angiograms (X-rays that can determine the condition of coronary arteries), Ruge said.

Silberman said that FAA requires similar testing for many types of arrhythmias and that, in many cases, after medical authorities are satisfied that the arrhythmia does not present a risk to the pilot's safe operation of an aircraft, he or she is issued a medical certificate.¹³ Medical certification generally is denied in cases involving the more serious arrhythmias, such as most ventricular fibrillations and many ventricular tachycardias; in such serious arrhythmias, decisions on medical certification take into consideration the underlying medical condition that led to the arrhythmia.

Treatments Include Medication, Pacemakers, Surgery

Some mild arrhythmias require no medical treatment, or they can be alleviated if the patient holds his or her breath or slowly drinks water.¹⁴ Other arrhythmias require treatment of an underlying cause, such as heart disease, or treatment of the arrhythmia itself. In some cases, treatment may preclude medical certification for pilots with all classes of medical certificates.

Treatment often includes antiarrhythmic medication to stop the abnormal transmission of electrical impulses, but the specific medication depends on several factors, including the type of arrhythmia, other medications being taken by the patient and the patient's response to the arrhythmia medication. Medications intended to manage arrhythmia can have serious side effects, including the worsening of the existing arrhythmia or the creation of a new arrhythmia. If medication is prescribed, an ECG or some other test often is conducted to monitor its effectiveness. JAA sometimes does not grant medical certification to pilots who use antiarrhythmic medications, Ruge said; FAA generally does grant certification, Silberman said.

Other medications sometimes are prescribed, including anticoagulants to prevent the clotting of blood pooled in the

atria.¹⁵ Ruge said that JAA requirements prevent medical certification of pilots using anticoagulation medications; in many cases, FAA allows medical certification of pilots who use anticoagulants.

Some tachycardias are treated with radiofrequency ablation, in which a thin, flexible tube with an electrode at its tip is inserted into the heart muscle to deliver radiofrequency energy to kill the aberrant heart muscle cells that were transmitting the electrical impulses responsible for the rapid heartbeats.¹⁶ JAA and FAA both generally require a six-month waiting period after ablation before a pilot is re-evaluated for medical certification.

Patients with serious ventricular arrhythmia can be treated with surgical implantation of an automatic defibrillator in the chest. The defibrillator monitors the patient's heart rhythm, identifies serious arrhythmias and delivers an electrical stimulus to prevent fatal arrhythmia. FAA and JAA do not grant medical certification to pilots with implanted automatic defibrillators.

In other cases, when the heart's sinus node is not functioning properly as the natural pacemaker or when one of the pathways for the heart's electrical impulses is blocked, an artificial pacemaker can be implanted. The artificial pacemaker then replaces the sinus node to send the electrical impulses that make the heart beat. Most civil aviation authorities require that medical certification be denied to a pilot who is dependent on a pacemaker.

When other treatments are ineffective, open-heart surgery may be performed to alter or remove the heart tissue that is causing an arrhythmia. One relatively recent surgical approach to treating atrial fibrillation is the Maze procedure, in which an incision is cut in the heart and then sewn together; the incision blocks irregular heartbeats and stops the fibrillation.¹⁷

In emergencies, cardioversion (electrical stimulus) may be administered to restore a normal heart rhythm. Afterward, medication usually is administered to prevent a recurrence of the arrhythmia.

Prevention Measures Include Healthy Diet, Exercise

Because people with heart disease have the greatest risk of developing arrhythmia, medical specialists say that prevention of arrhythmia involves preventing the development of heart problems in general (and receiving proper treatment for existing heart problems).

To eliminate risk factors for heart disease and arrhythmia, medical specialists recommend actions including the following:^{18,19}

- Exercise regularly. Typical recommendations are for 30 minutes of exercise on most days of the week;

- Consume a healthy diet that includes a variety of foods in moderate portions — especially fruits and vegetables, whole grains and low-fat meats — and that limits fats, cholesterol, sugar and salt;
- Maintain a healthy weight;
- Do not smoke, and avoid second-hand smoke;
- Limit consumption of caffeine, alcohol and other substances that may contribute to arrhythmias or heart disease;
- Avoid unnecessary stress and learn to manage stressful situations that are unavoidable; and,
- Schedule regular physical examinations and seek treatment for health problems that may contribute to arrhythmia or heart disease, including elevated blood pressure, elevated cholesterol, diabetes and thyroid disease.

An arrhythmia can be harmless, symptomatic of a serious disease or life-threatening. In pilots, a thorough medical evaluation is necessary to assess the severity of an arrhythmia, develop the best course of treatment and determine the advisability of continued medical certification.♦

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