



## **Undiagnosed Coronary Artery Disease Presents Risks of Incapacitation and Sudden Death**

*For pilots, coronary artery disease is a common cause of medical disqualification. Nevertheless, in many circumstances, pilots who have been treated for the disease — either with medication, surgery or other medical procedures — often regain medical certification and continue their flying careers.*

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*FSF Editorial Staff*

Coronary artery disease<sup>1</sup> occurs when the major arteries that carry blood to the heart are hardened and narrowed by the buildup of plaque (cholesterol deposits and calcium deposits) on their inner walls. As the arteries narrow, the flow of blood — and the oxygen carried by that blood — to the heart is reduced.

The accumulation of plaque can reduce significantly the flow of blood through a coronary artery — a problem that can result in angina (pain in the chest directly related to the restricted blood flow). More serious damage occurs when a plaque ruptures, causing the formation of blood clots that block the flow of blood. If a blockage occurs in a coronary blood vessel, the result is a heart attack, which can lead to the death of the part of the heart that is deprived of blood; if a blockage occurs in an artery that carries blood to the brain, the result is a stroke, which can lead to the death of the portion of the brain that is deprived of blood.

Worldwide, 7.2 million people a year die of coronary artery disease, the most common cause of death in most developed countries.<sup>2,3</sup> The International Task Force for Prevention of Coronary Heart Disease said that, although the incidence of coronary artery disease is decreasing in Australasia, North America and Western Europe, “its incidence has been increasing at an alarming rate in Central [Europe] and Eastern Europe, including many parts of the former Soviet Union” and



the disease is “by no means rare in the developing world.”

The most common symptom of coronary artery disease is angina. Other symptoms may include shortness of breath; pain in one or both arms, the left shoulder, the neck, the jaw or the back; numbness in the arms, shoulders or wrists; or swelling of the feet and ankles. In many cases, however, there are no obvious symptoms, and sometimes, a heart attack is the first indication of the presence of the disease (see “Symptoms of Coronary Artery Disease,” page 2).<sup>4,5</sup>

To some extent, the hardening and narrowing of the coronary arteries — and other arteries throughout the body — occur normally as people age; nevertheless, the condition progresses more rapidly in some people than in others. The process by which the arteries harden and narrow is called atherosclerosis. Atherosclerosis occurs in all parts of the body; when it occurs in the heart, it is called coronary artery disease.

Coronary artery disease is common among the general population as well as among pilots; the International Civil Aviation Organization (ICAO) *Manual of Civil Aviation Medicine* says that the disease “is a common cardiovascular cause of medical disqualification among personnel engaged in aviation duties,” especially those older than age 40 who live in industrialized countries.<sup>6</sup>

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## Symptoms of Coronary Artery Disease

Angina, a pain in the chest that results from a shortage of blood and/or oxygen in the heart, is the most common symptom of coronary artery disease.<sup>1,2,3</sup>

Angina usually involves pain below the sternum (breastbone) that feels like a weight on the chest or a squeezing, suffocating or burning sensation. Pain may radiate to the left shoulder or left arm (or sometimes to the right shoulder or right arm), back, throat, jaw or teeth.

Angina is most likely to occur during exercise or emotional stress, when the heart's need for blood increases, and can be relieved by rest or nitroglycerin, a medication that dilates coronary arteries. Nevertheless, angina also can occur at other times, unrelated to exercise or emotion, and might not be relieved by rest or nitroglycerin.

Angina often is worse in cold weather or when walking against the wind.

Other symptoms of coronary artery disease may include the following:

- Shortness of breath;
- Numbness in the arms, shoulders or wrists; or,
- Swelling of the feet and ankles.

In some cases, coronary artery disease is asymptomatic (has no symptoms). If undetected, the person may not know that he or she has coronary artery disease, until a heart attack occurs. (Heart attacks also can occur without symptoms, and sometimes, heart attacks are detected only when a subsequent electrocardiogram reveals damage to the heart. This is especially true among women, who are more likely than men to experience atypical symptoms that sometimes are not immediately recognized as symptoms of heart attack.<sup>4</sup>)

In addition to being a symptom of coronary artery disease, pain or discomfort in the chest (i.e., pressure, tightness, squeezing, crushing, intense burning or aching) also is the most common warning that a heart attack is in progress. The pain may radiate to the back, shoulder, neck, jaw and/or teeth, arm or wrist. The pain connected with a heart attack usually is more severe and lasts longer than the pain of angina and is not relieved by rest or by the medication that typically is used to treat angina.<sup>5</sup>

Chest pain is not always caused by heart problems. Typically, if pain increases when a finger is pressed against the painful area, the cause could be strained muscles, strained ligaments, a fractured rib or an inflammation of the cartilage in the chest wall. If chest pain worsens with a deep breath or a cough, it could be a result of pleurisy (inflammation of the lung membrane) or pneumonia. A peptic ulcer can cause pain below the breastbone, especially when the stomach is empty; gallstones can cause pain in the right side of the

chest or near the shoulder blade, especially after a meal or at night. Heartburn can cause a burning sensation in the chest, and shingles can cause a sharp, burning or tingling sensation in one side of the chest. A quick pain at the end of a deep breath or a shooting pain of a few seconds' duration usually is not characteristic of a heart attack.<sup>6</sup>

Other frequent symptoms of a heart attack include sweating, shortness of breath, dizziness, nausea or vomiting, unusual weakness and a rapid heartbeat and/or an irregular heartbeat. Someone having a heart attack may experience one or more of these symptoms.

Most heart attacks begin slowly, with mild pain or discomfort, and people often wait too long before seeking help, either because they are unsure of what their symptoms might signal or because they are concerned about embarrassment if their symptoms are found not to be indicators of a heart attack.<sup>7</sup> (Someone experiencing symptoms may find it extremely difficult to determine on their own whether a heart attack is likely in progress.)

Nevertheless, if one or more symptoms occur, immediate medical help is essential to prevent serious damage to the heart or death. Medical specialists say that patients who arrive at a hospital within an hour of experiencing the first symptoms have the best chance of avoiding substantial damage to the heart; within two hours to four hours, they have at least a fair chance of limiting heart damage. After four hours, irreparable damage to the heart is likely.<sup>8</sup>♦

— FSF Editorial Staff

### Notes

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3. Texas Heart Institute. *Coronary Artery Disease*. <[www.tmc.edu/thi/cad.html](http://www.tmc.edu/thi/cad.html)>. May 24, 2004.
4. American Heart Association. *About Women's Heart Health*. <[www.americanheart.org/presenter.jhtml?identifier=3016992](http://www.americanheart.org/presenter.jhtml?identifier=3016992)>. June 7, 2004.
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8. Best, Kenneth. "YNHH [Yale-New Haven Hospital] Patient Stories: Am I Having a Heart Attack?" <[www.ynhh.org/cardiac/stories/attack.html](http://www.ynhh.org/cardiac/stories/attack.html)>. June 7, 2004.

“Studies have clearly indicated that certain personality types, individuals who are time [conscious] and deadline conscious, goal oriented, highly motivated and involved in their activities are significantly more prone to overt coronary artery disease,” ICAO said.

Uncontrolled coronary artery disease can cause sudden incapacitation or death. On rare occasions, the disease has been cited as the probable cause of an accident or as an underlying cause or contributing factor to an accident.

For example, the U.K. Air Accidents Investigation Branch (AAIB) cited the captain’s “abnormal heart condition ... leading to lack of concentration and impaired judgment” as an underlying cause of a June 18, 1972, accident in which a British European Airways (BEA) Hawker Siddeley Trident struck the ground near Staines, England, about 2 1/2 minutes after takeoff from London Heathrow Airport. The airplane was destroyed, and all 118 people in the airplane were killed.<sup>7</sup>

Data from the flight data recorder revealed a “consistent failure” by the handling pilot to fly the airplane at the appropriate airspeed. Data also showed that the droops (retractable leading-edge high-lift devices similar to slats) had been retracted while the airplane was being flown 60 knots slower than the droops-retraction airspeed, that the flight crew failed to determine why the airplane’s stick-pusher system (which automatically pushed the control yoke forward to prevent a stall if the pilot failed to take corrective action) activated, and that the crew disabled the stick-pusher stall-recovery system.

The accident report said that the captain, whose autopsy showed that he had “severe atherosclerosis” in three coronary arteries, likely was distracted throughout the takeoff and initial climb by an increasing amount of pain and that his reasoning ability was “materially affected.” Others on the flight deck probably did not notice the captain’s difficulties, the report said.

The report said that associates had considered the captain “a picture of robust good health,” that his wife and his family physician “had no suspicion that anything was wrong” and that “there was no reason for anyone to suspect that his heart was anything but normal.” Medical specialists who were questioned during the accident investigation disagreed about whether the captain’s coronary artery disease should have been discovered during medical examinations. One physician said that electrocardiograms in November 1970 and November 1971 showed an abnormal heart condition that should have required further medical testing; another physician said he considered both electrocardiograms normal.

## **Coronary Artery Disease May Lead to Heart Attack, Other Ailments**

When coronary artery disease is undetected and/or untreated, the heart is weakened; the result sometimes is a sudden heart

attack. Other problems also may arise, including congestive heart failure, in which the heart fails to pump blood as effectively as it should, and arrhythmia, in which the normal rhythm of the heart is altered (see “Arrhythmias Present Pilots With Range of Risks,” *Human Factors & Aviation Medicine*, May–June 2003).

Medical specialists cite a number of risk factors for coronary artery disease, including obesity, lack of physical activity, elevated stress levels and a family history of cardiovascular disease. (Cardiovascular disease includes a number of diseases of the heart and blood vessels, including coronary artery disease; see “Guidelines for Preventing Coronary Artery Disease, page 4.”)<sup>8</sup> In addition, men are more likely than women to develop coronary artery disease, although the difference decreases with increasing age.

Several other factors can accelerate the progress of atherosclerosis. Those factors include:

- Elevated levels of cholesterol (a waxy substance found among fats in the blood and in all cells throughout the body) and triglycerides (another type of fat found in the blood). Health authorities generally say that total cholesterol levels should be less than 200 milligrams per deciliter (5.17 millimoles per liter) of blood (see “Elevated Cholesterol Levels Present Major Risk for Cardiovascular Disease,” *Human Factors & Aviation Medicine*, May–June 2001);
- Elevated blood pressure (the force of the blood against the walls of the arteries). Authorities worldwide do not agree on the definition of “normal” blood pressure. In the United States, normal blood pressure is considered to be systolic pressure (measured as the heart is beating) of less than 120 millimeters of mercury and diastolic pressure (measured as the heart is relaxing between beats) of less than 80 millimeters of mercury; the ICAO *Manual of Civil Aviation Medicine* says that, worldwide, measurements as high as systolic pressure of 150 millimeters of mercury and diastolic pressure of 90 millimeters of mercury “would appear to be reasonable as normal.”
- Tobacco smoke, which can damage blood vessels and speed the development of atherosclerosis not only in the coronary arteries, which deliver blood to the heart, but also in the aorta (the large blood vessel through which the heart pumps blood to the rest of the body) and the arteries in the legs;<sup>9</sup> and,
- Diabetes mellitus, a disorder in which the level of glucose (sugar) in the blood is higher than normal because the body cannot properly use insulin (a hormone secreted by the pancreas to regulate blood sugar levels). The increased glucose level damages the blood vessels.

Atherosclerosis is not fully understood, but medical researchers are studying complex interactions involving the oxidation

## Guidelines for Preventing Coronary Artery Disease

Medical specialists recommend the following actions to help prevent coronary artery disease:<sup>1,2</sup>

- Don't smoke;
- Eat a low-fat, low-cholesterol, low-sodium diet that includes plenty of fruits and vegetables;
- Exercise regularly;
- Maintain a healthy weight;
- Get regular medical exams, and regular checks of blood pressure and blood cholesterol levels; and,
- Minimize stress.♦

### Notes

1. International Task Force for Prevention of Coronary Heart Disease, with the International Atherosclerosis Society. "Coronary Heart Disease: Reducing the Risk." *Nutrition, Metabolism and Cardiovascular Diseases* Volume 14 (1998): 205–271.
2. Mayo Foundation for Medical Education and Research. *Coronary Artery Disease: Prevention*. <[www.mayoclinic.com](http://www.mayoclinic.com)>. May 24, 2004.

process — in which substances known as oxygen-free radicals are released in the artery lining, where they oxidize (chemically combine with oxygen) low-density lipoprotein (LDL, one form of cholesterol) — and an immune process known as the inflammatory response — in which the body's immune system releases white blood cells that consume the oxidized LDL cholesterol. This converts the LDL cholesterol into foam-like cells that attach to the artery walls and eventually change into hard plaque — a process that inflicts additional injury to the arteries and stimulates the immune system's release of a substance that attracts more white blood cells.<sup>10</sup>

Physicians use one or more of a number of diagnostic tools to determine whether someone has coronary artery disease. Traditionally, a physician begins with an interview of the patient, including questions about family history of cardiovascular disease, the patient's medical history and the patient's habits concerning exercise, diet, consumption of alcoholic beverages and use of tobacco. Blood tests, including tests to check cholesterol levels, triglyceride levels and sugar levels, also may be conducted. Chest X-rays may be reviewed.

In addition, common tests for evaluating the condition of the heart and/or coronary arteries include:<sup>11,12</sup>

- Electrocardiogram (ECG or EKG), which measures the rate and regularity of the heartbeat. Several wires are attached

to the chest, arms and legs to record electrical impulses from the heart. The results are available in graphic form. There usually are no risks associated with the procedure;

- Echocardiogram, which uses sound waves to create a picture of the heart with more detail than is available in a chest X-ray. There usually are no risks associated with the procedure;
- Exercise stress test, which evaluates how well the heart pumps blood during exercise, when it requires more oxygen. ECG readings and blood-pressure readings are taken before, during and after an exercise session on a treadmill or a stationary bicycle, or after receiving medicine to make the heart beat faster. In some cases, patients have experienced arrhythmias or other heart disturbances while undergoing the test;
- Cardiac catheterization, which measures blood pressure and blood flow within the heart, aids in evaluating how much oxygen is in the blood and determines whether a blood vessel is blocked. In this test, a physician inserts a thin, flexible plastic tube (catheter) into an artery at the top of the leg or in the arm and advances the tube into the coronary arteries or the chambers of the heart. The risk of serious complications is from one in 1,000 to one in 500; risks may include arrhythmia, damage to the blood vessels, hemorrhage, stroke and heart attack;
- Coronary angiography, which usually is performed with cardiac catheterization and has similar risks, involves injection of dye into the coronary arteries so that a physician can use an X-ray screen to evaluate the flow of blood through the heart.
- Nuclear heart scan (nuclear stress test), which uses radioactive substances called tracers to allow a physician to observe on a monitor the outline of the chambers of the heart and major blood vessels. The monitor also shows any damage to the heart muscle. The procedure involves little risk of complications, although staff members of the facility administering the test may be at risk because of frequent exposure to the radioactive substances; and,
- Positron emission tomography (position emission tomography; PET), which is similar to a nuclear heart scan but uses a different type of tracer to develop the image of the heart and blood vessels. Radiation risks are similar to those involving the use of X-rays; rarely, a person undergoing the test experiences an adverse reaction to the material in the tracer.

## Test Detects Calcium in Arteries

In recent years, high-speed computed tomography (a category including two procedures — electron beam computed tomography [EBCT] or helical ultrafast computed tomography)



has been used to detect calcium deposits in coronary arteries. (The calcium deposits are a result of the body's attempt to protect against irritants in the arteries — not a result of calcium in the diet or in supplements.) In some areas, these procedures have become readily available, often without a cardiologist's referral, as tools for assessing a person's risk of coronary artery disease.

EBCT and helical ultrafast computed tomography are similar procedures (although an EBCT scan requires about 100 milliseconds and a helical ultrafast computed tomography scan requires between 0.5 second and one second).<sup>13</sup> For a scan using EBCT, electrodes are placed on the chest to monitor the heartbeat while a scanner collects information to develop an image of the heart and coronary arteries. The process requires about 15 minutes; afterward, computer software is used to develop a three-dimensional image of the heart that shows the coronary arteries and any arterial calcium deposits detected by the scan. Information from the three-dimensional image is used to develop a coronary artery calcium "score" that indicates the severity of calcification.

James Ehrlich, M.D., medical director of Heart Check Washington, D.C., and EBCT centers in other U.S. cities, said that EBCT scans can evaluate a person's risk of developing coronary artery disease more accurately than traditional tests for the disease.<sup>14</sup>

"Our ability to detect which pilots, and which individuals generally, are at high risk for heart attack is very poor using the routine, office-based visit, and visiting a physician alone is not enough to figure out who's at high risk," Ehrlich said. "Many people who are now in coronary care units ... would have had an unimpressive amount of risk factors, their cholesterol would not have been remarkable, and they would have passed their stress test a week before their catastrophic event."

He said that by measuring the accumulation of calcium in the coronary arteries, EBCT scans can identify individuals most at risk of coronary artery disease.

Nevertheless, aeromedical specialists and civil aviation authorities often discourage routine use of high-speed computed tomography coronary artery scans that are performed without a cardiologist's referral.

In the United States, for example, the U.S. Federal Aviation Administration (FAA) does not condone the use of EBCT scans, said Warren Silberman, D.O., manager of the FAA Civil Aerospace Medical Institute Aerospace Medical Certification Division.<sup>15</sup>

"Should an airman have this test and it demonstrates *any* calcium, there will be requirements for further testing," Silberman said.

Pilots with first-class medical certificates or second-class medical certificates would be required to undergo an exercise

stress test and nuclear heart scan (maximum Bruce protocol nuclear stress test), Silberman said. Those with third-class medical certificates would be required to undergo an exercise stress test, he said. Pilots would be required to report results of the tests to aviation medical examiners at their next aeromedical exam; if the tests found "significant" amounts of calcium, pilots would be required to report the findings to FAA immediately, he said.

Quay Snyder, M.D., associate aeromedical adviser for the Air Line Pilots Association, International, which represents pilots at 42 airlines in the United States and Canada, said that the ALPA aeromedical office discourages airline pilots from undergoing routine EBCT scans. "I don't think the science is defined enough right now to know how to use the results of that test on a short-term basis," he said.<sup>16</sup>

"The current FAA policy is that if the EBCT test shows any calcification, it is disqualifying for all classes of medical certification until and unless the person has a subsequent normal stress test or other type of cardiac testing demonstrating the absence of aeromedically significant coronary artery disease," Snyder said. "From the pilot's perspective, it's a high-threat, low-yield type of screening tool. We counsel our pilots against getting it, unless there's a clinical reason. Alternate testing assessing physiological status, such as exercise stress testing, provides more useful information than the anatomically-based EBCT testing"

Ehrlich said, however, that the calcium score produced by an EBCT scan is "the most powerful predictor of coronary events in the future" and that it can aid in identifying people who require aggressive management of their risk factors. Relatively few pilots have visited his centers "because they're afraid that they may be disqualified for flying," he said.

"But a pilot who looks apparently healthy by any [medical] office visit and who has just passed his treadmill [stress] test could easily have coronary disease that was undetected by all other technologies," he said. "This is a noninvasive way to precisely determine individuals at high risk and also to reassure others that they're at suitably low risk."

He estimated that EBCT scans probably would reveal that less than 1 percent of pilots should temporarily lose medical certification because of severe coronary artery disease — "they're at such high risk that they should get an angioplasty [a procedure to open severely narrowed arteries], and then they'll be safe to fly."

## **Treatments Include Lifestyle Changes, Medication, Surgery**

Treatment of coronary artery disease varies, depending on symptoms and on how much the disease has progressed.

Some people can control their coronary artery disease through lifestyle changes such as adopting a low-fat, low-cholesterol diet; exercising regularly; and quitting smoking.

Other people with coronary artery disease may require medication. The following are among the most common medications used in treating coronary artery disease:<sup>17,18</sup>

- Medications to reduce the level of cholesterol in the blood. Side effects may include digestive disturbances, muscle pain or joint pain, fatigue, headache, skin rash or arrhythmia;
- Blood thinners (anti-platelet agents), including aspirin, to reduce the risk of blood clots. The most common side effects may include digestive disturbances; less frequently, side effects may include coughing up blood, skin rash, sore throat, more frequent bruising, headache or shortness of breath;
- Beta blockers to slow the heart rate and decrease blood pressure, thus reducing the heart's need for oxygen. The most common side effects may include fatigue, cold hands and feet, weakness, dizziness and dryness of the mouth, eyes and skin; less frequently, side effects may include shortness of breath or difficulty breathing, slow heartbeat, difficulty sleeping, swelling of the hands and feet, digestive disturbances, pain in the back or the joints, skin rash, depression, memory problems, or impotence;
- Nitrates, such as nitroglycerin, to dilate the coronary arteries, improve the supply of blood to the heart and control chest pain. The most common side effects may include dizziness, headache, flushed skin, vomiting or upset stomach, low blood pressure or arrhythmia; less frequently, side effects may include fainting, dryness of the mouth, skin rash or blurred vision;
- Calcium-channel blockers to relax the muscles surrounding the coronary arteries, dilate the arteries and increase blood flow to the heart. These medications also are prescribed to control high blood pressure (hypertension). The most common side effect is a dry cough; less frequently, side effects may include digestive disturbances; headache; fatigue; dizziness; fever; pain in the joints; numbness or tingling in the hands or feet; fever; chills; swelling of the face, mouth, hands or feet; or difficulty breathing or swallowing.
- Angiotensin-converting enzyme (ACE) inhibitors to allow the blood to flow more easily from the heart, thus decreasing the heart's workload. ACE inhibitors frequently are prescribed for congestive heart failure, a complication of coronary artery disease. The most common side effects may include feeling tired, flushed skin, heartburn or swelling of the abdomen, ankles or feet; less frequently, side effects may include a very fast heartbeat or very slow heartbeat, shortness of breath, dizziness, numbness or tingling in the hands or feet, digestive disturbances, headache, fainting, chest pain, fever, skin rash or bleeding gums.

- Diuretics, which help reduce blood pressure by reducing the amount of sodium and water in the body, which helps lower blood pressure. For some people, diuretics — which are less expensive than most blood pressure medications — may be more effective in lowering blood pressure and may have fewer side effects. Use of diuretics, however, may result in an increase in cholesterol; therefore, diuretic use must be monitored. Other side effects may include decreased levels of potassium in the blood, which sometimes can result in arrhythmia, and dehydration (excess loss of fluid);<sup>19</sup> and,
- Other medications to reduce high blood pressure.

In some cases, medical procedures are used in addition to — or instead of — medication.

A category of procedures known as percutaneous coronary interventions (also called transcatheter interventions, or nonsurgical treatments to remove blockages in coronary arteries) includes the following:<sup>20,21</sup>

- Coronary angioplasty involves the insertion of a long, thin tube called a catheter with a small balloon on its tip into an artery in the groin or the arm. The catheter is guided toward the narrowed portion of a coronary artery, where the balloon is inflated to widen the coronary artery and improve the flow of blood. Risks include breathing problems or reactions to medication, which are risks in any procedure involving anesthesia; bleeding or infection, which are risks in any surgery; damage to a heart valve or blood vessel; stroke; arrhythmia; bleeding at the catheter access site; and kidney failure. Rarely, death can occur;
- Coronary stenting, which sometimes is performed along with angioplasty, involves using a catheter to place a small wire tube called a stent in the narrowed portion of a coronary artery to keep the coronary artery open. Risks are similar to those of coronary angioplasty;
- Coronary atherectomy (directional coronary atherectomy), which sometimes is used instead of angioplasty, involves placing a small high-speed drill on the tip of a catheter. The drill is used to remove plaque from the walls of the artery. Risks are similar to those of cardiac catheterization, although the risk of heart attack is greater; other risks include injury to an artery and bleeding around the heart;<sup>22</sup>
- Laser ablation (ablative laser-assisted angioplasty) involves placing a metal laser probe or fiber optic laser probe on the tip of a catheter and using the laser probe to remove plaque from the artery walls. After the procedure has opened the artery, angioplasty is performed; and,
- Percutaneous transmyocardial revascularization (PTMR) involves insertion of a catheter into an artery in the leg.

A laser at the tip of the catheter is used to make small holes in the heart to allow blood to flow into oxygen-deprived portions of the heart. Some specialists believe that this procedure encourages the growth of new blood vessels and reduces angina pain. The procedure usually is performed on people who have not responded well to other treatments.

Surgical procedures are used to treat coronary artery disease, usually after angioplasty has failed to widen the arteries sufficiently or when the artery has become so narrow that angioplasty is unlikely to be effective. Types of surgery include the following:

- Coronary artery bypass surgery is open-heart surgery in which an alternate route is created for blood to flow around a severely narrowed portion of a coronary artery. After the patient is anesthetized, a surgeon separates the breastbone and grafts a blood vessel that has been removed from another part of the body, usually a leg or the chest, onto the narrowed coronary artery so that the blood can bypass the narrowed portion of the artery. During the surgery, the heart is stopped and the patient's body is connected to a heart-lung machine, which oxygenates the blood and circulates it through the body. When the procedure is complete, the surgeon uses wire to reconnect the breastbone. Risks may include, heart attack or stroke, each of which occur in about 5 percent of coronary artery bypass surgeries; blood clots; heavy bleeding; memory loss; and post-surgery fever and chest pain. Death occurs among 1 percent to 2 percent of surgical patients; and,
- Minimally invasive coronary artery bypass refers to several surgical procedures that are less invasive than bypass surgery and that do not rely on use of the heart-lung machine, which has been associated with increased risk of stroke, lung problems, kidney problems and memory problems. Nevertheless, stress placed on the heart during the procedures may result in heart damage, arrhythmia or brain injury. The minimally invasive procedures can be used only in cases in which a large incision is not required and only on patients with a low risk of complications. One relatively new procedure, transmyocardial laser revascularization, uses a carbon dioxide laser to create between 20 channels and 40 channels — each about as wide as the head of a pin — in the left ventricle (the left lower chamber of the heart) to improve blood flow.

Researchers are examining other new treatments, including radiation (brachytherapy) following coronary angioplasty. They want to know if new blockages could be prevented if the narrowed arteries were treated with radiation at the same time angioplasty is performed. Researchers also are examining gene therapy to determine if an injection into the heart could be used to deliver genes to produce proteins that would stimulate the growth of new blood vessels.

Coronary artery disease is a common cause of medical disqualification of pilots. Nevertheless, treatment of the condition with medication, coronary bypass surgery or other medical procedures such as angioplasty often enables pilots to regain medical certification and continue their flying careers. ♦

## Notes

1. Other terms used to describe coronary artery disease include coronary heart disease, heart disease and ischemic heart disease.
2. United Nations World Health Organization (WHO). *Cardiovascular Disease: Prevention and Control*. <[www.who.int/dietphysicalactivity/publications/facts/cvd/en](http://www.who.int/dietphysicalactivity/publications/facts/cvd/en)>. May 4, 2004.
3. The International Task Force for Prevention of Coronary Heart Disease, with the International Atherosclerosis Society. "Coronary Heart Disease: Reducing the Risk." *Nutrition, Metabolism and Cardiovascular Diseases* Volume 14 (1998): 205–271.
4. U.S. National Library of Medicine; U.S. National Institutes of Health (NLM). *Medline Plus: Coronary Heart Disease*. <[www.nlm.nih.gov/medlineplus/ency/article/007115.htm](http://www.nlm.nih.gov/medlineplus/ency/article/007115.htm)>. May 24, 2004.
5. Texas Heart Institute. *Coronary Artery Disease*. <[www.tmc.edu/thi/cad.html](http://www.tmc.edu/thi/cad.html)>. May 24, 2004.
6. International Civil Aviation Organization (ICAO). *Manual of Civil Aviation Medicine*. Part III, Chapter 1: "Cardiovascular System." Second edition, 1985.
7. U.K. Air Accidents Investigation Branch (AAIB). *Report of the Public Inquiry Into the Causes and Circumstances of the Accident Near Staines on 18 June 1972*. Aircraft Accident Report No. 4/73. AAIB. The report said that the immediate causes of the accident were the following:
  - "A failure by ... [the captain] to achieve and maintain adequate speed after noise-abatement procedures;
  - "Retraction of the droops [leading-edge high-lift devices similar to slats] at some 60 knots below the proper speed, causing the aircraft to enter the stall regime and the stick-shaker and pusher to operate;
  - "Failure by the crew to monitor the speed errors and to observe the movement of the droop lever;
  - "Failure by the crew to diagnose the reason for the stick-pusher operation and the concomitant warnings; [and,]
  - "The dumping by the crew of the stall-recovery system."

The report cited the following underlying causes:

- "The abnormal heart condition of [the captain], leading to lack of concentration and impaired judgment sufficient to account for his toleration of the speed errors and to his retraction of, or order to retract, the droops in mistake for the flaps;
- "Some distraction, the nature of which is uncertain, possibly due to the presence of [an off-duty captain seated in the jump seat], which caused [a second officer's] attention to wander from his monitoring duties;
- "Lack of training directed at the possibility of subtle pilot incapacitation;
- "Lack of experience in [another second officer];

- “Lack of knowledge in the crew of the possibility or implications of a change-of-configuration stall;
  - “Lack of knowledge on the part of the crew that a stick-shake and push might be experienced almost simultaneously and of the probable cause of such an event; and,
  - “Lack of any mechanism to prevent retraction of the droops at too low a speed after flap-retraction.”
8. Coronary artery disease is the most common form of cardiovascular disease; other forms of cardiovascular disease include arrhythmia, cardiomyopathy (abnormal functioning of the heart muscle), congestive heart failure, heart attack, peripheral vascular disease (narrowing or blockage of blood vessels in parts of the body other than around the heart or the brain), stroke and valve disease (improper functioning of the heart valves).
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