



Blood Clotting Presents Serious Medical Problems for Passengers and Crews, Especially on Long Flights

Blood clotting has resulted in fatalities after blood stagnated in the lower legs during long periods of sitting without physical activity.

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Any person who sits still for a long time may develop small clumps of clotted (congested) blood in the lower legs. Individuals in theater audiences, passengers in — and drivers of — automobiles, trucks, buses, etc., and even those who sit at desks may be at risk. Coach-class airline travelers are vulnerable because densely spaced seating and narrow aisles make it difficult to get up and move around.¹

Clotting of blood in the lower legs is known medically as deep venous thrombosis (DVT); it is also referred to as “economy-class syndrome,” a term introduced in 1977 by Symington and Stack.²

The general symptoms of a blood clot are pain, swelling, redness, warmth and sometimes, fever. The swelling in the leg usually includes everything below the clot. Airplane trips as short as three hours can induce DVT, but DVT can be present with no apparent symptoms.

According to a clinical study, DVT of the lower extremity is a serious disorder; the estimated incidence is one per 1,000 persons per year.³ As many as 600,000 persons with this condition may be hospitalized each year in the United States.⁴

DVT begins with the collection of stagnant pooled blood in the deep leg veins (Figure 1, page 2, and “Veins and Valves of the Leg,” page 3). During a period of only a few hours, if the legs are not exercised, blood clots can form. As the clots grow,



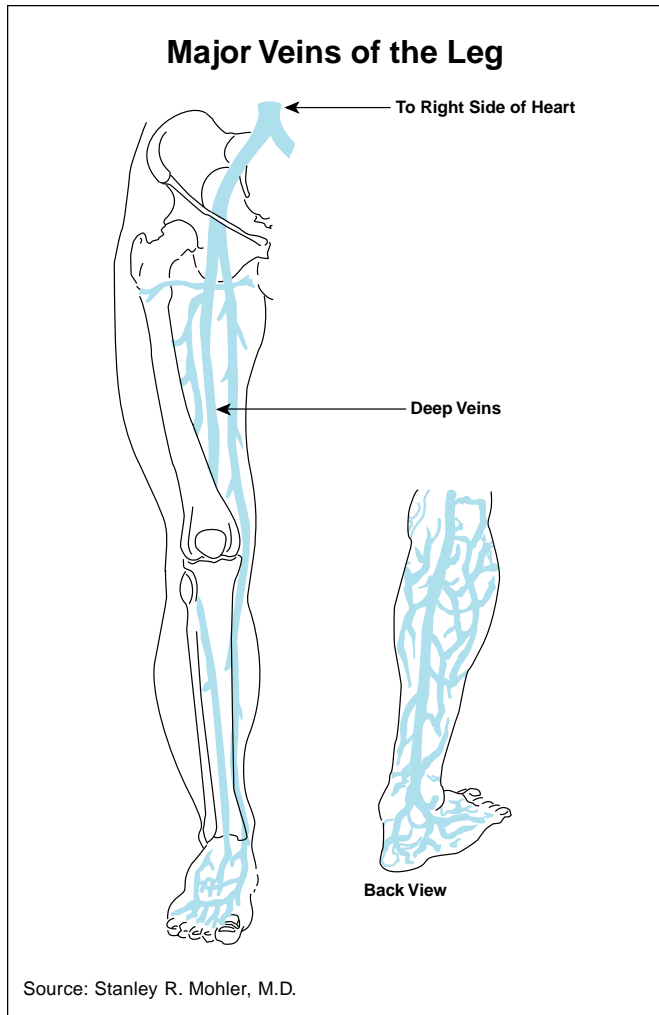
they tend to shed pieces (emboli) that are carried through the bloodstream to the right side of the heart. From there, they can be pushed into the lungs. This process is known as embolization.

Stagnation of body fluids (including blood) in the lower limbs while seated is a relatively common occurrence.⁵ A frequent symptom is swollen ankles, with difficulty in putting shoes back on. If the stagnation lasts long enough to create small blood clots, the clots usually dissolve before they can do any harm. If bigger clots have formed, and clot fragments have broken off, mild chest discomfort or coughing may occur, caused by the presence of

clot fragments in the lungs.

Longer periods of sitting can produce larger clots and more severe results, including death. A clot in a major leg vein can measure several inches. If a relatively big embolus were to reach the heart and lungs, death could result. Persons in whom large clots have entered the lungs often experience severe chest pain and shortness of breath. These persons often seek a physician, who is likely to be concerned about a possible acute heart attack. Because these occurrences can come some days after a long flight, an association between the flight and the medical event may not be evident.

Normal blood contains both blood-clotting and clot-dissolving mechanisms in a delicate balance. The clotting factors keep a



Source: Stanley R. Mohler, M.D.

Figure 1

person from bleeding to death when the skin is broken. If there is an inherited defect in this coagulation mechanism, as is the case in hemophilia, a simple cut can result in serious blood loss; a larger cut can be life threatening. On the other hand, if the clot-dissolving factors become overwhelmed, an artery or a vein can become plugged with a growing clot. The result can be a stroke, a coronary artery occlusion or a major circulation problem in other parts of the body. (See “What Makes Blood Clot,” right.)

Some persons may be especially at risk. In a study of long-distance passengers arriving at Heathrow Airport, London, England, 11 sudden deaths were attributed to DVT during a three-year period. The victims tended to be women over 40 years old with a history of DVT.⁶ Tall persons, with their greater vein lengths, are generally more susceptible to blood stagnation in the lower limbs.¹ (Physical factors that contribute to the risk of DVT are shown on page 3 in “Risk Factors for DVT.”)

The first reports on DVT appeared in the 1940s among Londoners who were forced to sit for many hours in air raid shelters. The earliest report of a flight-related leg vein problem was published in 1954.¹ In this report, a physician described flying from Boston

(Massachusetts, U.S.) to Venezuela in two flight segments of approximately six hours each. He subsequently developed DVT.

Another case involved a 61-year-old aviation executive who flew coach class from Rochester, Minnesota, U.S., to his home in Oklahoma City, Oklahoma, U.S., six weeks after having had surgery on his left knee at the Mayo Clinic. During the flight, a swelling began to develop in his left leg. He felt no calf or chest pain. The day after he arrived home, the swelling became worse, involving his entire leg, and he went to see his physician.

Tests showed that large blood clots had formed in the man’s major leg veins, in some cases completely blocking the flow of blood. He was hospitalized and treated with anticoagulant drugs. After two weeks, the swelling subsided and he was discharged from the hospital. As a safeguard, he continued to take oral anticoagulant drugs.¹

A more highly publicized case involved former U.S. Vice President Dan Quayle who, in November 1994, developed a blood clot in his leg following a series of airplane flights.⁷ Parts of the clot broke away and migrated to both of his lungs. Quayle, then 47 years old, complained of breathlessness and was diagnosed with “walking pneumonia.” The following day, his condition worsened, and he was admitted to the hospital. After further tests, doctors rediagnosed his condition as a pulmonary embolism, which can be fatal. Quayle was given a course of anticoagulants — “blood thinners”— and was released from the hospital after eight days. He was able to resume normal activities after a cautionary period of four months. During his vice presidency, Quayle had suffered from a mild case of phlebitis, a venous inflammation occurring in his legs.

In another case, a fit, nonsmoking physician who exercised regularly and who had no history of cardiovascular (involving the heart and blood vessels) disease made several flights in a four-week lecture tour of the Far East. He usually sat in an inside

What Makes Blood Clot?

Blood clotting is a complex process involving some 10 clotting factors that begins when a blood vessel is cut or damaged. How the factors interact is not fully understood, but the final result of the clotting process is the conversion of fibrinogen molecules, which circulate in the blood, to fibrin, a tough protein network that traps the blood cells and forms the clot. The clot plugs the injured blood vessel, preventing the loss of blood.

The process that leads to airborne DVT can be subtle; it can result from crossing the legs, naturally poor blood circulation or pressure from the seat cushion against the backs of legs. Passenger immobility completes the conditions in which DVT can develop.

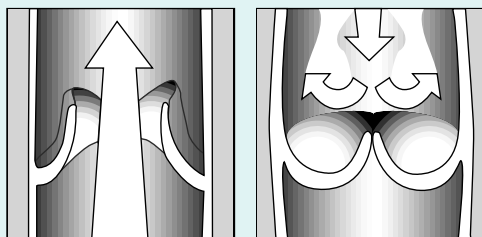
In addition to clotting, the blood has a system that can dissolve blood clots. Its function is the removal of tiny blood clots that form in the small capillaries, as well as removing any blood that has leaked into body tissue and clotted.♦

Source: Aerospace Medical Association

Veins and Valves of the Leg

The leg has two systems of veins: deep and superficial. The superficial veins lie just below the skin; the deep veins travel with the leg muscles. Special veins called perforators connect the two systems in the area of the calf.

The left side of the heart pumps oxygenated blood through the arteries (the blood vessels leading from the heart) to the capillary network in the tissues. The blood is returned from the capillaries through the major veins to the right side of the heart.



During walking or running, the muscles of the foot and calf help push blood upwards toward the heart against the pull of gravity. Special one-way valves, illustrated above, allow the blood to move upward but close behind the moving column of blood to prevent it from falling back down into the leg.♦

Source: Stanley R. Mohler, M.D.
Illustrations: Capital Region Vein Centre

seat. On the final day of the tour he developed a tender, nonswollen left calf, which he attributed to a pulled muscle. The calf tenderness lasted about a week after he returned to his home in the United States. He played tennis, and soon thereafter developed a chest pain that lasted several days.

The physician returned to Japan three weeks later and stayed for two days. The day after he returned, he developed a severe pain in his left chest and left shoulder.

He was diagnosed as having pneumonia and started on antibiotics. When the pain became worse, he was admitted to the hospital. He had a mildly raised temperature, but no shortness of breath, coughing or coughing-up of blood.

Anticoagulant therapy was started and was maintained for three months. The therapy was successful, and there has been no recurrence of the symptoms. He is now fit and well; he takes 150 milligrams of aspirin daily as a precaution; and on long-haul flights he sits in aisle seats, keeps his legs moving, takes numerous walks and keeps well hydrated with nonalcoholic drinks.⁶

DVT has occurred in cockpit crew members as well as passengers. A tall male pilot in his 30s flew a light plane from a central U.S. location to a western destination with a short layover and subsequent return. Some hours after he returned home, he felt chest pain and sought medical attention. He was diagnosed with DVT in the leg veins and given treatment. He was medically recertified upon full recovery.

Risk Factors for DVT

Two studies have identified risk factors for DVT. In the first study,⁸ identified factors included:

- Age greater than 40 years;
- Obesity;
- Malignant disease;
- Immobility;
- Previous occurrences of DVT;
- Varicose veins;
- Recent surgery or injury, especially to the abdomen, pelvis or lower extremities; and,
- The use of oral contraceptives.

In the same study, noninvasive tests of patients showed that:

- Among patients with no risk factors, 11 percent were found to have DVT;
- When three risk factors were present, half of the patients were found to have DVT; and,
- When four or more risk factors were present, all of the patients were found to have DVT.

In a second study, of 355 patients with acute DVT,³ individual risk factors were identified and measured. The patients included both males and females and ranged in age from 29 to 83. The most common site of DVT was the deep veins of the left leg.

The four highest risk factors identified were smoking, varicose veins, family history of DVT and recent surgery. In addition, 15 percent had a suspected pulmonary embolism, a life-threatening situation in which an embolus enters the lung and blocks the flow of blood from the heart.

The following table* shows the percentage of patients in this study with potential risk factors for DVT:

Smoking	34.9%
Varicose veins	24.2%
Family history of DVT	22.0%
Surgery less than three months before study	19.1%
Trauma or fracture	17.5%
Cancer	16.3%
Immobilization longer than seven days	14.6%
Impaired coagulation	13.0%
Use of oral contraceptives	11.2%
Obesity	11.0%
Pregnancy or childbirth	4.3%
High-dose estrogens	2.0%♦

*Because many patients had multiple risk factors, the figures total more than 100%.

A number of actions can be undertaken to prevent DVT.^{1,4,6,8} Passengers should drink adequate fluids. Smoking, which damages the blood vessels, should be avoided. So should alcohol, which is an aggravating factor for DVT. Sitting in an aisle seat is helpful, because it provides greater leg room than an inside seat. Passengers should avoid crossing their legs; they should shift the position of their bodies in their seats from time to time and, when possible, walk in the aircraft aisles; moving blood is less likely to clot.

Passengers can also exercise in their seats. One exercise suggested by British Airways is to bend the feet upward, spread the toes and hold for three seconds; then point the feet down, clench the toes and hold for three seconds.

Aspirin may also help. Blood coagulation is initiated by the clumping action of blood platelets, small disc-shaped structures that are manufactured in the bone marrow. For those who tolerate aspirin, a half tablet taken two days prior to flight and another on the day of flight reduces the tendency of platelets to clump, diminishing the probability of deep vein clots forming.

Cockpit crew members of large aircraft can periodically walk in the cabin. Pilots of smaller planes can do the exercises recommended for passengers.

Clothing is also a factor. Loose-fitting clothes are recommended. Girdles or stockings with tight, below-the-knee elastic bands should be avoided.

Added to this list is a long-term factor — lifestyle. A nonsedentary lifestyle — one that incorporates regular exercise plus maintenance of a lean, physically fit body — helps prevent DVT.

DVT is a recognized hazard of air travel. Education about in-flight DVT is the best preventive measure because knowledge can lead to actions that offset the development of the condition during flight. Preventive measures can include specific advice provided to passengers prior to takeoff, particularly on flights of several hours. ♦

References

1. Sahiar, F.; Mohler, S. "Economy Class Syndrome." *Aviation, Space, and Environmental Medicine* Volume 65 (1994): 957–960.

2. Symington, I.; Stack, B. "Pulmonary Thromboembolism after Travel." *British Journal of the Chest* Volume 71 (1977): 138–40.
3. Prandoni, P., et al. "The Long-Term Clinical Course of Acute Deep Venous Thrombosis." *Annals of Internal Medicine* (July 1996) 125: 1–7.
4. Kakkar, V. "Prevention of Venous Thrombosis and Pulmonary Embolism." *American Journal of Cardiology* Volume 65 (1990): 50C–54C.
5. Rayman, R.B., M.D. Telephone interview by Lofton, Todd. Alexandria, Virginia, U.S. July 15, 1997.
6. Cruickshank, M., et al. "Air Travel and Thrombotic Episodes." *Lancet* Volume 2 (1988): 497.
7. Brown, D. "Quayle Says His Condition Does Not Rule Out a Race." *Washington Post*, Dec. 7, 1994.
8. Silver, D. "An Overview of Venous Thromboembolism Prophylaxis." *American Journal of Surgery* Volume 161 (1991): 537–40.

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