AORTIC STENOSIS AND AORTIC VALVULOPLASTY

What is aortic stenosis?

Aortic stenosis is abnormal narrowing of the aortic valve. A number of conditions cause disease resulting in narrowing of the aortic valve. When the degree of narrowing becomes significant enough to impede the flow of blood from the left ventricle to the arteries, heart problems develop. The basic mechanism is as follows:

The heart is a muscular pump with four chambers and four heart valves.

The upper chambers, the right atrium and left atrium (atria - plural for atrium), are thin walled filling chambers.

Blood flows from the right and left atria across the tricuspid and mitral valves into the lower chambers (right and left ventricles).

The right and left ventricles have thick muscular walls for pumping blood across the pulmonic and aortic valves into the circulation.

Heart valves are thin leaflets of tissue which open and close at the proper time during each heart beat cycle.

The main function of these heart valves is to prevent blood from flowing backwards.

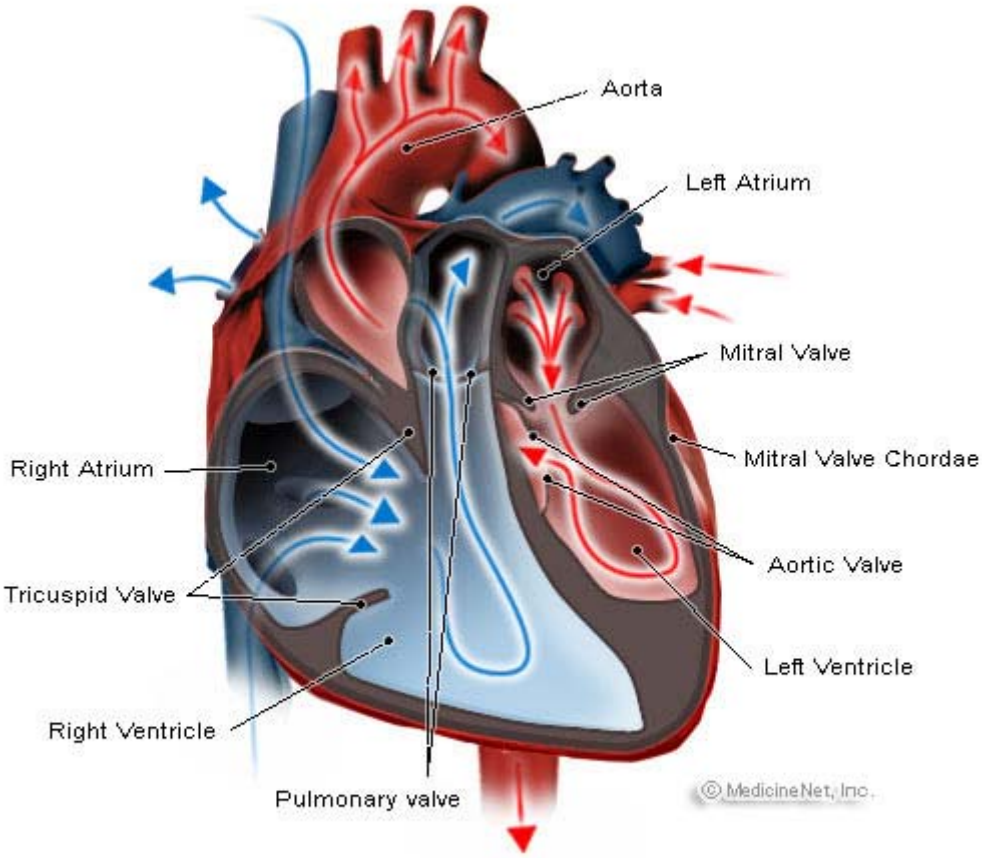
Blood circulates through the arteries to provide oxygen and other nutrients to the body, and then returns with carbon dioxide waste through the veins to the right atrium; when the ventricles relax, blood from the right atrium passes through the tricuspid valve into the right ventricle.

When the ventricles contract, blood from the right ventricle is pumped through the pulmonic valve into the lungs to reload on oxygen and remove carbon dioxide.

The oxygenated blood then returns to the left atrium and passes through the mitral valve into the left ventricle.

Blood is pumped by the left ventricle across the aortic valve into the aorta and the arteries of the body.

The flow of blood to the arteries of the body is impaired when aortic stenosis exists. Ultimately, this can lead to heart failure. Aortic stenosis occurs three times more commonly in men than women.



Heart and Valves

What causes aortic stenosis?

In adults, three conditions are known to cause aortic stenosis.

1. Progressive wear and tear of a bicuspid valve present since birth (congenital).
2. Wear and tear of the aortic valve in the elderly.
3. Scarring of the aortic valve due to rheumatic fever as a child or young adult.

Bicuspid aortic valve is the most common cause of aortic stenosis in patients under age 65. Normal aortic valves have three thin leaflets called cusps. About 2% of people are born with aortic valves that have only two cusps (bicuspid valves). Although bicuspid valves usually do not impede blood flow when the patients are young, they do not open as widely as normal valves with three cusps. Therefore, blood flow across the bicuspid valves is more turbulent, causing increased wear and tear on the valve leaflets. Over time, excessive wear and tear leads to calcification, scarring, and reduced mobility of the valve

leaflets. About 10% of bicuspid valves become significantly narrowed, resulting in the symptoms and heart problems of aortic stenosis.

The most common cause of aortic stenosis in patients 65 years of age and over is called "senile calcific aortic stenosis." With aging, protein collagen of the valve leaflets is destroyed, and calcium is deposited on the leaflets. Turbulence across the valve increases causing scarring, thickening, and stenosis of the valve once valve leaflet mobility is reduced by calcification. Why this aging process progresses to cause significant aortic stenosis in some patients but not in others is unknown. The progressive disease causing aortic calcification and stenosis has nothing to with healthy lifestyle choices, unlike the calcium that can deposit in the coronary artery to cause heart attack.

Rheumatic fever is a condition resulting from untreated infection by group A streptococcal bacteria. Damage to valve leaflets from rheumatic fever causes increased turbulence across the valve and more damage. The narrowing from rheumatic fever occurs from the fusion (melting together) of the edges (commissures) of the valve leaflets. Rheumatic aortic stenosis usually occurs with some degree of aortic regurgitation. Under normal circumstances, the aortic valve closes to prevent blood in the aorta from flowing back into the left ventricle. In aortic regurgitation, the diseased valve allows leakage of blood back into the left ventricle as the ventricular muscles relax after pumping. These patients also have some degree of rheumatic damage to the mitral valve. Rheumatic heart disease is a relatively uncommon occurrence in the United States, except in people who have immigrated from underdeveloped countries

What are the symptoms of aortic stenosis?

The major symptoms of aortic stenosis are:

- chest pain (angina),
- fainting (syncope), and
- shortness of breath (due to heart failure).

In 4% of the patients with aortic stenosis, the first symptom is sudden death, usually during strenuous exertion.

The exact reason for sudden death is unknown. It may be due to heart rhythm abnormalities secondary to inadequate blood flow through the narrowed aortic valve into the coronary arteries of the heart. Insufficient oxygen to the inner lining of the heart muscle occurs do to the lack of blood flow to the coronary arteries, particularly during strenuous exercise. Lack of oxygen in the heart muscles causes chest pain and possibly abnormal heart rhythms.

Chest pain is the first symptom in one-third of patients and eventually occurs in one-half of patients with aortic stenosis. Chest pain in patients with aortic stenosis is the same as

chest pain (angina) experienced by patients with coronary artery disease. In both of these conditions, pain is described as pressure below the breast bone brought on by exertion and relieved by rest. In patients with coronary artery disease, chest pain is due to inadequate blood supply to the heart muscles because of narrowed coronary arteries. In patients with aortic stenosis, chest pain often occurs without any underlying narrowing of the coronary arteries. The thickened heart muscle must pump against high pressure to push blood through the narrowed aortic valve. This increases heart muscle oxygen demand in excess of the supply delivered in the blood, causing chest pain (angina).

Fainting (syncope) related to aortic stenosis is usually associated with exertion or excitement. These conditions cause relaxation of the body's blood vessels (vasodilation), lowering blood pressure. In aortic stenosis, the heart is unable to increase output to compensate for the drop in blood pressure. Therefore, blood flow to the brain is decreased, causing fainting. Fainting can also occur when cardiac output is decreased by an irregular heart beat (arrhythmia). Without effective treatment, the average life expectancy is less than three years after the onset of chest pain or syncope symptoms.

Shortness of breath from heart failure is the most ominous sign. It reflects the heart muscle's failure to compensate for the extreme pressure load of aortic stenosis. Shortness of breath is caused by increased pressure in the blood vessels of the lung due to the increased pressure required to fill the left ventricle. Initially, shortness of breath occurs only during activity. As the disease progresses, shortness of breath occurs at rest. Patients can find it difficult to lie flat without becoming short of breath (orthopnea). Without treatment, the average life expectancy after the onset of heart failure due to aortic stenosis is between six to 24 months

How is aortic stenosis diagnosed?

Electrocardiogram (EKG): An EKG is a recording of the heart's electrical activity. Abnormal patterns on the EKG can reflect a thickened heart muscle and suggest the diagnosis of aortic stenosis. In rare instances, electrical conduction abnormality can also been seen.

Chest x-ray: A chest x-ray usually shows a normal heart shadow. The aorta above the aortic valve is often enlarged (dilated). If heart failure is present, fluid in the lung tissue and larger blood vessels in the upper lung regions are often seen. A careful inspection of the chest x-ray sometimes reveals calcification of the aortic valve.

Echocardiography: Echocardiography uses ultrasound waves to obtain images of the heart chambers, valves, and surrounding structures. It is a useful non-invasive tool, which helps doctors diagnose aortic valve disease. An echocardiogram can show a thickened, calcified aortic valve which opens poorly. It can also show the size and functioning of the heart chambers. A technique called Doppler can be used to determine the pressure difference on either side of the aortic valve and to estimate the aortic valve area.

Cardiac catheterization: Cardiac catheterization is the gold standard in evaluating aortic stenosis. Small hollow plastic tubes (catheters) are advanced under x-ray guidance to the aortic valve and into the left ventricle. Simultaneous pressures are measured on both sides of the aortic valve. The rate of blood flow across the aortic valve can also be measured using a special catheter. Using these data, the aortic valve area can be calculated. A normal aortic valve area is 3 square centimeters. Symptoms usually occur when the aortic valve area narrows to less than 1 square centimeter. Critical aortic stenosis is present when the valve area is less than 0.7 square centimeters. In patients over 40 years of age, x-ray contrast agents can be injected into the coronary arteries (coronary angiography) during cardiac catheterization to evaluate the status of coronary arteries. If significant narrowing of the coronary arteries is found, coronary artery bypass graft surgery (CABG) can be performed during aortic valve replacement surgery.

How is aortic stenosis treated?

Patients without symptoms can be observed until symptoms develop. Patients with mild aortic stenosis do not require treatment or restriction of activity. Patients with moderate aortic stenosis (valve area 1.5 to 1.0 square centimeters) are advised to avoid strenuous activities such as weight lifting or sprinting. Aortic stenosis can progress over a few years. Therefore, patients are usually examined annually and evaluated by echocardiography periodically to monitor disease progression. Since valve infection (endocarditis) is a serious complication of aortic stenosis, these patients are usually given antibiotics prior to any procedure in which bacteria may be introduced into the bloodstream. This includes routine dental work, minor surgery, and procedures that may traumatize body tissues such as colonoscopy and gynecologic or urologic examinations. Examples of antibiotics used include oral amoxicillin (Amoxil) and erythromycin (E-Mycin, Eryc, PCE), as well as intramuscular or intravenous ampicillin (Unasyn), gentamicin (Garamycin), and vancomycin (Lyphocin, Vancocin).

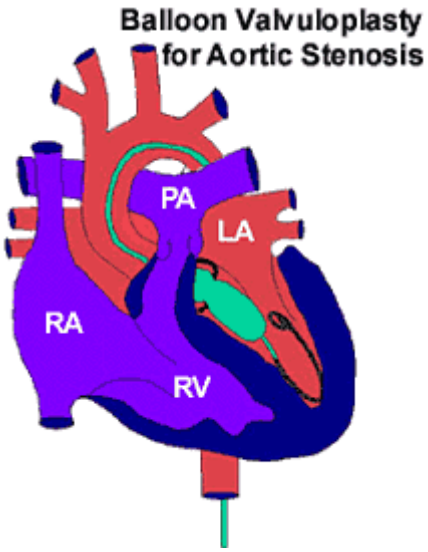
When symptoms of chest pain, syncope, or shortness of breath appear, the prognosis for patients with aortic stenosis without valve replacement surgery is poor. Medical therapy, such as the use of diuretics to reduce high lung pressures and remove lung fluid can provide only temporary relief of symptoms. Patients with symptoms usually undergo cardiac catheterization. If severe aortic stenosis is confirmed, aortic valve replacement is usually recommended. The overall mortality risk for aortic valve replacement surgery is about 5%. Advanced age should not be a reason for not recommending aortic valve replacement for aortic stenosis. Otherwise healthy patients in their 80s with strong heart muscles often benefit dramatically from aortic valve replacement for critical aortic stenosis.

Replacement aortic valves processed from pigs (porcine) or cows (bovine) are called bioprostheses. Bioprostheses are less durable than mechanical prostheses (discussed below) but have the advantage of not needing life-long blood thinning (anticoagulation) medication to prevent blood clots from forming on the valve surfaces. The average life expectancy of an aortic valve bioprostheses is 10 to 15 years. Bioprostheses rapidly calcify, degenerate and narrow in young patients. Therefore, bioprostheses are primarily

used in patients over 75 years old or in patients who cannot take blood thinners. Recently, aortic valves from human cadavers have been used in younger patients to avoid the need for anticoagulation medication. However, the availability of human aortic grafts is limited; though probably better than the other bioprostheses, its long term durability is unknown. The new "Ross Procedure" consists of moving the pulmonic valve to the aortic position and replacing the pulmonic valve with a valve from a human donor. This procedure has not been performed long enough to evaluate the long-term performance of the pulmonic valve when moved to the aortic position.

Mechanical prostheses have proven to be extremely durable and can be expected to last from 20 to 40 years. However, mechanical prosthetic valves all require life-long anticoagulation with blood thinners such as warfarin (Coumadin) to prevent clot formation on the valve surfaces. Otherwise, blood clots dislodged from these valves can travel to the brain and cause embolic stroke or embolic problems in other parts of the body. The original caged-ball Starr-Edwards prosthesis of the 1960s was replaced by the tilting disc Bjork-Shiley of the 1970s and early 1980s. Although the Bjork-Shiley valve provided a larger opening for blood flow, a second generation model of the valve posed the risk of potential breakage resulting in death, and is no longer available in the United States. The tilting pivoting disc Hall-Medtronic valve and the two leaflet (bileaflet) carbon St. Jude valve are commonly used mechanical prostheses today. These valves provide excellent flow characteristics but require life-long anticoagulation with blood thinners such as warfarin (Coumadin), to prevent embolic complications.

The aortic valve area can be opened or enlarged with a balloon catheter (**balloon valvuloplasty**) which is introduced in much the same way as in cardiac catheterization. With balloon valvuloplasty, the aortic valve area typically increases slightly. Patients with critical aortic stenosis can therefore experience temporary improvement with this procedure. Unfortunately, most of these valves narrow over a six to 18 month period. Therefore, balloon valvuloplasty is useful as a short-term measure to temporarily relieve symptoms in patients who are not candidates for aortic valve replacement. Patients who require urgent noncardiac surgery, such as a hip replacement, may benefit from aortic valvuloplasty prior to surgery. Valvuloplasty improves heart function and the chances of surviving non-cardiac surgery. Aortic valvuloplasty can also be useful as a bridge to aortic valve replacement in the elderly patient with poorly functioning ventricular muscle. Balloon valvuloplasty may temporarily improve ventricular muscle function, and thus improve surgical survival. Those who respond to valvuloplasty with improvement in ventricular function can be expected to benefit even more from aortic valve replacement. Aortic valvuloplasty in these high risk elderly patients has a similar mortality (5%) and serious complication rate (5%) as aortic valve replacement in surgical candidates.



Aortic Valve Stenosis At A Glance

- Aortic stenosis is narrowing of the aortic valve, impeding delivery of blood from the heart to the body.
- Aortic stenosis can be caused by congenital bicuspid aortic valve, scarred aortic valve of rheumatic fever, and wearing of aortic valve in the elderly.
- Aortic stenosis can cause chest pain, fainting, and heart failure leading to shortness of breath.
- Echocardiogram and cardiac catheterization are important tests in diagnosing and evaluating severity of aortic stenosis.
- Patients with aortic stenosis are usually given antibiotics prior to any procedures which might introduce bacteria into the bloodstream, such as dental procedures and surgeries.
- Patients with aortic stenosis who have symptoms may require surgical heart valve replacement.