



Cardiovascular Surgery (Heart Valve Thoracotomy and Catheter Surgery)

The heart is divided into four chambers. Four valves keep the blood flowing in one direction. Problems in the function of these valves are known as valvular heart disease. Valve replacement surgery, one surgical treatment for valvular heart disease, is to remove a deteriorated valve from a patient and replace it with a biological or mechanical valve. Since the first valve replacement surgery in 1952, a number of artificial heart valves have been devised as technology has advanced. In the same way, surgical techniques themselves have advanced remarkably, and valve replacement surgery is now a very common procedure. In recent years, minimally invasive treatment methods with less impact on a patient's body, are gaining ground.

History of artificial heart valves

Basic research into artificial heart valves began in the 1940s, and in 1960 ball valves were marketed as the first artificial heart valve products.

Subsequently, a thinner, disc-shaped valve (referred to as a mechanical valve) was developed and replaced the ball valves. Currently, the mainstream mechanical valves are two-leaf models which are highly durable and widely used across the world.



Two-leaf valve



Stentless biological valves fabricated from porcine aorta

Artificial heart valves also include tissue valves made from biological materials.

In 1956, a donated human valve was collected for treatment using a homograft (homogeneous valve) in which the valve is transplanted into the descending thoracic aorta of a patient with aortic regurgitation. However, homografts are difficult to obtain. As an alternative, porcine valves with stents; porcine aortic valves that are inserted into three stents, came into clinical use. In the 1970s, a bovine pericardial valve with stent; bovine pericardium, was used for the leaflet, came into clinical use.

In the 1990s, a stentless tissue valve processed from a porcine aorta was developed and is still in use after a number of improvements. Long-term durability has been a challenge for biological valves, but improvements in structure and methods of fastening leaflet tissue, especially in the 2000s and later, have accelerated better design and calcification suppression treatment, further improving hemodynamics and durability. Moreover, tissue valves that use metal-free stents and tissue valves that have the function of expanding the annulus frame has been developed in anticipation of new treatments. The ever-evolving tissue valve is used across the world to treat valvular heart diseases.



Tissue valves that expand the annulus frame

The evolution of surgery and minimally invasiveness

Surgical procedures also continue to evolve. Usually, in valve replacement surgery, a sternal incision is made to

open the ribs and approach the heart. However, from around 2000, minimally invasive cardiac surgery (MICS) that makes a smaller incision to approach the heart has been introduced. In addition, surgery using thoroscopes and surgical robots is also being introduced for the treatment of valvular heart disease.

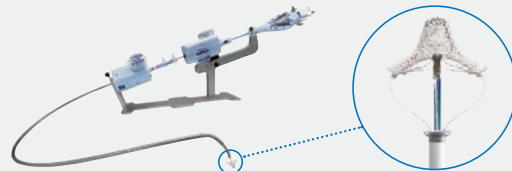
In 2002, Alain Cribier and his team made the world's first successful clinical use of transcatheter aortic valve implantation (TAVI), in which a tissue valve was placed in a human without opening the chest. Since then, a number of improvements have been made in tissue valves for TAVI. Now the established method is to crimp a tissue valve to the tip of the catheter, transport it to the valve position mainly through a small incision in the leg and place the tissue valve. The method is now widely used in the world, particularly on patients for whom open heart surgery is not an option.

The arrival of TAVI gave rise to a new treatment method; TAV in SAV (also known as Valve in Valve). For those patients who have already undergone valve replacement surgery using a tissue valve, but subsequently need a second valve replacement, this new method allows the placement of the second tissue valve through the catheter without another open heart surgery. It is very advantageous for patients since they can select treatment without another open heart surgery because tissues once incised through surgical procedures often fuse, making it difficult to conduct a second surgery.

In the treatment of valvular heart disease, valve repair is widely performed to shape the valves. Various types of annuloplasty rings and bands are used for atrio-ventricular valves such as mitral valves. Catheter treatment is now clinically available in the field of valve repair, using a catheter to approach the valve and form the valve by pinching the leaflets with a clip-shaped device.



Transcatheter aortic valve implantation (TAVI)



Procedure to form a valve by pinching the leaflets with a clip-shaped device

Increased therapeutic and product options allowed the selection of the optimal artificial valve and optimal treatment method for an individual patient's condition. In addition, the development of less invasive treatments and medical devices that make them possible, contribute to an improvement in quality of life (QOL) by reducing the burden on patients, such as fast post-operative recovery and less conspicuous surgical scars.