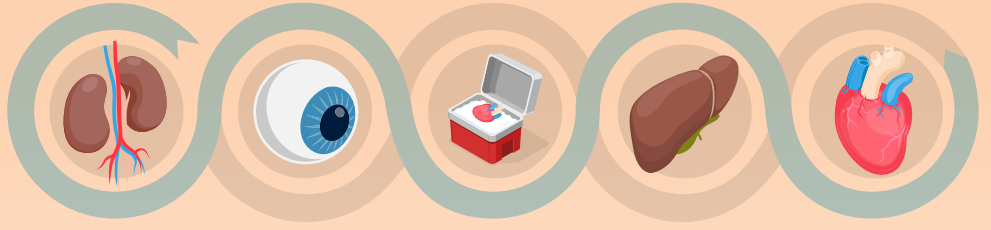


Special
Report

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Heart Swap

The Ultimate Life-Extending Procedure

Organ Transplantation Team
of Taipei Tzu Chi Hospital

By Liao Wei-Ching



In 1967, the South African surgeon Christiaan Barnard performed the world's first successful human heart transplant operation, which marks a milestone in the history of modern medicine despite the fact that the patient died only 18 days after the operation. 55 years later, a US surgery team successfully transplanted a genetically modified pig's heart into a 57-year-old man, surnamed Bennett, which marks another world's first. Although this man passed away two months after receiving the transplant, this surgery still represents a major breakthrough in the field of transplantation technology.

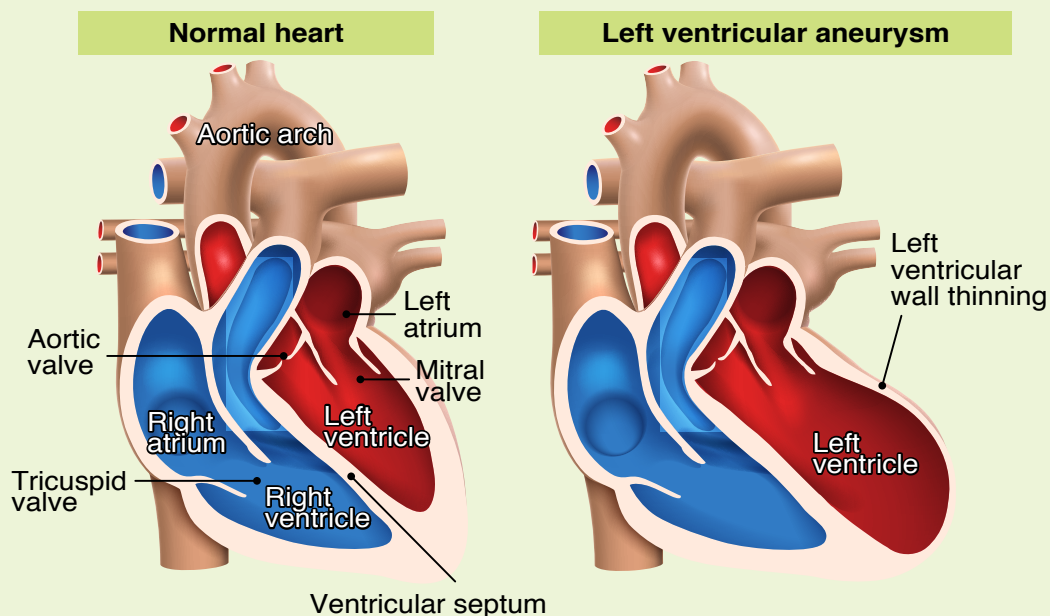
Heart transplantation surgery which is commonly known as "heart swap" is the only way to save the life of a patient suffering from aggravating heart disease and symptoms of terminal heart failure, which makes it impossible to sustain required blood supply and circulation. However, heart transplantation is more complicated than conventional surgery since it involves two different families. As a result, every country has highly complex regulations governing qualification criteria for hospitals and physicians. Consequently, not all medical institutions are qualified to perform heart transplantation surgery.



The cardiovascular surgery team of Taipei Tzu Chi Hospital features an impressive lineup of outstanding physicians who are capable of providing optimal surgical care for cardiovascular patients. From left to right: Perfusionists Ku Yu-Chen and Chou Ching-Yeh, Dr. Hsu Chan-Yang, Dr. Lo Chung-Yu, Dr. Tsai Kuei-Tung, Dr. Chang Yen, Director of the Center for Cardiovascular Medicine, Dr. Shen Ta-Chung, Director of the Cardiovascular Surgery Department, Dr. Sung Chen-Yu, NP Lo Yu-Ping, and Perfusionist Tu Ku-Hsin

Heart volume reduction surgery

Heart volume reduction surgery is one type of surgery for palliatively treated dilated cardiomyopathy or ischemic left ventricular aneurysm. In simple terms, it aims to reduce the size of the ventricle and thereby decrease the burden on the heart through surgical removal of part of the cardiac muscle. When heart volume reduction surgery (left ventricular aneurysm removal) is performed, the patient must undergo median sternotomy (a vertical incision of more than 30 centimeters) under CPB conditions. During surgical removal of part of the ventricular wall of the dilated left ventricle, damage to the coronary arteries and papillary muscles must be avoided. Finally, the ventricle opening must be sutured. After reduction of the heart volume, the heart beats and pumps blood more efficiently since the oval shape of the left ventricle is restored. The reduction of diastolic blood pressure in the left ventricle coupled with the increased blood flow to the coronary arteries decreases ventricular wall stress and thereby enhances the functions of the remaining cardiac muscle. It is even possible to restore the muscle functions to close to the normal state. After surgery, the patient must remain hospitalized for two to four weeks.



In Taiwan, hospitals performing such surgeries must be qualified to carry out heart procurement and transplantation. Such hospitals must be classified as regional hospitals or above, possess all required equipment, and hire at least one heart transplant physician. In addition, they must set up a dedicated organ transplant unit and employ physicians or experts with professional expertise in the fields of pharmacology, pathology, transplantation immunity, infectious diseases, anesthesiology, respiratory therapy, psychiatry, and hematology on a full-time basis. The hiring of transplant coordinators and social workers is also indispensable.

In addition to hospital restrictions, the criteria for heart transplant physicians are also very strict. The professional experience of such physicians must include the performance of at least 500 cardiopulmonary bypass (CPB) surgeries and off-pump coronary artery bypass grafting surgeries (CABG) as the primary surgeon. They are further required to complete at least 6 months of training at a Taiwanese or overseas hospital that specializes in heart transplantation surgery and successfully apply for a license issued by the Ministry of Health and Welfare. In view of all these requirements and restrictions and the risk such surgeries pose for the patient,



After three open heart surgeries (aneurysm removal, heart volume reduction, and automated defibrillator implantation, Ms. Liao, who had been at death's door, became the first patient to successfully undergo heart transplantation surgery at Taipei Tzu Chi Hospital.

it is not surprising that only very few physicians are willing to pursue a career in the field of heart transplantation.

First Heart Transplantation Surgery Four Years After Inception of the Hospital

Taipei Tzu Chi Hospital was officially inaugurated in 2005. However, a large majority of cardiovascular patients are not willing to undergo transplantation surgery at a newly commissioned hospital even if they know that that hospital and its facilities meet the required criteria. Dr. Shen Ta-Chung, Director of the Cardiovascular Surgery Department, remarks half-jokingly that “almost all of the patients we had were either from underprivileged backgrounds or in critical condition like shock probably because we are a Tzu Chi medical institution. In

the initial stage after inauguration, we were not the first choice of patients who needed heart transplantation surgery and had sufficient financial ability or physical mobility.”

Ms. Liao was the first heart transplant patient of Taipei Tzu Chi Hospital. This lady, who was in her 60s at the time of surgery, had been under long-term observation by a cardiovascular unit due to cardiomyopathy which occurred many years ago during a perinatal period. Later on, heart failure resulted in ventricular aneurysm, which had a serious impact on her heart functions. This triggered her decision to schedule an outpatient appointment with Director Shen Ta-Chung. Over ten years ago, the only way to treat a ventricular aneurysm was to surgically remove it. After removal of the aneurysm and heart volume reduction surgery, Ms. Liao felt

Stages of heart failure

Class	Patient Symptoms
Class I	No limitation of physical activity. Ordinary physical activity does not cause undue fatigue, palpitation, shortness of breath, or chest pain.
Class II	Slight limitation of physical activity. Ability to engage in ordinary activities such as climbing stairs. Strenuous exercise results in fatigue, palpitation, shortness of breath, or chest pain.
Class III	Marked limitation of physical activity. Comfortable at rest. Mild physical activity such as climbing stairs causes fatigue, palpitation, or chest pain.
Class IV	Symptoms of heart failure at rest. Any physical activity causes further discomfort. Even lying on the bed or standing without moving results in fatigue, palpitation, shortness of breath, or chest pain.



Once there is a suitable match for the patient, the team immediately harvests the organ regardless of day or night or inclement weather. The image shows Dr. Hsu Chan-Yang of the Cardiovascular Surgery Department heading down south late at night to harvest and bring back the donated transplant.

much better. However, one year later heart failure recurred, which triggered ventricular tachycardia. The medical team therefore performed extra-corporeal membrane oxygenation (ECMO) and was able to bring her back from the jaws of death after administering more than 400 electric shocks.

After receiving medication for a certain period, Ms. Liao's condition stabilized and ECMO could be removed. When he saw the severely deteriorated condition of her heart, Director Shen Ta-Chung decided to suggest heart transplantation surgery to the patient, but it turned out that not all medical teams supported his decision. He recalls that "everyone was concerned about the fact that this was the hospital's first heart transplantation surgery, and the patient was in very serious condition. In view of the fact that the patient had undergone surgery and 400 electric shocks had to be administered, it was obvious that heart transplantation surgery would pose a daunting challenge." In stark contrast to these concerns, Ms. Liao had a relatively high level of trust in the abilities of this doctor who had saved her life several times. After a period of careful assessment and anticipation, she became the first patient to successfully undergo heart transplantation surgery at Taipei Tzu Chi Hospital on November 11, 2009.

The term transplantation surgery

success is defined as post-transplant survival of at least 30 days and safe discharge from the hospital. If the patient dies for any reason within 30 days after transplantation, the surgery is considered a failure. Statistics released by ISHLT (International Society for Heart and Lung Transplantation) reveal that the annual success rate of heart transplantation surgery can reach over 90% and the 10-year survival rate is around 60 to 70%. After ten years, the survival rate gradually decreases. Director Shen points out that there are multiple causes of post-transplant death. Early post-transplant death can mostly be attributed to complications including serious infection and acute rejection. However, as a result of ongoing advances in the fields of technology and medication, the early death rate has been dropping and the safe discharge rate has reached over 90%. In the long run, we should not underestimate the risk posed by factors other than rejection or infection such as coronary artery stenosis experienced by a certain percentage of patients and rising cancer incidence caused by long-term administration of immune drugs. There are several reported cases of post-transplant death caused by cancer.

Ms. Liao's surgery was quite successful. However, many years later, she stopped taking immunosuppressants on her own, which triggered a serious rejection reaction and rapidly



Dr. Sung Chen-Yu of the Cardiovascular Surgery Department at Taipei Tzu Chi Hospital harvests the donated heart. The image below shows Dr. Sung Chen-Yu and Dr. Tsai Kuei-Tung preparing the heart for transplantation in a low-temperature environment.

deteriorating heart failure, resulting in her ultimate death after unsuccessful rescue attempts in a hospital in southern Taiwan.

Race Against Time Represents the Greatest Challenge

In view of the fact that patient conditions are complex, the eligibility for inclusion on the heart transplant waiting list must be carefully reviewed and assessed. Director Shen explains that, according to the heart transplantation guidelines and health insurance regulations, patients must be diagnosed with Class IV heart failure with significant symptoms. A heart examination must reveal poor cardiac functions involving left ventricular contraction of 20% or severe symptoms despite contraction of less than 20% determined through other assessments (including maximal oxygen consumption of less than 14ml per kg/min; necessity of maintenance of heart functions through inotropic agents; treatment with other medications or surgeries impossible). These criteria enable medical teams to determine whether or not the patient has reached the terminal stage of heart failure. In addition, the medical team must consult with other divisions and departments in the assessment of mental and physical conditions of the patient to determine his/her ability to adhere to medication

regimens in accordance with instructions of their physician. Serious systemic diseases, infectious diseases, or untreated cancer must also be ruled out. Only after confirmation of all these items can patients be placed on the waiting list.

When the transplant coordinator is notified of a suitable transplant match for the patient, the cardiovascular surgery team activates the following two teams: procurement and transplantation. Director Shen explains that “transplantation surgery usually requires collaboration by two physicians. A senior physician oversees procurement of the donated transplant performed by a junior doctor. The qualifications of physicians performing organ procurement are less strict than those for transplantation specialists. Attending physicians can perform organ procurement after a minimum of five years of training under a chief resident of the cardiovascular surgery department and successful application for a license issued by the Ministry of Health and Welfare.”

After removal of the heart from the donor’s body, it must be transplanted into the recipient’s body as fast as possible since it lacks blood supply. As a rule, the donated heart should be implanted into the recipient and made to beat again no more than four hours after removal from the donor’s body. However, this preset time limit can be affected by many factors including means of transportation,



Director Shen Ta-Chung performs heart transplantation surgery

sudden emergencies on the way to the hospital, and accidents associated with braindead donors. Dr. Shen, who has abundant experience in this field, therefore confesses that “ingenious coordination of time on both sides of this process” still represents the most daunting challenge of transplantation surgery. He further states that the donated heart goes into a “stunned” state after harvesting due to the lack of oxygen and blood supply. It slowly recovers after successful transplantation and restoration of heartbeat. The earlier

blood supply is restored, the shorter is the duration of the aforementioned “stunned state”. In some patients, this state does not appear. If the heart is not successfully transplanted and heartbeat is not restored within four hours, it will lack strength even if it is successfully implanted into the recipient’s body due to the long duration of the “stunned” state. The patient therefore has to rely on inotropic agents or ECMO to maintain his/her heart function and pull through. Since time management is so critical in this process, the primary physician responsible for the transplant patient usually waits until the donor is in the operating room before initiating surgery.

All-around Care for the Transplant Patient

During transplantation surgery, the patient has to rely on cardiopulmonary bypass for the maintenance physiological functions. The CPB circuit is only removed after the heartbeat of the transplanted heart is restored and stabilized. After surgery, the patient is transferred to the ICU unit for observation. Discharge from the ICU unit to the general ward is only possible after the patient is taken off the ventilator. During this period, physicians must conduct blood tests to assess the blood concentration of immunosuppressants and the presence of chronic viral infections. Finally,

normal functioning of the heart must be confirmed through repeated ultrasound examinations.

Prior to discharge from the hospital, a joint consultation with the cardiologist who performs endomyocardial biopsy with a catheter is scheduled. The goal is to remove a tiny piece of cardiac muscle tissue from the right ventricle which will be examined by a pathologist to determine the state of rejection. Director Shen adds that, “in the past, coronary angiography was performed prior to discharge of the patient to confirm unobstructed blood flow in the coronary arteries. However, due to the impact of the pandemic in recent years, most patients refuse to undergo invasive examinations. In addition, recent studies indicate that effective control of coronary artery disease can be achieved through regular medication. It is therefore possible to rely on non-invasive procedures to observe patient conditions.”

From the perspective of physicians, patient recovery and discharge is a source of joy. Director Shen bluntly states that the “greatest sense of achievement is to see the patients leave the hospital in an elated mood after they had been admitted in a comatose state accompanied by their devastated relatives and return a healthy dad, mom, or child back to their families.”

Among the 20 heart transplantation surgeries performed by the medical team of Taipei Tzu Chi Hospital, Mr. Wang is the most memorable case.

Director Shen points out the 59-year-old Mr. Wang was a typical underprivileged patient so commonplace in Tzu Chi medical institutions. He was a financially challenged single dad who suffered from heart failure and had to raise a teenage son in his second year of junior high school. Whenever his condition worsened, he would seek treatment in an emergency department of a hospital somewhere in Taiwan. Some time later, he



During transplantation surgery, the patient has to rely on cardiopulmonary bypass for the maintenance physiological functions.

would leave the hospital without returning for follow-up appointments since he had run out of money. When he was admitted to the emergency department of Taipei Tzu Chi Hospital, he suffered from acute heart failure accompanied by impaired liver functions and severe ascites. At the time of his admission, he only weighed a little more than 30 kg. The medical team decided to utilize a ventricular assist device (VAD) to keep him alive while he was waiting for a transplant. After an extended stay in ICU, a suitable transplant match was finally found, and he gained a new lease of life.

While Mr. Wang was hospitalized, his pubescent son would visit him every evening after school to turn him over and pat his back and care for his Dad in a meticulous manner. The medical team also spared no effort to search for a suitable

nursing home to provide them with an excellent environment for rehabilitation after discharge from the hospital. “In contrast to other hospitals, we provide care for many underprivileged patients, but an organ transplantation is a marathon requiring all-around care and long-term tracking. This represents a heavy burden for financially challenged families. The medical team must therefore provide even more care and assistance,” Director Shen adds with a sigh.

The Future of Heart Transplantation

In the past, patients who met the criteria for heart transplantation but were unable to maintain their heart functions until a suitable transplant match could be found had to rely on inotropic agents or extracorporeal assistive devices to support their heart functions. They had to remain hospitalized. Technological advances in recent years have resulted in the development of ventricular assist devices which can be implanted into such patients to enable them to maintain their regular lives while waiting for a suitable match. On the other hand, if patients fail to meet the criteria for transplantation surgery, their lives can be extended for many years by relying on these devices as an alternative solution.

Our heart is one of the most vital, life-supporting organs of the human



Director Shen is at the patient's side to offer comfort and concern before and after heart transplantation surgery .

body. If lives can be prolonged through heart transplants, many families remain free from grief and sorrow. However, there is a serious mismatch between the demand for transplants and the availability of suitable donors who are willing to donate their hearts after death. Medical professionals all over the world are therefore deeply engaged in research on xenogeneic transplantation (e.g. pig's hearts) and more advanced ventricular assist devices.

Director Shen further points out that there are two future directions in the field of heart failure treatment. The first trend is the increasing availability of constantly improving ventricular assist devices, which will enable patients not suitable for transplantation or waiting for suitable matches to maintain a good life quality. The other trend stems from the difficulty of obtaining heart transplants. Medical professionals have responded to this predicament by engaging in research on how to better preserve hearts in vitro and keep them in perfect condition until they are transplanted into a new body. After all, a perfectly healthy heart transplant represents the best choice for young patients in particular.

Ventricular assist devices (short-term and long-term VADs) which are commonly known as “artificial hearts” are mechanical pumps that take over most cardiac output functions in patients with terminal heart failure.

Taipei Tzu Chi Hospital organ / tissue transplantation statistics (as of March 7, 2023)

Heart	20 cases
Liver	7 cases (incl. 1 living liver transplantation)
Kidney	58 cases (incl. 8 living kidney transplantations)
Cornea	49 cases

Short-term VADs are extracorporeal electrical devices that are connected to patients' hearts after surgery. These patients can leave their beds but must stay hospitalized. Short-term VADs should not be used for more than one month. Long-term VADs are fully implanted into the patient's body. After surgery, patients must carry a battery pack and charging cable at all times. This allows them to resume their normal lives after discharge from the hospital. Use of these devices can range from several months to several years.

Due to the fact that the blood is circulated via the tubes of the device, there is a significant risk of various complications such as thrombosis and hemolysis, gastrointestinal bleeding caused by changes in blood flow patterns, and device-related infections regardless of the device type.