Heart transplant: an overview

Introduction

Heart transplant is a transplant procedure surgery where the malfunctioning heart or end-stage heart-related disease are replaced by a function heart. Indeed, this is a very complicated, risky and time-consuming operation since it needs a function heart from the person who has just died and implant it into the patient. It is usually done in emergencies and to find a donor heart is difficult.

Have you ever thought of how was the first heart transplant done? Who was actually the first person in the world that conducted this sound seemed " impossible" surgery? Who was the first courageous patient who willing to put his life in such a great risk? And have you ever wondered how exciting it would be to cause a breakthrough in medical world that could end up saving millions of lives from all over the world?

This great success was from a heart surgeon, Dr. Christiaan (Neethling) Barnard from South Africa. He was the first person who carried out a human-to-human heart transplant on December 3, 1967 in Cape Town, South Africa. It was done at Groote Schuur Hospital in Cape Town on Louis Washkansky, a South African grocer who would most certainly die without the heart transplant. Meanwhile, the donor was from a young woman, Denise Darvell who was killed in an accident.

The heart transplant surgery had surprised the whole world. Dr. Christiaan (Neethling) Barnard also became a well-known heart surgeon overnight. Besides heart transplant, he had other astonishing achievement in kidney transplant and gastrointestinal pathology.

Dr. Barnard is also attributed in mounting a new design for artificial heart valves, doing heart transplanting on animals, and correcting the problem of the blood supply to the fetus during pregnancy. With the efforts of Dr. Barnard and his surgical team, the survival rates of 50% of the patients to at least 5 years of living after heart surgery.

Background of Christiaan Barnard

Christiaan Barnard was born in Beaufort West, Union of South Africa on 8 November 1922.[1] His father, Adam Barnard was a minister of the Dutch Reformed Church for the mixed race population of the town. When he was a child, he always pumped the bellows of the church's primitive organ which his mother played during services. After a long time, he told a joke that the heart was not the first organ he had had to deal with in his life. One of his four brothers, Abrahim died at the age of five because of the heart problem. After that incident, Barnard determined to be a surgeon to help people who faced heart problem since he was young.

Christiaan Barnard came from a very poor family and he studied at the local public school. He matriculated from the Beaufort West School in 1940. After that, Barnard got a place at the University of Cape Town Medical School. He obtained Bachelor of Medicine, Bachelor of Surgery in medicine at the University of Cape Town in 1946. He worked as a general practitioner in Ceres, South Africa when he was a resident doctor at the Groote Schuur Hospital in Cape Town. In 1951, he returned to Cape Town and worked as a Senior Resident Medical Officer at the City Hospital. Besides, he was also a registrar in the Department of Medicine at the Groote Schuur Hospital.

Since Christiaan Barnard was interested in his research and gaining a new surgical skills and experiences, he furthered his postgraduate studies at the University of Cape Town and at the University of Minnesota. He acquired Master of Medicine in medicine for a dissertation entitled Meningitis" from the University of Cape Town in 1953[2] whereas he was awarded Doctor of Philosophy degree for his dissertation entitled " The aetiology of congenital intestinal atresia" at the University of Minnesota. [3]After that, he went back to South Africa to be a cardiothoracic heart surgeon.

Before he left for America (1953-1955), Barnard had gained recognition for research in gastrointestinal pathology. He proved that the fatal birth defect known as congenital intestinal atresia (a gap in the small intestines) was due to the fetus receiving an inadequate supply of blood during pregnancy and that it could be remedied by a surgical procedure. [4] He was a specialist in cardiothoractic surgery and heart transplantation. His first successful open heart surgery program is at Groote Shuur Hospital. In 1967, he led a team to perform in the world's first human-to-human heart transplant. Barnard was contributed the treatment of cardiac diseases, such as the Tetralogy of Fallot and Ebstein's anomaly. In 1972, he was promoted to be Professor of Surgical Science in the Department of Surgery at the University Of Cape Town. He got an appellation – Professor Emeritus in 1984.

Christiaan Barnard's advances in heart surgery brought him honors from a host of foreign medical societies, governments, universities, and philanthropic (charitable) institutions. He had also been presented many honors, including the Dag Hammarskjold International Prize and Peace Prize, the Kennedy Foundation Award, and the Milan International Prize for Science.

Since 1960, Christiaan Barnard had been bothered by rheumatoid arthritis (a severe swelling of the joints). This limited his surgical experimentation in later years. As a result, he turned to writing novels as well as books on health, medicine, and South Africa. At the same time, he also served as a scientific consultant. Christiaan Barnard died on September 2, 2001, when he was seventy-eight years old.

Contributions of Christiaan Barnard in Science

Doctor Barnard with some of his medical team

1. Proof Of The Fatal Birth Defect

Christiaan Barnard showed that the fatal birth defect that was known as congenital intestinal atresia was a gap in the small intestines. The fetus did not receive sufficient blood during pregnancy cause the defect.[5] This research made him being recognised in gastrointestinal pathology which is about intestinal diseases. Besides, he also proved that surgical procedure could treat this condition.

2. Heart Transplantation

Christiaan Barnard was a pioneering cardiac surgeon but his advances were based on work that came before him. The first use of hypothermia in 1952 and the introduction of a heart-lung machine in 1953 were crucial important for his advances. In 1960, these advances which combined with other techniques enabled him to undergo the first heart operation.

Ø The First Heart Transplantation

Preparation for the first heart transplant

Upon he returned to South Africa, he introduced open-heart surgery and designed artificial valves for the human heart. During 1967, in the

preparation for the first heart transplantation, he spent 3 months with the pioneer kidney transplant surgeon who was David Hume in Richmond, Virginia and another 2 weeks with Thomas Starzl in Denver, Colorado. He learnt the basics of immunosuppressive therapy in organ transplantation from these attachments. Furthermore, he got the chance to watch an orthotopic heart transplant on a dog which was performed by Richard Lower, head of cardiac surgery when he was at the Medical College of Virginia. Lower spent many years with Norman Shumway at Stanford University to develop, perfect the surgical technique and study other kinds of experimental heart transplantation.

In addition, Christiaan Barnard underwent a single kidney transplant in Cape Town was to gain some experience about immunosuppressive therapy. The patient did exceptionally well. Therefore, Barnard claimed that he was the only kidney transplant surgeon in the world with a 100% 20-year patient and graft survival.

The First Patient—Louis Washkansky

Making history:

The First Patient

Louis Washkansky

After a decade of heart surgery, Christiaan Barnard was ready to accept the challenge posed by the human heart transplantation. In 1967, he performed the first human-to-human orthotopic heart transplant in his patient, Louis Washkansky who was a fifty four years old patient, suffering from extensive coronary artery disease, peripheral vascular disease and also diabetic. He could either wait for death or risk transplant surgery with an 80% chance of

surviving. He at last chose the surgery. As Barnard wrote, “ For a dying man it is not a difficult decision because he knows he is at the end. If a lion chases you to the bank of a river filled with crocodiles, you will leap into the water convinced you have a chance to swim to the other side. But you would never accept such odds if there were no lion.” [6] On December 2, 1967, Washkansky’s heart was replaced by the heart of a young woman killed in an accident.

Barnard’s assistants immediately opened the chest, initiated pump-oxygenator support, cooled the heart to a low temperature, and excised it once medicolegal official announced that the young woman was dead. The heart was kept alive in a heart-lung machine that circulated Washkansky’s blood before removing the patient’s diseased organ and replacing it with the healthy heart. All the procedures were run well and the heart functioned satisfactorily by using the technique which was developed in dogs by the Stanford group[7].

Washkansky’s daily progress was followed intensely. In the beginning, he recovered very well. His peripheral edema was lost rapidly as his new heart functioned strongly. However, after 12 days, his condition started to deteriorate and his lungs were developed radiographic infiltrates. The surgical team was not sure if these were associated with cardiac failure from rejection or with infection. Mistakenly, they elected to treat for rejection and intensify the immunosuppressive therapy. They made a wrong decision because Washkansky had pneumonia. As a result, Louis Washkansky died on December 21, 1967.

Ø The second patient—Philip Blaiberg

Not daunted by the failure, within a year, Christiaan Barnard replaced the diseased heart of Philip Blaiberg who was a fifty eight years old retired dentist. On this occasion, Barnard slightly modified the surgical technique. The incision in the right atrium of the donor heart was extended from the inferior vena cava into the atrial appendage to avoid the area of the sinus node at the root of the superior vena cava.[8] This is the first time when antilymphocyte serum was used in the patient.

After heart transplantation, Blaiberg recovered well and he was the first heart transplant patient who can leave hospital. Nevertheless, he died on the 19th month. His autopsy showed that he infected a severe and widespread coronary artery disease. The medical profession was shocked because he had not expected that atherosclerosis could develop such rapidly. This was the first example of graft atherosclerosis, otherwise known as chronic rejection that now dominates as the major cause of graft failure after the first post transplant year. Blaiberg wrote a short book about his experience which was Looking At My Heart[9] before he died.

Ø Twin-Heart Operation

Christiaan Barnard performed a “ twin-heart” surgery in the year 1974, November 25 as the history of medical had been changed by him again. The only infected part of heart of Ivan Taylor (58 years old) was being removed and replaced with the heart of a child who was only 10 years old. The heart of the child was used to support the patient’s diseased organ. Although Barnard was confident in this new operation since this was less dangerous compared to the heart implantation, the patient passed away in four- month

time. Double transplants was included in twin-heart operation by combining a well heart to the patient's heart to produce a " double pump", manipulating synthetic heart valves and making the lives of seriously ill people longer by using monkeys' hearts.

Ø Orthotopic heart transplantation

Barnard's medical team had only performed ten orthotopic heart transplants between the year 1967 and 1973.[10] The results were outstanding even though the medical standards last time were not as high as today's, as one considers the ancient nature of the immunosuppressive therapy accessible at the time which are mainly azathioprine, corticosteroids, and antilymphocyte serum, and the team was not expert enough in diagnosing and treating rejection episodes since they did not have many experiences in these aspects.

Dirk Van Zyl who was the sixth patient was notable in orthotopic heart transplant. His ischemic heart disease was too bad that he had a cardiac arrest when he was anesthesia.[11] At the time of giving external cardiac massage, he was attached to the pump-oxygenator via cannulation of the femoral vessels. He made an ordinary healing from the heart transplant surgery. He did not receive any cyclosporine, only being maintained on azathioprine and prednisone. He died when he was 24 years old from a cerebrovascular accident.

Ø Heterotopic heart transplantation

Jaques Losman, a junior surgeon, was being set by Barnard on his team in order to develop a surgical technique of heterotopic heart transplantation. This is a kind of transplantation where the second heart is located in the

chest and the two hearts have the chance to work in parallel. There are two techniques were successfully developed in the laboratory, in one of which the donor heart help the left ventricle only and another in which biventricular support was offered[12]. Only two left ventricular assist procedures were carried out in patients, the remaining processes were related to biventricular assist.

Forty-nine following heterotopic heart transplants were done in Cape Town between 1974 and 1983 with rather excellent results for that period. 3 out of the first 5 of patients managed to live more than 10 years. Two 14-year-old boys, both of whom firstly received heterotopic transplants, went through second (orthotopic) heart transplants for joining atherosclerosis, and were thus the first patients in the world to have two donor hearts in their chest at the same time. The first of these two boys stays alive and healthy 20 years more. In the other, the second transplant also finally failed and he underwent a third graft, again in the orthotopic site, and therefore turned into one of the few humans to have had four hearts in his life-time.

One of the advantages of heterotopic heart transplantation was that information on the retrenchment of both the recipient and donor left ventricles could be supplied by an outer pulse trace. The changes in the ratio of these two pulses as the donor pulse deteriorating in relation to the recipient pulse, recommended that rejection was happening.[13] Increase immunosuppressive therapy could then be controlled. If there were any doubts, an endomyocardial biopsy could be performed. The other hypothetical benefit is that, in patients with a severe myocarditis, the back-up that given by the transplant might allow the myocarditis to resolve and

the patient’s own heart to recover. In fact, this had happened in one patient, making it feasible to remove the transplanted heart while it developed a fairly acute rejection episode.

Ø Xenotransplantation

The heterotopic heart is able to provide temporary circulatory support to a failing native heart, in the hope that the native heart would recover, was extended into the realm of xenotransplantation.[14] On two occasions in 1977, when a patient’s left ventricle failed acutely after routine open heart surgery and when no human donor organ was available, Barnard transplanted an animal heart heterotopically. On the first occasion, a baboon heart was transplanted, but this failed to support the circulation sufficiently, the patient dying some 6 hours after transplantation. In the second patient, a chimpanzee heart successfully maintained life until irreversible rejection occurred 4 days later, the recipient’s native heart having failed to recover during this period. Barnard abandoned further attempts at xenotransplantation since, in his own words, “ I became too attached to the chimpanzees.”

Ø Hypothermic perfusion storage of the donor heart

A young biochemist working in Barnard’s department, Winston Wicomb, a hypothermic perfusion system was developed for storing hearts ex vivo for up to 48 hours. It proved possible to remove a baboon’s heart, store it by hypothermic perfusion for 24 or 48 hours, and then replace it in the original baboon, the baboon having been maintained alive during this period by an orthotopic cardiac allograft. With the success of this storage system in the

laboratory, Barnard encouraged his juniors to use it in the clinical transplant program.

This phenomenon of delayed function, suggesting temporary depletion of myocardial energy stores, was believed to be related to the fact that, whereas in the baboon experiments the heart had been removed from a healthy anesthetized animal, in the clinical situation the heart had been excised from a brain-dead subject.

3. Books

Barnard had been bothered by rheumatoid arthritis since he was young, and advancing stiffness in his hands forced his retirement from surgery in 1983. He took up writing, however, and wrote a cardiology text, a (sometimes sensational) autobiography, and several novels, including a thriller about organ transplants. Christiaan Barnard wrote two autobiographies. His first book, One Life, was published in 1969 and subsequently sold copies worldwide. Some of the proceeds were used to set up the Chris Barnard Fund for research into heart disease and heart transplants in Cape Town. His second autobiography, The Second Life, was published in 1993. Apart from his autobiographies, Dr Barnard also wrote several other books including The Donor, Your Healthy Heart, In The Night Season, The Best Medicine, Arthritis Handbook: How to Live With Arthritis, Good Life Good Death: A Doctor’s Case for Euthanasia and Suicide, South Africa: Sharp Dissection, 50 Ways to a Healthy Heart and Body Machine.[15]

Christiaan Barnard had influenced much in the current scientific knowledge. His first heart transplant done in 1967 had contributed a lot in the knowledge

of heart transplant. In December 1967, Dr. Barnard placed the heart of a 25-year-old woman who had died in an auto accident in the chest of Louis Washkansky, a 55-year-old man dying of heart damage. Barnard and his team of cardiac specialists gave the patient large doses of drugs in order to suppress the body's defense mechanism that would normally reject a foreign organism. However, Washkansky's body was unable to defend itself against infection and only survived for 18 days.[16] However, Washkansky's brave election to be the first heart transplant recipient had proved the technique feasible. After Barnard's successful operations, surgeons in Europe and the United States began performing heart transplants, improving upon the procedures first used in South Africa.

Despite many failures worldwide in heart transplant, this relative success did much to generate guarded optimism that heart transplantation might eventually become a feasible therapeutic option. Barnard then developed the operation of heterotrophic heart transplantation which had some benefits in the pre-cyclosporine era when immunosuppressive therapy was very limited. In 1981, his group was the first in successfully transporting donor hearts using a hypothermic perfusion storage device. Several studies on the hemodynamic and metabolic sequelae of brain death were carried out in his Department's cardiovascular research laboratories at the University of Cape Town. The concept of hormonal replacement therapy in organ donors was also developed. In the Chris Barnard Division of Cardiothoracic Surgery at Groote Schuur Hospital and the University of Cape Town, an active heart transplant program still continues. The thrust of clinical activity within the Division and the research within its state-of-the-art cardiovascular research

laboratories is now directed towards valvular and ischaemic heart which are common in the African population.[17] Dr. Barnard had learned much of his technique from studying with the Stanford group. This first clinical heart transplantation experience stimulated world-wide notoriety, and many surgeons quickly co-opted the procedure. However, because many patients were dying soon after, the number of heart transplants dropped from 100 in 1968, to just 18 in 1970. It was recognized that the major problem was the body’s natural tendency to reject the new tissues.

Advances in tissue typing and immunosuppressant drugs

Over the next 20 years, important advances in tissue typing and immunosuppressant drugs allowed more transplant operations to take place and increased patients’ survival rates. The most notable development in this area was the discovery of cyclosporine, an immunosuppressant drug derived from soil fungus, in the mid 1970s. It was the first immunosuppressive drug that allowed the selective immuneregulation of T cells without excessive toxicity. Today’s surgical techniques and procedures are more sophisticated. Refinements in patient selection, newer immunosuppressants, better myocardial protection, and the use of right ventricular endomyocardial biopsy to identify rejection have resulted in better survival rates.

After his breakthrough, he continued to work with a professional passion that excited the public and frightened his colleagues. He was the first to explore further cardiac techniques. These included double transplants which involved the of joining a healthy heart to the patient’s to create a “ double pump”, designing artificial heart valves and using monkeys’ hearts to keep ill people alive. [18]

Following the determination of Dr. Barnard, coronary assist devices and mechanical heartsare being developed to perform the functions of live tissues. Since the 1950s, artificial hearts have been under development. A booster pump was first implanted successfully as a temporary assist device in 1966.

Barnard made medical history again when he performed a “ twin-heart” operation in 1974, which is seven years after his first heart transplant. This time, he only removed the diseased part of the heart of a 58-year-old man and replaced it with the heart of a 10-year-old child. The donor heart acted as a booster and back-up for the patient’s disease-ravished organ.[19] However, the patient died within four months even though Barnard was optimistic about this new operation which he believed was less radical than a total implantation.

Conclusion

Barnard retired as Head of the Department of Cardiothoracic Surgery in Cape Town in 1983 after developing rheumatoid arthritis in his hands, which prevented him from operating. At the time of his retirement, Barnard investigated the controversial “ rejuvenation” therapy offered by the Clinique La Prairie in Switzerland. In particular, he received considerable adverse publicity over his comments with regard to an “ anti-ageing” skin cream, known as Glycel, which was intended to reduce wrinkling. Barnard was also invited to act as a consultant at Baptist Medical Center in Oklahoma City where a new heart transplant program was being planned. In later life spending much of his time at the Baptist Medical Centre in Oklahoma, where he tried to find a way of slowing the ageing process. It seemed he was

searching for a miracle to match his first. Despite the problems and techniques faced, Barnard continued to further his knowledge and researches in heart transplant. This has become an inspiration to the others in the aim to perform more successful heart transplant. The hard-work of Dr. Barnard and his team will be memorized by people forever.

Reference

1. Barnard, Christiaan. (n. d.). Retrieved August 21, 2009, from http://www. encyclopedia. com/doc/1G2- 3437500078. html

2. Christiaan Barnard. (n. d.). Retrieved August 21, 2009, from http://en. wikipedia. org/wiki/Christiaan_Barnard

3. Christiaan Barnard. (n. d.). Retrieved August 21, 2009, from http://www. answers. com/main/ntquery? s= christiaan+barnard&gwp= 13

4. Christiaan N. Barnard. (n. d.). Retrieved August 21, 2009, from http://www. novelguide. com/a/discover/ewb_02/ewb_02_00449. html

5. Christiaan Barnard Biography. (n. d.). Retrieved August 24, 2009, from http://www. notablebiographies. com/Ba-Be/Barnard-Christiaan. html

6. Dr Christiaan Barnard. (n. d.). Retrieved August 24, 2009, from http://www. dinweb. org/dinweb/DINMuseum/Dr%20Christiaan%20Barnard. asp

Christiaan Barnard. (n. d.). Retrieved August 24, 2009, from http://www. answers. com/main/ntquery? s= christiaan+barnard&gwp= 13

8. Heart Transplant, History of Heart Transplantation. (n. d.). Retrieved August 25, 2009, from http://www. cumc. columbia. edu/dept/cs/pat/hearttx/history. html

9. http://www. springerlink. com/content/q3266367g54588th/. Retrieved 24. 8. 2009.

10. BBC News | HEALTH | Christiaan Barnard: Single-minded surgeon. (2001). Retrieved August 25, 2009, from http://news. bbc. co. uk/2/hi/health/1470356. stm

11. Dr. Christiaan Barnard: Biography. (n. d.). Retrieved August 25, 2009, from http://www. answers. com/topic/dr-christiaan-barnard

12. Lower, R. R., & Shumway, N. E. (1960). Studies on orthotopic homotransplantation of the canine heart. Surg Forum, 11, pp. 18-20.

13. Barnard, C. N. (1968). What we have learned about heart transplants. J Thorac Cardiovasc Surg, 56, pp. 457-468.

14. Blaiberg, P. (1969). Looking at my heart. London: Heinemann.

15. Cooper, D. K. C., & Lanza, R. P. (1984). Heart transplantation at the University of Cape Town—an overview (appendix). In Cooper, D. K. C. & Lanza, R. P. (Eds.), Heart transplantation (pp. 351-360). Lancaster: MTP Press.

16. Brink, J. (1996). Twenty-three year survival after orthotopic heart transplantation [letter]. J Heart Lung Transplant, 15, pp. 430-431.

17. Barnard, C. N., & Losman, J. G. (1975). Left ventricular bypass. S Afr Med J, 49, pp. 303-312.

18. Novitzky, D., Cooper, D. K. C., Rose, A. G., & Barnard, C. N. (1984). The value of recipient heart assistance during severe acute rejection following heterotopic cardiac transplantation. J Cardiovasc Surg, 25, pp. 287-295.

19. Barnard, C. N., Wolpowitz, A., & Losman, J. G. (1977). Heterotopic cardiac transplantation with a xenograft for assistance of the left heart in cardiogenic shock after cardiopulmonary bypass. S Afr Med J, 52, pp. 1035-1039.

20. Cooper, D. K. C. (2001). Christiaan Barnard and his contributions to heart transplantation. The Journal of Heart and Lung Transplantation, 20 (6), 599-610.

21. Brink, J. G., &Cooper, D. K. C. (2005). Heart transplantation: The contributions of Christiaan Barnard and the University of Cape Town/Groote Schuur Hospital. World Journal of Surgery, 29 (8), 953-961.

22. (Heart Transplantation: The Contributions of Christiaan Barnard, 2005; Heart Transplantation: The Contributions of Christiaan Barnard, 2005)

[1] Barnard, Christiaan. (n. d.). Retrieved August 21, 2009, from http://www. encyclopedia. com/doc/1G2- 3437500078. html

[2] Christiaan Barnard. (n. d.). Retrieved August 21, 2009, from http://en. wikipedia. org/wiki/Christiaan_Barnard

[3] Christiaan Barnard. (n. d.). Retrieved August 21, 2009, from http://www. answers. com/main/ntquery? s= christiaan+barnard&gwp= 13

[4] Christiaan N. Barnard. (n. d.). Retrieved August 21, 2009, from http://www. novelguide. com/a/discover/ewb_02/ewb_02_00449. html

[5] Christiaan Barnard Biography. (n. d.). Retrieved August 24, 2009, from http://www. notablebiographies. com/Ba-Be/Barnard-Christiaan. html

[6] Dr Christiaan Barnard. (n. d.). Retrieved August 24, 2009, from http://www. dinweb. org/dinweb/DINMuseum/Dr%20Christiaan%20Barnard. asp

[7] Lower, R. R., & Shumway, N. E. (1960). Studies on orthotopic homotransplantation of the canine heart. Surg Forum, 11, pp. 18-20.

[8] Barnard, C. N. (1968). What we have learned about heart transplants. J Thorac Cardiovasc Surg, 56, pp. 457-468.

[9] Blaiberg, P. (1969). Looking at my heart. London: Heinemann.

[10] Cooper, D. K. C., & Lanza, R. P. (1984). Heart transplantation at the University of Cape Town—an overview (appendix). In Cooper, D. K. C. & Lanza, R. P. (Eds.), Heart transplantation (pp. 351-360). Lancaster: MTP Press.

[11]Brink, J. (1996). Twenty-three year survival after orthotopic heart transplantation [letter]. J Heart Lung Transplant, 15, pp. 430-431.

[12] Barnard, C. N., & Losman, J. G. (1975). Left ventricular bypass. S Afr Med J, 49, pp. 303-312.

[13] Novitzky, D., Cooper, D. K. C., Rose, A. G., & Barnard, C. N. (1984). The value of recipient heart assistance during severe acute rejection following heterotopic cardiac transplantation. J Cardiovasc Surg, 25, pp. 287-295.

[14] Barnard, C. N., Wolpowitz, A., & Losman, J. G. (1977). Heterotopic cardiac transplantation with a xenograft for assistance of the left heart in cardiogenic shock after cardiopulmonary bypass. S Afr Med J, 52, pp. 1035-1039.

[15] Christiaan Barnard. (n. d.). Retrieved August 24, 2009, from http://www. answers. com/main/ntquery? s= christiaan+barnard&gwp= 13

[16] Heart Transplant, History of Heart Transplantation. (n. d.). Retrieved August 25, 2009, from http://www. cumc. columbia. edu/dept/cs/pat/hearttx/history. html

[17] (Heart Transplantation: The Contributions of Christiaan Barnard, 2005; Heart Transplantation: The Contributions of Christiaan Barnard, 2005)

[18] BBC News | HEALTH | Christiaan Barnard: Single-minded surgeon. (2001). Retrieved August 25, 2009, from http://news. bbc. co. uk/2/hi/health/1470356. stm

[19] Dr. Christiaan Barnard: Biography. (n. d.). Retrieved August 25, 2009, from http://www. answers. com/topic/dr-christiaan-barnard