

# The Arterial Switch Operation (1954-1975)

The arterial switch operation, also called the Jatene procedure, is an operation in which surgeons redirect the flow of blood through abnormal hearts. In 1975, Adib Jatene conducted the first successful arterial switch operation on a human infant. The arterial switch operation corrects a condition called transposition of the great arteries, abbreviated TGA, also called transposition of the great vessels, abbreviated TGV. TGA occurs when the pulmonary artery, which supplies deoxygenated blood to the lungs, and the aorta, which takes oxygenated blood to the body, are switched, or transposed. The switch between the aorta and pulmonary artery results in dangerously low levels of oxygen, a condition called cyanosis, in newborn infants, which causes them to die if a surgeon does not correct it.

The arterial switch operation replaced the common surgical technique used to correct TGA called the Mustard operation, which William Mustard had developed in the 1950s. The Mustard operation was an operation that diverted blood flow through a series of baffles, or pieces of tissue, to redirect blood flow through the transposed arteries instead of anatomically correcting the switch. Mustard, along with Åke Senning, had enabled infants born with the TGA to live a relatively normal life. However, later surgeons wanted not just to treat those with TGA, but also to correct the issue and to put the vessels back to their anatomically correct positions.

Mustard attempted his version of the arterial switch operation in 1954 on three infants at the Toronto's Hospital for Sick Children in Toronto, Ontario. Mustard's attempt was performed on a six-week-old infant and two nineteen-day-old infants. There are two coronary arteries, left and right, and are normally attached to the aorta. Mustard transferred the aorta and pulmonary artery but chose to only transfer the left coronary artery.

Mustard's attempts at the operation were unsuccessful as all three infants died in the operating room. The six-week-old infant died from bleeding where Mustard and his team had closed the aorta in the new position. One of the nineteen-day-old infants died from an irregular heart rhythm called ventricular fibrillation. The other nineteen-day-old infant died from a blockage in the left coronary artery.

After those operations, Mustard made several notes in regards to the operation. Mustard noted that there was a difference in the size of the pulmonary artery and aorta and that there was a variation in coronary artery patterns. Coronary artery patterns are patterns in size discrepancies along with striations on the coronary arteries.

During the early 1950s, Charles Bailey and his colleagues at the Hahnemann University Hospital in Philadelphia, Pennsylvania, attempted several times to perform the arterial switch operation successfully. Bailey termed the surgery the switchover operation.

Bailey theorized that the death of TGA patients resulted from an insufficient amount of blood returning to the heart via the coronary arteries. Bailey and his coworkers experimented on domestic dogs and lowered the dogs' blood temperatures below normal, a phenomenon called hypothermia. They did so to see if they could use that technique to operate on animals and then use the technique in cardiac surgery on humans.

After successfully operating on dogs, Bailey and his colleagues began testing the technique on humans. They used the initials H.D. to refer to the first human patient that they operated on using their hypothermia technique. Their operation on H.D. occurred on 29 August 1952. That patient was not afflicted with TGA but had a different cardiac condition that required a similar treatment.

Bailey and his colleagues next used their hypothermia technique on patients with TGA. On 7 November 1952, Bailey and his team performed their first operation on a patient with TGA. The patient was a ten-month-old male infant referred to as E.K. Bailey and his team performed an atrial septal defect operation, a procedure that creates a hole between the left and right atrium of the heart. Bailey theorized that the operation would allow oxygenated and deoxygenated blood to mix, resulting in increased amount of oxygen in the heart. After Bailey and his team closed the atrium, E.K. died of an irregular heart rhythm.

Following the failed operation, Bailey and his team performed surgery on patients with TGA three additional times. C.R. an eleven-day-old infant girl, G.N. a three-month old boy, and K.C. a seven-month old boy, were operated on 24 December 1952, 6 March 1953, and 10 November 1952 respectively. All three died.

On 10 November 1952, Bailey operated on K.C. under hypothermia at a temperature of 71 degrees Fahrenheit, or about 22 degrees Celsius. Bailey and his team cut and switched the pulmonary artery and aorta, and then permanently connected them. In the operation of K.C., Bailey noted that the blood flow ceased for twenty-two minutes, the longest of Bailey's operations under hypothermia. Despite the length of time without circulation, K.C. was awake and crying three hours after operation. During a bronchoscopy, in which doctors observe the airway, K.C. had a cardiac arrest and died thirty hours after his operation. Bailey said that without this accident, K.C. would have survived.

After Bailey, Viking Björk, a physician in Stockholm, Sweden, made a proposal about the mechanisms of the arterial switch operation. In a 1954 article, Björk theorized about connections between the aorta and pulmonary artery as a means of correcting blood flow. Björk tested his theories through surgeries on domestic dogs.

In the early 1970s, Jatene proposed another technique and began looking into TGA. In his 1976 article "Anatomic Correction of Transposition of the Great Arteries," Jatene was affiliated with the Instituto Dante Pazzanese de Cardiologia, or Dante Pazzanese Institute of Cardiology, in São Paulo, Brazil. Jatene prepared for the surgery before he actually attempted the surgery to correct TGA. Part of his preparation included observing sixty-two specimens of TGA that he observed in the lab of Dante Pazzanese. Based on the research he had done, he theorized that the operation would be successful if both of the coronary arteries were switched.

The arterial switch operation involves surgically switching the vessels and switching the coronary arteries to put them on the pulmonary artery instead of the aorta where they were previously located. On 4 May 1975, Jatene first attempted the arterial switch operation on a three-month old female infant. The infant died three days after the operation from kidney failure.

On 8 May 1975, Jatene performed the first successful arterial switch operation on a forty-day-old male infant. To perform the operation, Jatene and his surgical team cooled the infant to a temperature of 16 degrees Celsius, 21 degrees colder than the normal body temperature. Once the infant's heart stopped beating, Jatene began operating to correct the transposition. Jatene cut the aorta, pulmonary artery, and both coronary arteries, and then aligned them into their correct anatomical position. As the aorta and pulmonary artery were in the wrong anatomic locations, the surgeons surgically placed in their correct positions. Along with the vessels being switched, the coronary arteries were placed from the aorta to the pulmonary artery. Jatene transferred both coronary arteries, a technique that differed from other surgeons' techniques or proposals.

After Jatene published his results in 1976, the Jatene operation steadily began replacing the Mustard operation as the standard treatment of TGA. Other physicians began modifying the arterial switch operation in the following decades. In 1982, Yves Lecompte and Pascal Vouhé published "Réparation à l'Etage Ventriculaire (REV Procedure)" to discuss the changes in the arterial switch operation, which became known as the Lecompte procedure, which decreases some of the late complications of the arterial switch operation. In 2006, additional revisions to the technique had developed after Hisashi Nikaidoh published his results, which became known as the Nikaidoh procedure.

## Sources

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