Revisiting the Baffes Operation: Its Role in Transposition of the Great Arteries

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Thomas Baffes developed one of the first operations for transposition of the great arteries directing inferior vena cava flow to the left atrium using an interposed homograft in the era before open heart surgery. He performed 117 Baffes operations from 1953 to 1960, with 30% overall mortality, and an additional 85 Baffes procedures before 1968, allowing many to survive until the atrial baffle operations. During the early days before hospitals had cardiopulmonary bypass machines, Tom Baffes and colleagues purchased a heart-lung machine and transported it to various Chicago hospitals to treat patients and stimulate interest in this emerging technology.


Thomas Baffes is known for developing one of the first operations for transposition of the great arteries that directed inferior vena cava flow to the left atrium using an interposed homograft in the era before open heart surgery, but many are unaware of the selfless contribution Dr Baffes also made to medicine and congenital heart patients while traveling with a portable pump performing congenital heart surgery.

Correlation of Transposition of the Great Arteries

During Baffes’ training with Dr Willis Potts (Fig 1), first as a resident and then as an associate, he approached Potts about the possibility of correcting transposition [1]: “When I first broached to Dr Potts the idea of designing a partial venous correction for transposition of the great arteries, he puckered up his mustache, as he was wont to do, and lapsed into deep thought. After a while he said: ‘Transposition represents about half of the defects in cyanotic children coming into this hospital. We haven’t been able to do much for any of them, except those special ones having pulmonary stenosis with ventricular septal defects.’ He thought a little longer; then his eyes twinkled with excitement. ‘Go to it! I’ll get the necessary funds.’ Thus I began many happy years of inquiry and discovery under the guidance of the master surgeon.”

In 1953, Baffes embarked on a major effort in a laboratory to attempt to correct transposition in approximately 150 dogs [2]. Results paralleled those described by Blalock, Lillehei, Mustard, Bjork, and associates but on the basis of their observations, Baffes concluded that the best approach to transposition was to transpose the major veins at the base of the heart. Lillehei and colleagues had shown that patients with transposition of the aorta and pulmonary artery could live long enough to do the necessary venous anastomoses, even with the right pulmonary artery occluded. Furthermore, transfer of the veins instead of the aorta and pulmonary artery would eliminate the necessity for transferring the coronary arteries from pulmonary to systemic circulation. Baffes was faced with two undetermined issues: how much of the venous return to the heart needed to be transposed to relieve the cyanosis, and how to stage the procedures so that the patient could tolerate the maneuvers. The first clinical experience entailed transferring the right pulmonary veins to the right atrium, but the degree of clinical improvement was minimal. So they tried transferring the superior vena cava to the left atrium at the same time that they transferred the right pulmonary veins to the right atrium. In 1 patient, a temporary polyethylene shunt was used and in another, a homologous aortic graft; both patients died immediately postoperatively of superior venal caval obstruction.

It was determined to use the inferior vena cava because the position allows that no other structure would compress it after being transferred to the left atrium, and the amount of blood that returns to the heart through the inferior vena cava parallels the amount delivered through the right pulmonary veins, allowing for balance after transposition [2]. The transfer of the inferior vena cava and right pulmonary veins was through thoracotomy at the right fifth interspace [3]. The right pulmonary artery was then dissected free and early temporary occlusion was completed. The early occlusion of the right pulmonary artery before dissecting the hilar structures is a change made by Baffes and colleagues to prevent
hemorrhagic pulmonary congestion and thereby reduce operative mortality from approximately 50% to 10%. The pericardium was used to suspend the heart from the chest wall to prevent the weight of the enlarged heart from collapsing the left lung. This made survival possible for tiny infants who certainly would have died of anoxia during the procedure. Additionally, lowering the patient’s body temperature to 30°C helped infants who may not have tolerated occlusion of the pulmonary artery at a normal body temperature.

Baffes performed his first successful clinical operation on May 6, 1955, using a homologous aortic graft to transpose the inferior vena cava and the right pulmonary veins for partial correction of transposition of the aorta and pulmonary artery (Fig 2) [2, 4]. He realized that he needed a supply of homografts and established a homograft artery bank, one of the first children’s homograft artery banks in the Midwest, to preserve and store segments of processed blood vessels for use in cardiac surgery (personal communication, Mary Lou Baffes, February 9, 2013). All of these operations were performed without cardiopulmonary bypass [4].

By 1960, the team had performed the Baffes procedure on 148 total patients [3]. Patient age ranged from 6 days to 15 years. In the 1960 analysis, 117 operative procedures were evaluated for mortality, clinical results, and 6 months to 5 years of postoperative follow-up. The remaining patients were separated into a second group owing to shorter postoperative follow-up and because Teflon grafts had been used for the procedure. At the time of publication, any child with a transposition defect who...
was deemed a satisfactory operative risk was operated on regardless of age. Operative mortality was reduced significantly over the 5 years of the report (Table 1) [3].

Postoperative results were satisfactory [3]. Eighty-three patients survived with 6 months to 5 years of postoperative observation. Fifty-eight patients (70%) had minimal residual cyanosis after partial correction of the transposition defect. Exercise tolerance was improved and weight and muscular development approached normal limits, even in the youngest patients. Although dyspnea and heart failure had decreased, 18 patients (21.6%) had mild cyanosis at rest and significant cyanosis during exercise. Muscular development, although improved, was below normal. No decrease in heart size was apparent. Two patients (2.4%) had poor clinical results without improvement in cyanosis; both died several months postoperatively. Five patients (6%) who survived the procedure were lost to follow-up [3].

Thirty patients died immediately after the operation. Thirteen had cardiac failure, and 3 had cerebral vascular accidents. Six patients died of severe pulmonary hemorrhage during or immediately after the operation, and 5 infants succumbed to severe edema of the right lung. Two patients died of intercostal hemorrhage and 1 of supraventricular tachycardia. Four patients died after discharge to home: 1 of dehydration from severe diarrhea and 3 from poor response to the operative procedure and severe continued cyanosis. After review of clinical results, it was decided to not operate on transposition patients with arterial oxygen saturations of 75% or greater because these patients do not show significant improvement of peripheral arterial saturation [3].

By 1968, Baffes and coworkers completed 202 partial venous corrections (Baffes procedures) and studied 415 patients with (simple or d-) transposition of the great arteries, 140 of whom were infants who did not undergo operative therapy, allowing for an analysis of the natural progression of this anomaly [5].

Follow-up data were gathered on 45 infants and children who had postoperative catheterization studies 6 months to 10 years postoperatively [5]. Those who survived the Baffes procedure had the highest postoperative systemic arterial oxygen saturations of all palliated infants (range, 70% to 85%) even if preoperative levels were as low as 10% to 20%. These results were found to be better than palliation with the creation of atrial septal defect by the Blalock-Hanlon or open-heart techniques that resulted in arterial oxygen saturation of 60% to 75% [5].

Originally, Baffes had intended to perform a second stage that would switch the superior vena cava with the left pulmonary veins, but this was never performed clinically [4]. The Baffes operation remained an excellent treatment option for infants with transposition over the next 10 years to prolong their lives until they were large enough and old enough to undergo corrective operations [4, 5]. In addition, some patients who underwent the Baffes procedure by Dr Baffes also underwent the Mustard procedure by Dr Mustard [6] (personal communication, Mary Lou Baffes, February 9, 2013).

It is interesting that Tom Baffes reported his operation as the sole author [2]. Some contributions are thought to be so innovative, so avant garde, and so personal in execution that the originator of the idea publishes the findings alone, not so much as a selfish act but rather as a distinction that this contribution was of a singular thought and expression. William Mustard [7] reported successful two-stage correction of transposition of the great arteries in a single-authored manuscript, and Ake Senning [8] reported his Senning procedure without collaborating authors.

**Have Pump, Will Travel**

Although serious science should never be romanticized, innovative ideas are oftentimes the result of a singular mind in pensive moments. Literature and folklore is filled with these illusions to Don Quixote, the Lone Ranger, and Paladin, “the knight with no armor in a savage land.” That mid-20th century television personage traveled alone to right wrongs and settle disputes in the Old Wild West. His calling card was “Have Gun, Will Travel.” In the early days of extracorporeal circulation, Tom Baffes and his colleagues purchased a heart-lung machine and traveled between hospitals performing open heart surgery to garner support and interest in this new and growing technology (Fig 3). For them, it was “Have Pump, Will Travel.”

In 1953, Dr C. Walton Lillehei contacted Mr Van Hungerford of SigmaMotor Inc, requesting help to adapt a typical laboratory pump to be used as a blood pump in open heart surgery [9]. As is well known, before this, Dr Lillehei used donors to provide oxygenation of the blood for the patient during open-heart procedures. The team from SigmaMotor Inc traveled to Minnesota to observe Dr Lillehei’s fourth cross-circulation operation [6].

SigmaMotor’s pump was selected because two tubes could be pumped in the same unit, and the pump was modified numerous times to accommodate the needs of the patients [9]. During the period from 1953 to 1966 or 1967, about 2,700 heart pumps were sold to almost all of the open heart surgery teams of the era [9].

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Reprinted with permission from Baffes et al [3].
privileges and perform open heart surgery. Baffes literally placed the pump in the trunk of his car and transported it to the hospital where he was to perform open heart surgery. The tubes and oxygenators were purchased and used only once for each procedure. Once the operation was over, he would clean the apparatus and transport it home to be used for the next case at one of the participating hospitals.

It was during this era that he met and courted Mary Lou Baffes, a tireless nurse who attended pediatric patients at Children’s Memorial Hospital. On his first date with Mary Lou, he visited the animal laboratory with her to check on an experimental animal that he operated on earlier that day. She was fascinated. After “rounds,” they went to the movies. Shortly thereafter, they decided to marry and chose as the pastor a Greek Orthodox Priest who was Tom’s very close friend, The Reverend Andrew Kleamanakis. There was no such thing as formally trained perfusionists during this era. This function was served by interested cardiologists, specially trained nurses, or medical technicians. Baffes solved this problem by training Rev Kleamanakis, who performed admirably for quite some time in his role as traveling pump technician.

In 1964, after Dr Baffes, Riker, and De Boer had been using the traveling pump for some time in the greater Chicago area, they reported the experience, stating that although perfusion of infants and small children is similar to that of older patients, their size introduces certain challenges [10]. They repaired various congenital heart anomalies (ventricular septal defects, atrial septal defects, tetralogy of Fallot, aortic stenosis, and so forth) using the perfusion apparatus with 70 patients, each with a body surface of 0.5 m² or less. There were many changes made to the pump initially (small chambers, small venous reservoirs, and so forth), but the miniature reservoirs originally designed for the pump were unable to store enough blood to accommodate fluctuations when going on or off bypass so the standard size was used. The only two changes made to the perfusion apparatus were the insets to accommodate 3/8 inch tubing and a heat exchanger to prevent serious heat loss to the youngest patients. Mortality or morbidity was associated with the pump in only 2 of 70 patients, both of whom were extremely small owing to poor nutrition, making the patient’s length proportionately greater than weight. In both instances, the patient was overperfused because flow rates calculated by surface area were used [10].

In time, hospitals purchased their own machines and started on the policies that govern the use of the heart lung machine, specialized intensive care units, and associated professionals that we experience today. It is left to speculation how soon this would have occurred if it were not for the innovative and intrepid personalities that these cardiac surgeons exhibited.

Conclusion
Baffes went on to earn a juris doctorate of law at DePaul University and served as a partner in a law firm representing physicians wrongly accused of medical malpractice. In 1990, during his lifetime, The Thomas Baffes Visiting Lectureship was inaugurated at Children’s Memorial Hospital in Chicago, sponsored by a grateful patient who grew up to be a talented general surgeon and by the Baffes family. It is a fitting legacy for Tom Baffes to be commemorated at the very hospital that launched his career and at which he made his singularly innovative contribution to surgery and mankind. His humility and humanity are expressed in his own words: “My greatest sense of accomplishment is derived from having been heavily involved in the education of about 100 surgeons,

Fig 3. The SigmaMotor Inc pump used by Thomas Baffes and colleagues. Courtesy of Mary Lou Baffes.
who have gone all over the world to serve their communities” [11].

References