The Blalock-Taussig-Thomas Collaboration
A Model for Medical Progress

SUMMARY OF THE ORIGINAL ARTICLE

The Surgical Treatment of Malformations of the Heart in Which There Is Pulmonary Stenosis or Pulmonary Atresia

Alfred Blalock, MD; Helen B. Taussig, MD

JAMA. 1945;128(3):189-202

Heretofore there has been no satisfactory treatment for pulmonary stenosis and pulmonary atresia. A “blue” baby with a malformed heart was considered beyond the reach of surgical aid. During the past three months we have operated on 3 children with severe degrees of pulmonary stenosis and each of the patients appears to be greatly benefited. In the second and third cases, in which there was deep persistent cyanosis, the cyanosis has greatly diminished or has disappeared and the general condition of the patients is proportionally improved. The results are sufficiently encouraging to warrant an early report.

The operation here reported and the studies leading thereto were undertaken with the conviction that even though the structure of the heart was grossly abnormal, in many instances it might be possible to alter the course of the circulation in such a manner as to lessen the cyanosis and the resultant disability. It is important to emphasize the fact that it is not the cyanosis, per se, which does harm. Nevertheless, since cyanosis is a striking manifestation of the underlying anoxemia and the compensatory polycythemia, a brief discussion of the causes of cyanosis and the factors operative in congenital malformations of the heart is essential in order to understand the principles underlying the present operation.

See www.jama.com for full text of the original JAMA article.

Commentary by Anne M. Murphy, MD
Duke E. Cameron, MD

At the time the classic study of Alfred Blalock and Helen Taussig was published in 1945, the care of patients with cyanotic congenital heart disease was an exercise in clinical-pathologic correlation, rather than care with therapeutic hope. Historically it occurred at a time when the Johns Hopkins Hospital had racially segregated wards, and women were rarely appointed to medical school faculty. As a result of the publication of this study, an era of cardiac surgical intervention blossomed, and the field of pediatric cardiology rose to prominence as a subspecialty in pediatrics. The work also served as a model for bench to bedside investigation and later became a catalyst to address historical injustices in medicine.

The most common congenital heart defect associated with cyanosis is tetralogy of Fallot. This lesion consists of a defect in the ventricular septum that lies below an aorta that is dextroposed and thus overrides the defect, obstruction to pulmonary blood flow, and right ventricular hypertrophy that is secondary to pressure overload. The authors clearly stated their view that the fundamental cause for cyanosis in this type of defect and the more severe variant with pulmonary atresia was a decrease in blood flow to the pulmonary arterial bed. As a previous commentary about this article noted, this pathophysiologic mechanism was by no means generally accepted at the time. The clinical observations of Taussig that infants with pulmonary atresia would often die of profound hypoxemia when the ductus arteriosus spontaneously closed led to the hypothesis that providing additional pulmonary blood flow, by connecting a systemic artery to the pulmonary artery, would alleviate cyanosis. This concept was tested in Blalock’s surgical laboratory; although they were unsuccessful in creating a model with pulmonary stenosis and cyanosis, a model with partial lung resection and creation of pulmonary arteriovenous fistulae sufficed to reproduce the right to left shunt and decreased pulmonary blood flow. Using this animal model Blalock’s team demonstrated that anastomosis of a systemic artery to the pulmonary artery was feasible and improved the arterial oxygen saturation.

The study provided a detailed description of the operations on the first 3 children in the series. All patients were...
clinically improved. In 2 of the patients, laboratory studies clearly demonstrated the increase in arterial oxygen saturation and decrease in polycythemia as a result of the surgery, whereas 1 patient was too small to conduct these studies. Careful serial observation of the patients provided reassurance that use of the subclavian artery or, as in the last 2 cases, the innominate artery for the shunt did not result in loss of the extremity or brain injury. Severe bleeding from the anastomosis site was not an issue in the first patients, although minor bleeding was one of the more common complications (13%) in the early era of the procedure. Furthermore, these studies demonstrated that anesthesia could be successfully provided to cyanotic and critically ill infants and children. The summary provided a thoughtful description of the forms of heart disease for which the surgery would be helpful, specifically more complex lesions in which decreased pulmonary blood flow contributed to hypoxemia, as well as situations in which the shunt might not provide relief. The depth of analysis was remarkable for an era in which the primary diagnostic tools were the clinical history, physical examination, plain films, and fluoroscopy.

**Progress and Advances**

What advances have ensued in the subsequent 6 decades in the care of patients with tetralogy of Fallot? Progress in the interim has occurred in several areas. Definitive surgery for tetralogy of Fallot first became available in 1954. Subsequent progress in surgical technique, anesthetic management, and postoperative care has occurred to the present when early (<90 days of life) definitive repair of tetralogy of Fallot can be performed with an operative mortality rate of 3% or less. Indeed, as recently reported, the “classic” shunt has been replaced for the most part by use of prosthetic material, typically polytetrafluoroethylene. This type of “modified” Blalock-Taussig shunt is currently used in more complex disease not amenable to early definitive repair. In fact, the progress in primary repair of lesions such as tetralogy of Fallot has greatly diminished the use of the shunt in practice and now is used predominantly in more complex single-ventricle lesions.

The field has also benefited from advances in imaging technologies, from the introduction of 2-dimensional echocardiography to Doppler blood flow mapping and now to use of computed tomography and magnetic resonance imaging. Imaging spans the natural history of the disease from in utero to intraoperative studies to late follow-up in adults. These technologies provide a window not only to anatomic defects, but to pathophysiology and even metabolism. Although cardiac catheterization played a major role in anatomic assessment in tetralogy of Fallot, catheterization is currently focused on anatomic details in more complex cyanotic lesions and interventional procedures to rehabilitate pulmonary arteries with balloons and stents in more severe forms of cyanotic heart disease. Hybrid catheter interventional procedures simultaneously performed with surgical intervention have also addressed challenging issues in complex congenital heart disease.

There has also been great progress understanding the genetic contribution to tetralogy of Fallot and other congenital heart lesions. The increased incidence of associated extracardiac anomalies was documented in congenital heart disease presenting in infancy in the population-based Baltimore-Washington Infant Study. Subsequent progress has been made in identifying a number of specific genetic mutations and syndromes such as microdeletion on chromosome 22q11 in association with tetralogy of Fallot and other conotruncal defects. Increasing recognition of the lifelong needs and specific issues of adult survivors of congenital heart disease, specifically the adverse effects of right ventricular pressure and volume overload late after tetralogy of Fallot, has also led to progress in this area as well as development of strategies to train specialists devoted to this patient population. Surgical and interventional strategies have been applied to remediate the late effects of long-term pulmonary regurgitation after repair of tetralogy of Fallot.

**Cooperation Across Disciplines**

The Blalock-Taussig article foreshadowed areas of progress in medicine by providing a model for cooperation across disciplines to make striking medical progress. The surgical treatment of patients with cyanotic congenital heart disease began as collaboration between pediatric cardiologist, cardiac surgeon, and anesthesiologist as described in the article by Blalock and Taussig. To this day the interdependence and
collaboration of these specialties remain the model. Perhaps more remarkable was the prominent role of Taussig, who later became the second female full professor at Johns Hopkins. Taussig was able to attend the Johns Hopkins University School of Medicine because of the legacy of female philanthropists, including Mary Elizabeth Garrett and M. Carey Thomas, who endowed the school with the stipulation that women be admitted as students on the same basis as men.

Tragically, however, the authors of this classic article did not acknowledge a key individual in the work. The silent partner was Vivien Thomas, an African American man and Blalock’s surgical technician, who helped develop the subclavian to pulmonary anastomosis in the animal laboratory. Indeed his role was of such vital importance that he attended the early operations and is captured in a photograph standing behind Blalock in the operating room (FIGURE). The remarkable contributions of this man have been detailed in the recent HBO movie Something the Lord Made and the earlier PBS documentary Partners of the Heart. Thomas was ultimately recognized by the institution he served so well, first by the commission of a portrait that is displayed near that of his mentor Blalock, and later by the awarding of an honorary doctoral degree. Today 1 of the 4 advisory colleges for medical students at Johns Hopkins is named for Thomas, and the story of his role in this surgery is explained to every entering class.

The landmark article by Blalock and Taussig anticipated the bedside to laboratory to operating room approach that has become a cornerstone for therapeutic progress in all great academic institutions. Astute clinical observations of the presentation of an untreatable disease were combined with thoughtful laboratory experimentation and careful application to patient treatment. In this century, this model of clinical-scientific-surgical collaboration must remain vigorous to respond to ongoing challenges of complex medical conditions.

Financial Disclosures: None reported.

Additional Contributions: We thank Gerard Shorb and Andrew Harrison from the Alan Mason Chesney Medical Archives at Johns Hopkins Medical Institutions for assistance with the photograph and Vincent L. Gott, MD, and Catherine A. Neill, MD, for many discussions about the history of cardiac surgery and pediatric cardiology at Johns Hopkins.

REFERENCES