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Eponymous Cardiovascular Surgeries for Congenital Heart Diseases—Imaging Review and Historical Perspectives

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Advances in pediatric cardiology and cardiac surgical techniques over the past few decades have revolutionized the management of the patients with congenital heart disease, and many now survive into adulthood. Several eponymous surgical procedures performed for congenital heart disease have been named after eminent surgeons. In this article, we provide a short biography of the surgeons associated with these eponymous surgical procedures along with their other important scientific contributions. This is followed by a review of these surgical procedures and their most common complications. Imaging appearances of these surgical procedures along with common complications are described and illustrated, with particular emphasis on magnetic resonance imaging. The surgical procedures described in this review include Blalock-Taussig, Potts, Waterston, Glenn, Fontan, Kawashima, Norwood, Sano, Damus-Kaye-Stansel, Mustard, Senning, Jatene, LeCompte, Rastelli, Rashkind, Ross, and Waldenhausen.

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Advances in pediatric cardiology and cardiac surgical techniques over the past few decades have revolutionized the management of the patients with congenital heart disease (CHD), and many now survive into adulthood. Several eponymous surgical procedures performed for CHD have been named after eminent surgeons. The story behind the development of these surgical procedures is fascinating, which is briefly described in the article, along with other important scientific contributions of these pioneers. We then describe the surgical procedure and illustrate the postsurgical appearances, with particular emphasis on cardiac magnetic resonance imaging. This is followed by discussion of the most common complications of these surgical procedures.

Table summarizes the various surgical procedures discussed in this review. The surgical procedures described in this review include Blalock-Taussig, Potts, Waterston, Glenn, Fontan, Kawashima, Norwood, Sano, Damus-Kaye-Stansel (DKS), Mustard, Senning, Jatene or LeCompte, Rastelli, Rashkind, Ross, and Waldenhausen.

Blalock-Taussig Shunt

Biography and History

In 1944, Alfred Blalock and Helen Taussig introduced a systemic-to-pulmonary artery shunt for tetralogy of Fallot, which was then a pioneering surgical procedure in the field of pediatric cardiac surgery.[1] Alfred Blalock (1899-1964) had built his own animal laboratory while working at Vanderbilt following his surgical residency, conducting research on cardiovascular surgical procedures and shock.[2] In 1930, Vivien Thomas joined Blalock's laboratory and assumed a central role in many of his research projects. Blalock and Thomas developed an experimental model of a dog with cyanosis and subclavian to pulmonary artery shunt. When Blalock assumed the chairmanship of surgery at Johns Hopkins in 1941, Vivien Thomas[3] accompanied him to Baltimore, where they encountered Helen Taussig, the head of cardiology clinic at Hopkins, fresh out of residency. Helen Taussig (1898-1986) was born in Boston and became one of the pioneers who founded the field of pediatric cardiology and one of the first women to be awarded a full professorship at Johns Hopkins and the first female president of the American Heart Association. Taussig approached Blalock with an idea of creating a shunt that simulates patent ductus arteriosus to increase pulmonary blood flow for palliation of a "blue baby" with pulmonary stenosis. Blalock-Taussig shunt (BTS) procedure became so effective that Blalock was able to review 600 cases by 1948. Subsequently, other groups reported the effectiveness and safety of BTS for long-term palliation.[4,5] Since its development, the original technique has undergone numerous modifications but remains as an integral component of palliation for cyanotic CHD.

Surgical Procedure

The classic BTS involves ligation and division of the right or left subclavian artery followed by its direct anastomosis to the ipsilateral pulmonary artery branch (Fig. 1A and B). BTS results in improvement of arterial oxygen saturation by supplementation of pulmonary blood flow. It also helps growth of the pulmonary arteries over time as the children grow. *The modified BTS* typically

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Table
List of eponymous surgeries, the technique, and complications

Surgery	Procedure	Indications	Complications
Blalock-Taussig	End-to-side anastomosis of subclavian artery to ipsilateral pulmonary artery	Palliative for tetralogy of Fallot and RV outflow lesions First stage of Norwood	Shunt obstruction Shunt pseudoaneurysm Pulmonary artery stenosis Steal syndrome Bacterial endocarditis Chylothorax or chylous ascites Pulmonary edema Phrenic nerve paralysis
Modified Blalock-Taussig	Graft between subclavian artery and ipsilateral pulmonary artery	Palliative for tetralogy of Fallot and RV outflow lesions First stage of Norwood	Serous fluid leakage or seroma Shunt stenosis Shunt pseudoaneurysm
Potts shunt	Side-to-side anastomosis of left pulmonary artery to descending aorta	Palliative for tetralogy of Fallot and RV outflow lesions	Increased pulmonary blood flow Pulmonary edema Pulmonary hypertension Respiratory failure Cardiac failure
Waterston shunt	Side-to-side anastomosis of ascending aorta to the right pulmonary artery	Palliative for tetralogy of Fallot and RV outflow lesions	Stenosis or obstruction of anastomotic site Increased pulmonary flow Thrombosis Hypoplasia of left pulmonary artery Pulmonary artery aneurysm, rupture, or dissection
Glenn	Original—right atrium-pulmonary artery Bidirectional—SVC to right pulmonary artery	Second stage of single ventricular repair	Pleural effusion Shunt occlusion or obstruction Pulmonary AVM or fistula Atrial arrhythmia Atrial thrombus
Fontan	IVC connected to right pulmonary artery	Third stage of single ventricular repair	Arrhythmias Thrombosis in Fontan conduit or right side of heart Pulmonary AVM Right atrial hypertension Chylothorax Protein-losing enteropathy
Kawashima	Bilateral bidirectional Glenn, placement of conduit between intact SVC-right atrial junction and pulmonary artery	Single ventricle and interrupted IVC	Pulmonary AVM
Norwood procedure	Stage I—anastomosis of proximal pulmonary artery to hypoplastistic arch; atrial septectomy; resection of coarctation; aortopulmonary shunt Stage II—Hemi-Fontan or Bidirectional Glenn Stage III—Fontan	Single ventricle repair	Respiratory failure Renal failure Neurologic complications Pleural effusion Pericardial effusion Ascites Pulmonary hypertension
Sano	RV pulmonary artery shunt	First stage of Norwood instead of BT shunt	Dynamic outflow obstruction or shunt stenosis Stenosis or kinking of shunt Dysrhythmia Hypoxia
Damus-Kaye-Stansel	Transection of pulmonary artery near bifurcation and anastomosis to the side of ascending aorta.	D-TGA and VSD Tricuspid atresia with TGA Double-inlet left ventricle TGA with hypoplastic right heart Common AV canal	Pulmonary regurgitation Recurrent systemic ventricular outflow obstruction
Mustard	Atrial switch using a prosthetic patch	D-TGA	RV failure Baffle stenosis Pulmonary hypertension Pulmonary edema Pleural effusions Hepatic congestion Ascites
Senning	Interatrial baffle using autogenous atrial tissue	D-TGA	Chronic RV overload and dysfunction Systemic or pulmonic baffle stenosis or leaks Atrial arrhythmia Tricuspid insufficiency Sudden cardiac death

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