

Cardiac Cath Labs

Their Origins and Their Future



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More than 1 million diagnostic cardiac catheterizations (excluding percutaneous coronary intervention–only procedures) are performed each year in the nearly 2,000 cardiac catheterization laboratories in the United States.¹ CHEST 2018; 154(3):487-490

How Did the Diagnosis of Heart Disease by Catheter Begin?

It began in 1929 when Werner Forssmann, a surgical intern in Germany, was trying to find a method to inject drugs into patients with cardiac emergencies. He inserted a urinary catheter into one of his arm veins and advanced it to the right atrium. Then he documented the presence of the catheter within the heart with a chest radiograph.² His success disproved the commonly held view at the time that such an invasion of the heart would be immediately fatal.³

In 1941, Cournand and Richards were studying shock and cardiac output at Bellevue Hospital in New York. Noting Forssmann's paper,² they determined that if they could pass a catheter to the right atrium, they could obtain a sample of mixed venous blood that was needed to calculate cardiac output by the Fick method. They succeeded in measuring the oxygen content of blood from the right atrium and published the first paper on cardiac catheterization of the right auricle in man in 1941.⁴ These investigators then further developed the technique of right heart

catheterization to measure oxygen content and intracardiac pressure in the right atrium, right ventricle, and the pulmonary artery in normal subjects and in hundreds of patients with a variety of diseases.⁵

Cournand did not study patients with heart disease and did not use right heart catheterization to diagnose heart disease. He left that for others. In a 1947 paper, he stated: "Sound physiologic methods for the study of the pulmonary circulation are now at the disposal of the clinical investigator and may be used for diagnostic purposes in well-chosen cases of congenital cardiac malformation."⁶ One of the co-investigators listed in this 1945 publication⁵ was one of the first individuals to use the technique of right heart catheterization to diagnose congenital heart disease. In a 1946 paper, Baldwin and colleagues⁷ reported the diagnosis of ventricular septal defect by right heart catheterization in two patients. The patients were studied at Presbyterian Hospital in New York City. We were unable to find other publications from Baldwin or evidence that she had established a cardiac catheterization laboratory.

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In 1956, Forssmann, Cournand, Richards, and Ranges were awarded the Nobel prize in Medicine for their catheterization investigations.

Emergence of Diagnostic Cardiac Cath Labs

Over the 3 years from 1943 to 1945, cardiac cath labs to diagnose congenital heart disease were established in three major medical centers in the United States.⁸⁻¹⁰ Each used the technique of right heart catheterization developed by Cournand and Ranges⁵ to measure oxygen content and pressures within the right heart chambers. Of note, each of these first three cardiac cath labs were staffed by young investigators who had strong support from major leaders in their medical school (Table 1).

Grady Hospital, Emory Medical School

Eugene Stead was a fellow in the laboratory of Soma Weiss at the Peter Bent Brigham Hospital, Boston, when in 1942 at age 34, he was named chairman of Medicine at his alma mater, Emory Medical School. He established several research laboratories in the basement of Emory's major teaching hospital, Grady Hospital, in Atlanta.¹¹ Stead encouraged James Warren, then age 28, to establish the world's first diagnostic cardiac cath lab at Grady Hospital in 1943. In 1945, this lab reported the diagnosis of atrial septal defect in four patients.⁸

By 1946, Warren and his colleagues had performed > 500 right heart catheterizations in patients with a wide variety of medical conditions.¹²

Peter Bent Brigham Hospital, Harvard Medical School

The second cardiac catheterization laboratory was established at the Peter Bent Brigham Hospital by Lewis Dexter in 1945.⁹ In 1944, Dexter, age 35, who also had been a fellow with Soma Weiss, was investigating renin in patients with hypertension. He used a fluoroscope to place a catheter in the renal vein to draw blood from the

kidneys of patients with hypertension. In December 1944, he was maneuvering the catheter when its tip suddenly appeared in the lung field. He at first feared that the catheter had perforated the heart. He then realized that the catheter had found its way through the right heart chambers and into the pulmonary artery.¹³ At lunch that day, Dexter sat next to the dean of Harvard Medical School, Charles Burwell, who had a great interest in cardiac physiology. He told Dexter: With what you did today "you can now diagnose congenital heart disease." Furthermore, he told Dexter that he could use the dean's own laboratory to get started.¹⁴ Dexter stopped working on renin and established the world's second cardiac cath.⁹ In 1946⁹ and 1947,^{15,16} he reported the diagnosis of ventricular septal defect, patent ductus arteriosus, tetralogy of Fallot, pulmonic stenosis, and atrial septal defect. He was the first to report that pulmonary capillary pressure measured when a catheter occluded a distal branch of the pulmonary artery was, in fact, pulmonary venous pressure.¹⁷ That discovery made it possible for Richard Gorlin, a Dexter trainee, to develop a formula to calculate mitral valve area in patients with rheumatic mitral stenosis.¹⁸

Dexter continued to direct his cath lab at the Peter Bent Brigham Hospital until his retirement in 1975. During the 30 years of the Dexter lab, he and his fellows published important papers on congenital heart disease, valvular heart disease, and pulmonary embolism.¹³

Johns Hopkins Hospital, Johns Hopkins Medical School

Johns Hopkins in the 1940s was the center for the study and treatment of patients with congenital heart disease. Helen Taussig, a brilliant diagnostician despite being deaf, was director of the Children's Cardiac Clinic. In 1940, Alfred Blalock was appointed chief of surgery at Hopkins. Working with Taussig, Blalock developed a systemic to pulmonary shunt to treat patients with tetralogy of Fallot. This procedure, later to be called the "blue baby operation" was successfully performed at Hopkins in 1944. The success of this first operation in patients with congenital heart disease sparked interest in congenital disease throughout the world.¹⁹

R.J. Bing, a German physician, came to the United States in 1936 to begin an apprenticeship at the Rockefeller Institute. During the next 10 years, he held a variety of positions. He spent several years as a resident in surgery at Columbia Presbyterian Hospital and then three years

TABLE 1] First Three Diagnostic Cardiac Catheterization Laboratories

Hospital	Year	Investigator	First Publication
Grady, Atlanta (Emory)	1943	James Warren	1945 ⁸
Peter Bent Brigham (Harvard)	1945	Lewis Dexter	1945-1947 ⁹
Johns Hopkins Hospital	1945	Richard Bing	1947 ¹⁰

as an instructor in physiology at Columbia. While at Columbia, he spent some time in Cournand's laboratory. His next appointment was as an instructor in medicine at Johns Hopkins. At the outbreak of World War II, he joined the US Army Medical Corps. One day in 1944, while he was eating in the mess hall, he received a phone call that changed his life. Alfred Blalock called to ask him to come back to Hopkins and establish a cardiac cath lab in the department of surgery to study patients with congenital heart disease.¹⁹ At that time, there were only two diagnostic cath labs in the world: Grady hospital in Atlanta and Peter Bent Brigham in Boston.²⁰

Bing, age 36, set up his catheterization laboratory in 1945; by 1947, he had published a series of papers describing how to diagnose congenital heart disease.^{10,21,22} Bing worked closely with Helen Taussig. Together they delineated the hemodynamic features of 20 different forms of congenital heart disease.¹⁹ After establishing and directing the cardiac cath lab at Hopkins for seven years, Bing moved to The University of Alabama Medical School to work with Tinsley Harrison.¹⁹

Table 2 lists the first diagnosis of a variety of congenital heart defects by the leaders of these first three cardiac cath labs.

Beyond Right Heart Catheterization

With the introduction of left heart catheterization by Zimmerman et al in 1950,²³ the primary indication for cardiac catheterization shifted from the diagnosis of congenital heart disease to the diagnosis and evaluation of valvular heart disease. The introduction of echocardiography led to a decrease in the number of catheterizations for congenital heart disease as well as for valvular heart disease.²⁴ However, the introduction of coronary arteriography²⁵ led to a huge increase in catheterizations to evaluate coronary artery disease. The

TABLE 2] Diagnosis of Congenital Heart Defects by Cardiac Catheterization

Defect	First Published Report	Year
Atrial septal defect	Brannon et al ⁸	1945
Ventricular septal defect	Baldwin et al ⁷	1946
Patent ductus arteriosus	Dexter et al ⁹	1946
Pulmonic stenosis	Dexter et al ⁹	1946
Tetralogy of Fallot	Bing et al ²¹	1947
Eisenmenger's complex	Bing et al ²¹	1947

introduction of percutaneous transluminal coronary angioplasty by Gruentzig et al²⁶ revolutionized the practice of cardiology. The number of cath labs in the United States has now increased to nearly 2,000,¹ and the number of catheterizations for percutaneous coronary interventions now exceeds the number of diagnostic catheterizations.¹

A Final Note

Did any of these three investigators or their mentors suspect that one day millions of people each year in the United States would undergo diagnostic catheterization or percutaneous coronary intervention in one of the nearly 2,000 cath labs in the United States?¹ Did they ever suspect that one day cardiac catheterization would be a billion-dollar business? Did they ever dream that one day virtually every type of heart disease would be identified by cardiac catheterization and other procedures and, once identified, could be successfully treated?

The Future of Cardiac Cath Labs

Recent years have seen a variety of new procedures performed in the cardiac cath lab and in a variety of similar interventional suites in other areas of the hospital: valve repairs and replacement, closure of a number of congenital heart defects, peripheral vascular interventions for limb and cerebral vascular obstruction, mechanical approaches seeking to prevent arterial embolism from the heart or dissolving thrombi already present in the peripheral and cerebral arterial circulation. Other catheter interventions include a variety of approaches for managing venous disease as well as cardiac electrophysiology procedures seeking to control atrial and ventricular arrhythmias. The volume of these procedures is increasing every year, resulting in a lessened need for so-called "open" operations for many individuals with cardiovascular disease. Practitioners are no longer cardiologists alone. Indeed, a considerable number of radiologists, vascular surgeons, and cardiothoracic surgeons are now performing interventional procedures in the cath lab and in specially designed interventional suites. Indeed, the cardiac cath lab has now "metastasized" and is found in radiology departments and in operating rooms. It is anticipated that this trend will continue in the future, leading to shorter hospitalizations, less morbid interventions, and shorter times for patients to recover from procedures.

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