History of Cardiac Catheterization

- Catheter inserted here (femoral artery)
- Path of catheter into coronary artery
- Catheter in left ventricle
Catheterization

= Putting a hollow tube into a lumen
3000 B.C. – Egyptians performed bladder catheterizations using metal pipes

400 B.C. – Catheters fashioned from hollow reeds and pipes were used in cadavers to study the function of cardiac valves

1711 – Hales conducted the first cardiac catheterization of a horse using brass pipes, a glass tube and the trachea of a goose
1844 – French physiolologist **Bernard** coined the term “cardiac catheterization” and used the catheters to record intracardiac pressures in animals

1844 : 1\textsuperscript{st} cardiac right and left heart catheterization: **Claude Bernard**

- in a horse: RV entered via jugular vein
- LV entered via carotid artery

**Claude Bernard**: French physician & professor of physiology
Followed by period of investigations of CV physiology in animals:

→ pressure manometry

→ Fick cardiac output
1929: 1st documented cardiac catheterization in human
- **Werner Forssmann**, in Eberswald, Germany, on himself
- Catheter in L antecubital vein, guided by fluoroscopy into RA
- Walked to Radiology, on a different floor
- Documented on CXR
1941 – Cournand and Richards employed the cardiac catheter as a diagnostic tool for the first time, utilising catheter techniques to measure cardiac output.
Cardiac Catheterization

Passage of a catheter through peripheral arteries or veins into cardiac chambers and coronary arteries

Can be used to perform various tests:

- measure O2 saturation
- Measure pressures
- Measure cardiac output
- angiography
- intravascular ultrasound, FFR
- measurement of cardiac output CO
- endomyocardial biopsy
Andre Cournand: 1895 – 1988
French physician and physiologist
Moved to USA and became an American citizen in 1941

Cournand catheter:
➣ A right heart catheter w end hole, no side holes
➣ Suitable for wedge pressure measurement
The Nobel Prize in Physiology or Medicine 1956:
- Andre F Courmand
- Werner Forssmann
- Dickinson w. Richards

1956 – Forssmann, Courmand and Richards shared the Nobel Prize.
Courmand stated in his acceptance speech “the cardiac catheter was . . . the key in the lock”.

For the development of cardiac catheterization
The technique employed in catheterization of the left heart in man is described. A catheter is introduced into the left ulnar artery and passed through the brachial, axillary and subclavian arteries into the arch of the aorta. With the tip of the catheter at the root of the aorta, we have succeeded in entering the left ventricle only in patients with free aortic insufficiency due to syphilis. Failure to pass the aortic valves in normal subjects is discussed.
1953: Percutaneous technique: Seldinger

The Seldinger technique
1958: The diagnostic coronary angiogram – the key to selective imaging of the heart was discovered by: Mason Sones

1958 – Selective coronary angiogram: Mason Sones
Mason Sones (1919 – 1985)

While conducting an imaging procedure in which dye was to be injected into the aortic valve of a patient with valvular disease, Dr Mason Sones, a paediatric cardiologist at the Cleveland Clinic discovered that the catheter had accidentally entered the patient’s right coronary artery and, before it could be removed 30 ccs of contrast dye had been released. He expected the heart to fibrillate, but it did not and Sones discovered that the coronary arteries could tolerate contrast dye. Sones recalled “I knew that night that we finally had a tool that would define the anatomic nature of coronary artery disease.”
While conducting an imaging procedure in which dye was to be injected into the aortic valve of a patient with valvular disease, Dr. Mason Sones, a paediatric cardiologist at the Cleveland Clinic discovered that the catheter had accidentally entered the patient’s right coronary artery and, before it could be removed, 30 ccs of contrast dye had been released. He expected the heart to fibrillate, but it did not and Sones discovered that the coronary arteries could tolerate contrast dye. Sones recalled “I knew that night that we finally had a tool that would define the anatomic nature of coronary artery disease.”

Sones went on to perfect a revolutionary new technique for producing high quality diagnostic images of the coronaries, using specially designed catheters. This breakthrough would make possible, for the first time, accurate diagnosis of coronary disease and set the stage for future therapeutic interventions, such as bypass surgery and, later on, coronary angioplasty.
Selective catheterization of the left coronary artery using the Sones catheter.

The standard approach involved forming a smooth shallow loop and gradually “inching up” to the ostium from below.
Selective catheterization of the left coronary artery using the Sones catheter. The standard approach involved forming a smooth shallow loop and gradually “inching up” to the ostium from below.

When the Sones method is used from the right arm, catheter tip pressure should be monitored continuously once the catheter enters the brachial artery. Further passage of the catheter into the subclavian and brachiocephalic arteries should be accomplished under both pressure monitoring and fluoroscopic visualization. Occasionally, it may be difficult to pass the catheter from the subclavian artery to the aortic arch, but a simple manoeuvre by the patient – such as deep inspiration, shrugging of the shoulders or turning the head to the left – often facilitate passage of the catheter into the ascending aorta.
Melvin Judkins & Mason Sones:
Co-founders of the Society for Cardiac Angiography 1977

Now, Society of Cardiovascular Angiography and Intervention SCAI
In 1977, the Cardiac Catheterization and Angiography Study Group met to discuss the establishment of a professional society. The first meeting of the society was held in 1978, with Sones and Judkins as Co-Chairs. Sones became the first president of the society and Judkins the second president. The society was open only to individuals who had become experts in the broad field of catheterization and angiography.
1959 – Transeptal catheterization: Ross and Cope
1964: Transluminal Angioplasty, the concept of remodelling of the artery, was introduced by Dr Charles Dotter

Charles Dotter: Considered father of Interventional Radiology. Chair of Diagnostic Radiology, Uni of Oregon Med School
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"Eclectic on the lecture platform, sociable with friends, an absolute terror to many of his peers and unprepared interns" Like Melvin Judkins, Dotter a workaholic, cared deeply for patients. Unlike Judkins, Dotter was expensive, had many interests outside his work. Judkins prefered to stay in lab or work on projects at home. Dotter, Judkins [& Gruentzig] died in 1985.
According to Angioplasty.org, in 1964, a vascular radiologist, Dr. Charles T. Dotter at the University of Oregon, introduced to the world a groundbreaking technique that opened blocked human arteries. By using multiple catheters of increasing diameters, Dr. Dotter demonstrated how blocked human arteries could be remolded and opened. Doctors had been able to see dye flowing through arteries since the late 1950’s using technology known as radiographic angiography (a test that uses an injection of a liquid dye to make the arteries easily visible on X-rays). Using angiography, Dr. Dotter was able to visually demonstrate his remarkable technique. The technique became known as transluminal angioplasty.

It was not until around 1980 that Dr. Dotter’s transluminal angioplasty technique gained acceptance in the US. Reported complications, difficulty reproducing results, and philosophical resistance plagued this medical pioneer. In the meantime, a young German physician working in Switzerland named Andreas Gruentzig began experimenting with adding a balloon to the Dotter multiple catheter prototype. He practiced inflating a small balloon on one catheter to achieve the same result. After successful animal experimentation, Dr. Gruentzig presented his study results to the American Heart Association (AHA) in 1976. While generally rebuffed following his presentation, he gained the interest of another physician by the name of Richard Myler from San Francisco. Together they formed a collaboration and performed the first human coronary balloon angioplasty in 1977, and in 1980 were widely applauded by the AHA on their results.
Percutaneous coronary angiography

1962: Ricketts and Abrams
1967: Judkins
1967 – First saphenous vein graft (bypass) surgery: in Cleveland Clinic Dr Rene Favaloro

Pericutaneous coronary angiography

1962: Ricketts and Abrams
1967: Judkins

1967 – Introduction of the Judkins technique of coronary angiography
With his left & right coronary catheters & pigtail catheters
He initially formed catheters by bending them to conform to the pt’s anatomy.
Later, these catheters were commercially preformed by Cordis.
Catheter from groin to heart

Catheter placed in coronary artery

Heart

Coronary artery

Catheter
Lateral: One of three positions used for High Resolution Serial Radiography
1970:

- balloon-tipped, flow guided catheter by Swan and Ganz

Further advancements:

- Better radiographic imaging
- Less toxic contrast
1974: Andreas Gruentzig performed first peripheral human balloon angioplasty

1976: Gruentzig presented results of animal studies of coronary angioplasty at American Heart Association meeting

1977: 1st PTCA: Andreas Gruntzig performed first cath lab PTCA on a 38-years old awake patient in Zurich; starting with this case, all PTCA data was entered into a worldwide registry.
To the Editor:

Coronary angiography performed in a 38-year-old man on September 14, 1977, showed a high-grade but discrete stenosis of the proximal left anterior descending coronary artery just before the first large diagonal branch (Figure 1A). The remainder of the coronary arteries and the left ventricle were normal.

I told the patient that Dr. Andreas Gruentzig would offer him an alternative to bypass surgery. The alternative was coronary angioplasty. Gruentzig candidly explained the results that had been obtained in a few hundred patients treated with a balloon for peripheral-artery stenoses and mentioned the possibility of an immediate coronary bypass operation in case of problems. The patient consented without hesitation. Later, he stated that he instinctively trusted Gruentzig and hence his method.
The angioplasty procedure, performed on September 16, 1977, went well and eliminated the patient’s symptoms.² He quit smoking and soon stopped taking all his cardiac medications. On the 20th anniversary of the procedure, I convinced him to take acetylsalicylic acid and a statin for his slightly elevated cholesterol levels.

In 2000, at the age of 61, the patient had recurrent chest discomfort for the first time. It occurred at rest but not during exercise. He underwent coronary angiography on April 10, 2000. It revealed that the site that had been dilated earlier had normal patency (Figure 1B). There were only minor abnormalities elsewhere. The results of an exercise test the next day were clinically and electrocardiographically normal at a peak heart rate of 140 beats per minute and a blood pressure of 190/105 mm Hg.

Gruentzig and his wife died in an airplane crash on October 27, 1985. I do not believe Gruentzig would have dreamed that his first patient could remain free of recurrent symptoms of coronary artery disease for such a long time.

Bernhard Meier M.D.
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1978: First PTCA cases performed in America by Myler in San Francisco and Stertzer in New York;

Gruentzig conducted first demonstration course in Zurich, Switzerland, attended by 28 pioneering physicians, International Dilatation Society was established.

1980: Gruentzig conducted the last of 5 demonstration courses in Zurich with Sones, Judkins & Dotter in attendance. He then moved to Atlanta, GA where he became the Director of Interventional Cardiology @ Emory University; National Heart, Lung & Blood Institute began support of the existing PTCA registry; 1st 1000 angioplasties were performed worldwide; guiding catheters were introduced.
Balloon Angioplasty
1985 – A year of loss in the history of interventional medicine: Dotter, Sones, Judkins and Gruentzig all passed away within 9 months of each other.
1982 – over-the-wire coaxial balloon systems were introduced, brachial guiding catheters & steerable guide wires were developed

1985 – A year of loss in the history of interventional medicine: Dotter, Sones, Judkins and Gruentzig all passed away within 9 months of each other

1986 – coronary atherectomy devices were introduced

1987 – 1st use of coronary stents in humans was reported

1987 – 1993: a large number of new interventional devices were invented & perfected: some like lasers, were less effective than hoped for; others were approved & used worldwide, including rotational atherectomy devices (rotablator), intravascular ultrasound (IVUS) & stents
1993 – 1991: stents became common place, they eliminated many complications

1997: over 1 million angioplasties would be performed worldwide, making angioplasty the most common medical intervention in the world

1997: almost 2 million angioplasties would be performed worldwide, with an estimated increase of 8% annually

2002: 25th anniversary of the 1st angioplasty performed in awake patient

2007: 30th anniversary of the 1st angioplasty performed in awake patient
Albert Starr. Oregon cardiac surgeon, professor of surgery and chief of cardio-pulmonary Surgery division at the University of Oregon Medical School developed the Starr-Edwards heart valve in 1960. Starr requested that all valve replacement patients over 50 years of age receive routine preoperative coronary arteriography.