Angiography

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Angiography is a medical X-ray imaging technique using liquid contrast agents (known as contrast media) injected into the bloodstream to visualize the lumen of blood vessels mainly focused on arteries and veins as well as the chambers of the heart. The images taken are called angiograms. The contrast agent is necessary as blood vessels are not clearly visible on normal X-rays as their attenuation is very similar to that of the surrounding soft tissue. Traditionally, angiography was used to provide only information about blood vessel abnormalities, such as narrowing, blockage, inflammation, abnormal widening and bleeding. However, in recent decades, radiologists, cardiologists and vascular surgeons have used X-ray angiography also to guide therapeutic procedures (this is known as Interventional Radiology) where abnormal blood vessels need to be blocked off if they are bleeding (called 'embolization'), or to guide minimally invasive surgery procedures of the blood vessels and arteries and as part of other medical investigations or surgical treatments. The term angiography specifies the use of projection radiography in this type of imaging. However, in the last several years, vascular images can also be produced using computed tomography angiography or magnetic resonance angiography.

History

Only several years after the discovery of X-rays by **Roentgen** in 1895, attempts to image the vascular system were made by injecting blood vessels of cadavers using solutions of halide salts. These initial efforts showed the enormous potential of radiographic imaging of the vascular tree. However, it was not until the observation by **Osborn** in 1923 that the urinary bladder became radiopaque after the ingestion or intravenous administration of sodium iodide as treatment of syphilis, that the concept of an intravascular contrast agent began to evolve.

In 1927, a Portuguese physician, **Egas Moniz** first used the technique of contrasted X-rays to diagnose diseases of the nervous system - tumors and artery diseases in the brain. A 25% sodium iodide contrast solution was injected directly into the cervical carotid artery to produce an X-ray image of the intracranial circulation. This early work gave rise to better, less toxic contrast materials. Advances were made in the quality of X-ray tubes, film-screen techniques, and fluoroscopy. Angiography was further improved by the introduction of high-speed film changers, allowing a better appreciation of the dynamics of blood flow. In addition to anatomic diagnoses made by intravascular catheterizations, physiological information such as blood pressure could now be obtained during angiography. This made possible the evaluation of pathological states such as pulmonary hypertension, valvular heart disease, and portal hypertension.

The first angiographic procedures used sharp trocars to create a lumen for a catheter to pass through to the desired vessel or organ. This method resulted in high complications, mainly infection where the skin was cut and risk of hemorrhaging. A quantum leap forward was made with the introduction of the Seldinger technique in 1952, named after a Swedish radiologist **Dr Sven-Ivar Seldinger**, greatly increased the safety of angiography, especially as applied to the femoral artery. The desired vessel was located using ultrasound and is punctured using the trocar. The puncture site is much smaller than in the previous technique therefore decreasing the risk of excessive bleeding and infection. A round tipped guide wire is passed through the trocar and the trocar is removed. A sheath can be passed over the guide wire into the desired vessel followed by a catheter. This process is needed to inject the contrast agent into the vessel for visualization.

Technique

As the contrast agent moves through the blood vessels, a series of X-rays is taken to examine how it flows. By tracking its movement, radiologists can visualize and identify any problems with the blood vessels, such as blockages or sites where the vessel is narrower than usual.

Angiography is usually performed at a hospital by a specially trained radiologist (Interventional Radiologist) and assisting technician or nurse. It takes place in an X-ray or fluoroscopy suite, and for most types of angiograms, the patient's vital signs will be monitored throughout the procedure.

Angiography requires the injection of a contrast dye that makes the blood vessels visible to X-ray. Tissues such as bones and certain organs, such as lungs, also absorb X-rays as they pass through the body and they show up as white areas on X-ray images too. Using digital subtraction angiography, the bones and other organs are subtracted from the results so only vessels with contrast agent can be seen. The dye is injected through a procedure known as arterial puncture. Access to the blood vessel is mainly established through the femoral artery. The site is cleaned with an antiseptic agent and injected with a local anesthetic. First, a small incision is made in the skin to help the

needle pass. A needle containing an inner wire called a stylet is inserted through the skin into the artery. When the radiologist has punctured the artery with the needle, the stylet is removed and replaced with another long wire called a guide wire. It is normal for blood to spout out of the needle before the guide wire is inserted.

The guide wire is fed through the outer needle into the artery and to the area that requires angiographic study. A fluoroscopic image that displays a view of the patient's vascular system is used to pilot the wire to the correct location. Once it is in position, the needle is removed and a catheter is slid over the length of the guide wire until it to reaches the area of study. The guide wire is removed and the catheter is left in place in preparation for the injection of the contrast medium, or dye.

Depending on the type of angiography procedure being performed, the contrast medium is either injected by hand with a syringe or is mechanically injected with an automatic injector connected to the catheter. An automatic injector is used frequently because it is able to propel a large volume of dye very quickly to the desired site. The patient is warned that the injection will start, and instructed to remain very still. The injection causes some mild to moderate discomfort. Possible side effects or reactions include headache, dizziness, irregular heartbeat, nausea, warmth, burning sensation, and chest pain, but they usually last only momentarily. To view the area of study from different angles or perspectives, the patient may be asked to change positions several times, and subsequent dye injections may be administered.

Throughout the dye injection procedure, X-ray pictures and/or fluoroscopic pictures (moving X-rays) will be taken. Because of the velocity of arterial blood flow, the dye will dissipate through the patient's system quickly, so pictures must be taken in rapid succession.

Once the x-rays are complete, the catheter is slowly and carefully removed from the patient. Pressure is applied to the site with a sandbag or other weight for 10 to 20 minutes in order for clotting to take place and the arterial puncture to reseal itself. A pressure bandage is then applied.

Angiogram showing aortic arterial disease (narrowing of the arteries due to fatty plaques) at the point where the blood supply to the two legs separate. Arrow 1 shows the aorta and 2 shows the left common iliac artery

Types of angiography

Cerebral angiography

Used to study the blood vessels in the head and neck if it is thought that vessels supplying the brain are narrowed or impeding blood flow which could result in a stroke. It can also be used after a stroke to assess the damage to the vessels or to identify an aneurysm or a brain tumor. The catheter is inserted into the femoral artery (the main artery of the thigh) or the carotid artery in the neck, and the injected contrast medium travels through the blood vessels of the brain. Patients frequently experience headache, warmth, or a burning sensation in the head or neck during the injection portion of the procedure. A cerebral angiogram takes two to four hours to complete.

Coronary angiography

Used to study blood vessels that supply the heart.The arterial puncture is typically given in the femoral artery, and the cardiologist uses a guide wire and catheter to perform a contrast injection and X-ray series on the coronary arteries. The catheter may also be placed in the left ventricle to examine the mitral and aortic valves of the heart. If the cardiologist requires a view of the right ventricle of the heart or of the tricuspid or pulmonic valves, the catheter will be inserted through a large vein and guided into the right ventricle. The catheter also serves the purpose of monitoring blood pressures in these different locations inside the heart. The angiogram procedure takes several hours, depending on the complexity of the procedure.Mainly used in patients who have had a heart attack, angina or heart disease which all involve blocked or interrupted blood vessels. This type of angiography can be used to determine which treatment would be most successful in patients with heart conditions. If the patient had a narrowed artery but the damage was not severe, an angioplasty may be recommended but if the artery is clogged then an artery bypass graft may be more suitable.

Pulmonary angiography

Used to examine blood vessels in the lungs. Computerised tomography pulmonary angiography is used more often in this case to lower the risk of complications. The procedure differs from cerebral and coronary angiograms in that the guide wire and catheter are inserted into a vein instead of an artery, and are guided up through the chambers of the heart and into the pulmonary artery. Throughout the procedure, the patient's vital signs are monitored to ensure that the catheter does not cause arrhythmias, or irregular heartbeats. The contrast medium is then injected into the pulmonary artery where it circulates through the lung capillaries. The test typically takes up to 90 minutes.It is frequently carried out on patients who have a pulmonary embolism.

Extremity angiography

Used to examine blood vessels in arms and legs. It is also called peripheral angiography. Mainly used if patient is suffering from extreme pain in the legs due to reduced blood flow to legs and feet. This type of angiography can also be used to identify atherosclerosis (plaque in the vessels) in the arms and legs.

Kidney angiography

A renal angiogram is an imaging test to look at the blood vessels in kidneys. It can be used it to find such problems as the bulging of a blood vessel (aneurysm), narrowing of a blood vessel (stenosis), spasm of a blood vessel, an abnormal connection between arteries and veins (arteriovenous malformation), blood clot (thrombosis), blockage (occlusion). It can also be used to diagnose tumors, bleeding (hemorrhage), complicationsfrom a kidney transplant.During a kidney angiogram, the guide wire and catheter are inserted into the femoral artery in the groin area and advanced through the abdominal aorta, the main artery in the abdomen, and into the renal arteries. The procedure will take approximately one hour.

Celiac and mesenteric angiography

Celiac and mesenteric angiography involves X-ray exploration of the celiac and mesenteric arteries, arterial branches of the abdominal aorta that supply blood to the abdomen and digestive system. The test is commonly used to detect aneurysm, thrombosis, and signs of ischemia in the celiac and mesenteric arteries, and to locate the source of gastrointestinal bleeding. It is also used in the diagnosis of a number of conditions, including portal hypertension and cirrhosis. The procedure can take up to three hours, depending on the number of blood vessels studied.

Splenoportography

A splenoportography is a variation of an angiogram that involves the injection of contrast medium directly into the spleen to view the splenic and portal veins. It is used to diagnose blockages in the splenic vein and portal vein thrombosis and to assess the strength and location of the vascular system prior to liver transplantation.

Safety

The benefit of having an angiography greatly outweighs any risks that it may pose but nevertheless, no medical procedure is risk free, that’s why an overnight stay in the hospital is sometimes recommended following an angiography procedure, particularly with cerebral and coronary angiograms. Minor complications that may occur include excessive bleeding or infection at the site of incision and an allergic reaction to the contrast agent used. There are more severe risks that could occur as a result of an angiography but these are very rare for example only 1 in 1000 people suffered a stroke due to this procedure. Other serious complications include blood vessel damage, organ damage and blood clots and irregular heart rhythms (arrhythmias).

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