Synthetic, Cryograft, or Xenograft: Which Bypass Graft Can Best Save YOUR Life?

The Comparative Study of Patency related to Synthetic, Cryogenic, and Xenographic Bypass Material vs an Autologous Conduit in Peripheral Artery Disease

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Peripheral Artery Disease is a disease where the arteries in a body become narrowed and do not allow for the flow of oxygen-rich blood throughout the body. PAD most commonly affects the legs and symptoms include leg pain, wounds that fail to heal, and poor hair and nail growth (The Society for Vascular Surgery). The main cause of PAD is atherosclerosis, the tightening of arteries due to the buildup of plaque (Culvert; The Society for Vascular Surgery). Composed of calcium, cholesterol and fibrous tissue, plaque is an adhesive substance that accumulates around the walls of arteries and obstructs the normal pathway of the blood (Harvard Women’s Health Watch).

When it is time for a surgeon to decide which type of graft to utilize during bypass surgery, the choice can be a deciding factor on whether or not surgery will be effective. Patients with Peripheral Artery Disease (PAD) are constantly afflicted by poor blood circulation. This major problem is caused by plaque buildup in the arteries, which causes a lack of blood flow. Without oxygenated blood constantly flowing to all parts of the body, a person's extremities begin to experience painful symptoms. Arteries require strong blood flow to push blood from the heart and throughout the body. Plaque buildup prevents blood flow and causes vessels to become constructed, narrow, and weak. Once the vessels face these problems and are no longer viable to carry blood, a patient is in need of bypass surgery. No other methods can be used to combat a completely occluded vessel so a bypass procedure is necessary to redirect blood flow. Although there are many new types of grafts to operate with as bypass grafts such as xenografts, cryografts, synthetic grafts and autologous grafts, autologous grafts provide the greatest quality and length of success due to their higher statistical patency rates, the greater rates of limb salvage, and its living tissue composition.
There are many factors involved in the development and detection of PAD (Harvard Women’s Health Watch). The most major symptom of PAD is intermittent claudication: pain or discomfort when you walk which is relieved when you rest. Critical Limb Ischemia, a symptom of an advanced stage of the disease, occurs when legs do not receive sufficient oxygen, even when resting. Severe PAD may cause the development of extremely painful sores on toes or feet. Poor circulation causes these wounds to not heal and they become dry, blackened, and eventually gangrene (The Society for Vascular Surgery). Although a person is more likely to develop PAD as they age, a history of diabetes and/or smoking can increase the chances of early development of the disease. Other factors that lead to a higher risk include high blood pressure, high LDL cholesterol, ethnicity, and heredity (Harvard Women’s Health Watch).

Peripheral Artery Disease is diagnosed using the ankle–brachial index (ABI), a test that compares a person’s systolic blood pressure in the ankle and the arm. Patients with PAD display an ankle to arm ratio of less than 0.9, and an extreme case shows a 0.5 or lower ratio. Comparably, a healthy adult ration is considered between 1.0 and 1.4 (Harvard Women’s Health Watch). When it is acknowledged that PAD is present, doctors may order imaging studies such as a Doppler ultrasound, computed tomography angiography (CT scan), or a magnetic resonance angiography (MRI scan), to develop a better understanding of the patient’s specific condition (The Society for Vascular Surgery).

Once a patient has progressed to showing extensive physical symptoms of PAD, a bypass procedure is effective in treating the problem (Femoral Popliteal Bypass Surgery). Bypass surgery introduces a new pathway, or detour, around narrowed or occluded section of an artery. By attaching the bypass above and below the area of the blockage, this procedure creates a new path for blood to travel (The Society for Vascular Surgery).
Although there are many different conduits that can be used in bypass surgery, determining the best graft material for bypass can shape how effective the procedure will prove to be. The condition of the patient’s existing vessels that can be used as grafts, as well as the presence of infection, influences a surgeon’s decision of which type of graft will be most useful for a successful procedure. Synthetic bypass grafts are ones that have been made out of inorganic material to work as a substitute to the traditional autologous vein grafting.

Synthetic grafts are incredibly practical: they can be created from numerous materials and composed in any way that is needed. Synthetic graft conduits can be specialized to best suit the patients’ anatomy and/or what is need for the patient to serve the purpose of the procedure (Stoeckel). These grafts provide a good amount of primary and secondary hemodialysis access. Synthetic grafts are also easy to cannulate during surgery, which add to its practicality (Korzets). Researchers are having success in the area of self-expanding stented grafts based on Nitinol material. Nitinol (nickel-titanium) alloys have properties that allow them to have shape-memory and super-elasticity. After stress is put on Nitinol and deformation is enabled, the material reacts to the force because of a change in its crystal structure (Stoeckel).

A fourteen year retrospective study of polytetrafluoroethylene (PTFE) grafts showed that 73% of patients who received femoral grafts showed no long-term complications. The same study recorded that no perioperative (referring to before, during, and after procedure) mortality was found. This study shows that patients receiving synthetic PTFE grafts proved to display variable success in most cases of its use (Korzets).

Synthetic graft material has a high potential for infection (Stoeckel). This is due to the fact that a bypass procedure utilizing synthetic material is not only introducing the body to a
foreign material, but also introducing it to an inorganic material. Without tissue to act in synthesis with the autologous arterial anatomy, synthetic grafts cannot be used in a surgical field that is already contaminated with an infection. Infected synthetic material must be removed from the body because they cannot be sterilized; nor can a patient be simply given antibiotics (Gashti).

When performing bypass on an uninfected field, as long as surgeons stay above the knee autologous and synthetic grafts operate to the same degree of patency. A procedure below the knee is far less effective with tubing because of reasons including smaller arteries and the crossing of a major joint (Gashti). Surgeons agreed that for short grafts, such as from the femoral artery to above-knee popliteal arteries, there would not be much of an advantage of using autologous vein and it would unnecessarily destroy good vessel (Gashti; Simlote). Autologous grafts are better to use in your legs but when grafting around the subclavian artery, autologous grafts have some issues with kinking and it would be better to use a synthetic graft reinforced with rings to prevent kinking (Nelms).

Cryograft bypass graft technology introduced a way for doctors to use human tissue when a patient’s own vessels are not viable. Cryografts can be seen as a poor solution to Peripheral Artery Disease bypass grafting because decellurized tissue become stiff (Cryolife). In order for cadaver vessels to be used and introduced to a diseased patient’s body, the vessels must first be “cleaned” in order to increase their compatibility with the patient’s body. This process essentially strips the vessels of part of what makes them efficient in carrying blood (Kakiss). When doctors use cadaver vessels they are essentially using dead tissue that is very stiff and lacking the necessary compliance (Gashti).
Human tissue allows for natural pulsability and suturability (CryoVein Saphenous Vein for Peripheral Bypass – Animation). Cryografts provide a naturally porous structure that allows for surgeons to appropriately attach the conduit to the point of insertion. This graft material is human tissue so once it is used in a patient; it reassumes its natural ability to pulse and move oxygen carrying blood throughout the body (Kakiss).

Cryografts are far less likely to become infected because they are comprised of human tissue (Kakiss). In the presence of an infected field, cadaver grafts allow for resistance against the further spreading of infection because it is composed of actual tissue. Although cryografts is introducing a foreign element to a body, because it is still actual fibrous tissue, it promotes healing and fights against infection.

Xenografts are grafts harvested from animal tissue, such as porcine or bovine, and are used as conduits during bypass. Xenograft conduits are composed of actual tissue for optimal suturability and healing (Jacobsen). Although xenografts are composed of animal tissue, the fact exists that as a possible conduit for bypass, it is still contains a mammalian extracellular matrix composed of laminin, fibronectin, elastin, and collagen. These factors allow them to effectively act as bypass conduits as they continue to promote characteristics of autologous patient tissue (Jacobsen).

Like cryografts, xenografts are decellurized, which causes it to breakdown easily (Femoral Popliteal Bypass Surgery). Tissue from sources foreign to the patient must be cleansed in order to ward of the bodies antibody responses. While xenografts and cryografts are more resistant to infection, they see major difficulties with deterioration (Gashti).
Autologous grafts are composed of the patient’s own tissue and provide the most natural solution to peripheral bypass procedures. Autologous grafts are less susceptible to infection because they are of the patient’s own tissue (Goldman). Autologous tissue maintains patient antibodies and is naturally fitted to anti-rejection (Moore). In some cases, especially when the degree of PAD has spread throughout the body, a patient may not have viable vessels left that can be used as bypass grafts (Goldman). A patient may have used their best vessels for previous procedures and has run out of autologous options. Interviewed vascular surgeons were asked how it was decided which vessels to use as autologous grafts in bypass surgery, each surgeon delivered very similar responses leading to one answer, the greater saphenous vein (Perler; Gashti; Simlote; Nelms).

Although many different responses were given such as the fact that it provides the greatest runoff to the foot, provides the best results as a conduit when there is an infected field, its impressive length, and that it would stay open for the most amount of time post-operative, each reason alone allowed the greater saphenous vein to stand alone as the most effective for successful bypass surgery (Gashti; Simlote; Nelms).

Even though each bypass graft discussed has usable benefits, autologous grafts show the highest potential for successes. Autologous graft patency rate is much higher. Autologous vessels have higher patency rates for all statistical groups of people (men, women, old, young) than in all other types of grafts (Jacobsen). Cryografts are prone to failure because it was once dead tissue that has been revitalized (CryoVein Saphenous Vein for Peripheral Bypass). Because autologous means it’s of the patient’s own tissue, this conduit has no problem bonding to the grafting areas most appropriately (Goldman). Autologous tissue also does not reject itself and is naturally porous, with has high sutureability (Jacobsen). This conduit is superior as it is far less
prone to infection because it is tissue, and is native to the patient, whereas synthetic material would further infect the surgical field (The Society for Vascular Surgery) (Kakisis).

Although certain circumstances may not allow for an autologous grafting conduit to be utilized, such as when no viable vessels are available or the patient has run out of grafting vessels due to multiple surgeries, autologous grafts should always be the first choice for surgeons. Autologous conduits have been tested to show the most amount of success at all time intervals when compared to synthetic, xeno and cryo material. Synthetic material shows the most similar results to autologous conduits at the one-year post operative level. However, unlike autologous conduits, synthetic grafts become increasingly less patent as they approach the five-year threshold and continue to lose its patency. Although cryografts and xenografts display lower levels of infection and are, therefore, more appropriate to use for a patient with an infected field, they still display lower limb salvage rates. Even though doctors value overall health of a patient, limb salvage remains an overwhelmingly important factor in bypass grafting. Autologous conduits are the patient’s own tissue so it easily synthesizes for a better overall procedure. Autologous grafts are the best grafts to use during bypass surgery because of their patency, their analogous tissue, their ability to combat infection, and their limb salvage rates.
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