Vascular substitutes

Biological vascular substitutes

Transplants from non-vascular tissue

The creation of a vascular substitute from other than vascular tissue became the subject of research in many workplaces in the second half of the last century. The purpose was to find an adequate replacement for vessels with small lumen and low flow. Experiments were carried out mainly on dogs and pigs with an effort to use pericardium, muscle tissue, peritonea, ureter, diaphragm or [[small intestine|small intestine]]. Most operations ended in rupture or thrombosis within a few weeks. Also, the use of these xenografts proved to be problematic due to the time and technical demands of creating a replacement of the appropriate size.

Arterial allografts

The boom in the use of arterial allografts occurred at the end of the last century, mainly thanks to the development of modern immunosuppressants and the creation of banks for storing processed transplants. For transplantation, the arterial trunk from aorta descendens to arteria femoralis is most often used.

Allografts are kept at a low temperature of 1-4 °C. Subsequently, antibiotics and heparin are added to the prepared grafts. Under normal circumstances, they are used within 48 hours, but can be stored for up to 30 days.

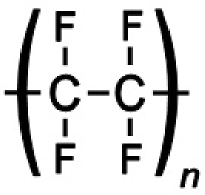
Artificial vascular substitutes

Artificial vascular substitutes are commonly used as a bypass in operations for peripheral stenoses or to access the vascular bed for the purposes of hemodialysis. Their length is limited for substitutes with a cross-section of less than 10 mm, therefore they are not used for myocardial revascularization. The basic prerequisite for their applicability is the recipient's biological tolerance to their material. These tend to be bioinert polymers - Teflon (polytetrafluoroethylene) and dacron (polyethylene terephthalate), rarely polyurethane (Lycra), and the use of polyetherurethane urea for low-light restorations is in the stage of clinical study. When used in areas of the body caudal to the ligamentum inguinale, the use of artificial substitutes has worse results than an autologous biologic substitute. Sometimes, however, a suitable vessel is not available in the patient, in which case Teflon substitutes are used. Artificial vascular grafts are sometimes wrapped (transversely strangulated), which facilitates bending of the graft and reduces the risk of strangulation, but increases flow resistance and the risk of thrombi formation. Currently, there are several types of vascular replacements from different companies on the market, based on both Teflon and dacron with bound carbon or heparin reducing the risk of thrombogenesis. In the testing stage, there are attempts to use similarly hirudin, tissue plasminogen activator or other substances. At the research stage, there is also the possibility of culturing the patient's endothelial cells on the artificial replacement or attaching substances that release nitric oxide to the replacement. Individual restorations also differ in their degree of porosity.

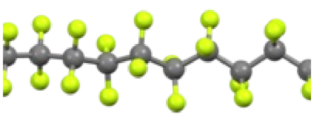
Physical Properties

The most important physical properties of healthy arteries are strength and elasticity. These are mainly influenced by the proportional representation of the three basic layers of the arterial wall, which change considerably in the course of the artery. Another parameter that can affect these properties is the fixation of the arteries to their base, or various pathological phenomena - especially arteriosclerosis. In the case of vascular replacements, it is necessary to maintain, above all, strength to prevent ruptures, as well as flexibility in terms of pressure regulation. Other parameters can be influenced by choosing a suitable transplant, which we divide according to the production method into woven and knitted, made of dacron, and cast Teflon prostheses. Regarding the strength of currently used artificial substitutes, they usually achieve much better or at least the same parameters as a healthy vessel in the given place. The elasticity, expressed by the quantity compliance, which reaches values of around 6 for arteries, is, however, only about 4.5 for autograft from vena saphena magna, 2 for dacron and only about 1.5 for Teflon.

Polytetrafluoroethylene (Teflon)



Polytetrafluoroethylene formula



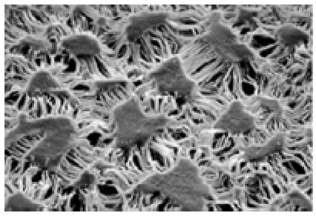
Structural model of polytetrafluoroethylene

Polytetrafluoroethylene (PTFE) is known by its original trade name Teflon. It is a white, highly *hydrophobic thermoplastic fluorocarbon*, its coefficient of friction is the third lowest of all known substances, it is also an excellent dielectric. For the purpose of constructing vascular replacements, its surface-extended form with the trademark "Gore-Tex" is used. The smooth walls of PTFE prostheses are less thrombogenic than dacron, but must also be reinforced due to a higher risk of strangulation when bending. Due to the production by casting, these restorations are minimally porous. Thanks to this, they do not integrate into the tissue and are practically not even covered with fibrin, which, of course, has no practical significance for their durability in the patient's body. This material is mostly used for restorations with a diameter of less than 10 mm, where possible post-implantation reduction of flow plays a greater role and at the same time flexibility is not a priority. It can also be used together with the own vessel as a composite replacement.

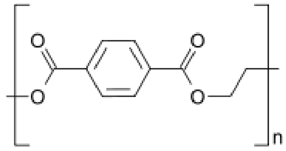
Samples of vascular substitutes made of Gore-Tex material

Polyethylene terephthalate (dacron)

Polyethylene terephthalate (PET, PETE, PES), with the trade name Dacron, is a "thermoplastic polyester" with extensive use in the textile industry and as a packaging material in the food industry. Vascular substitutes are made from its fibrous modification, they are either "knitted or woven". Knitted prostheses are more porous and bleed more, so their breathability must be temporarily regulated pre-coagulation of the patient. On the other hand, fraying can occur with woven prostheses, so the choice of a specific model is a matter of the operator's choice. Dacron substitutes are used for operations on large vessels, especially the aorta throughout its range. Currently, there are dacron prostheses on the market with an inner wall coated with collagen, gelatin or albumin to limit blood loss or with antibiotics to eliminate the risk of infection.



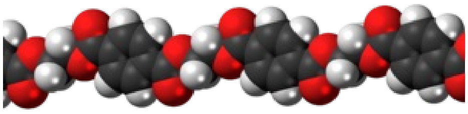
Gore-Tex structure in scanning electron microscope



Polyethylene terephthalate formula

Complications of vascular graft use

- Clogging of the prosthesis - often caused by hyperplasia neointima, scarred vascular tissue
- Infection of implants - a rare (1-2%) complication, but usually with very serious consequences for the patient. It usually occurs during the operation itself. It often requires reoperation and removal of the prosthesis.
- Aneurysm at the site of anastomosis - are caused by partial or complete rupture of the anastomosis. They are mostly asymptomatic, but can cause problems by putting pressure on surrounding structures. The remedy consists in introducing a short bypassu.
- Distant embolization
- Erosion extending to adjacent structures – eg aortoenteric fistula – usually appears months to years after vascular replacement. A diagnosis of aortoenteric fistula should be considered in any patient with a vascular replacement in the abdominal area and bleeding into the GIT.



Structural model of polyethylene terephthalate

History of vascular replacements

The development of vascular replacements has been recorded since the end of the 19th century. In 1898, Jaboulay and Briau first used an arterial autograft in experiments on dogs. In the same year, Gluck used the first venous autotransplant. In 1906, the first replacement of a resected bulge on the a. poplitea was performed with a transplant from the v. poplitea. In 1907, an autograft from the v. saphena magna was used as a replacement after a resected bulge on the subclavian artery. At that time, fresh arterial allografts were also experimented with. Although their results were promising, they were not used in the clinic at the time. Messrs. Carrel and Guthrie wanted to change that, who dealt with how to preserve arterial allografts. With their research, they laid the foundations of the field, which, however, began to develop several decades later.

A major turning point in development was World War II, which saw major advances in materials, anesthesia, anti-infection measures, and patient care. Attention in vascular replacements has turned to preserved arterial allografts. In 1945, Blakemore and Lord proposed the establishment of a vascular bank. It was founded only three years later by Gross, who in the same year replaced the resected coarctation thoracic aorta with a preserved arterial allograft. In 1951, Kunlin began the highly successful era of grafts from venous autografts, which are still being used successfully. In the following years, progress was made in biological as well as artificial vascular replacements. Currently, vascular replacements are an integral part of vascular surgery.

Links

Related Articles

- Arterial reconstruction
- Bypass

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