

BIODEGRADABLE POLYMERIC ENDOLUMINAL SEALING PROCESS

This is a continuation of Ser. No. 593,302, filed Oct. 3, 1990, now abandoned, which is a continuation of Ser. No. 235,998, filed Aug. 24, 1988, now abandoned.

BACKGROUND OF THE INVENTION

This invention relates to a novel method for the *in vivo* paving and sealing of the interior of organs having hollow or tubular geometry for example, blood vessels such as arteries or veins. Often times, this geometry has functional significance such as in the facilitation of fluid or gas transport (blood, urine, lymph, oxygen or respiratory gases) or cellular containment (ova, sperm). Disease processes often times affect these organs or their components by encroaching upon, obstructing or otherwise reducing the cross-sectional area of the hollow or tubular elements. Additionally, other disease processes may violate the native boundaries of the hollow organ and thereby affect its barrier function and/or containment ability. The ability of the organ or structure to properly function is then severely compromised. A good example of this phenomena can be seen by reference to the coronary arteries.

Coronary arteries, or arteries of the heart, perfuse the actual cardiac muscle with arterial blood. They also provide essential nutrients and allow for metabolic waste and gas exchange. These arteries are subject to relentless service demands for continuous blood flow throughout the life of the patient.

Despite their critical life supporting function, coronary arteries are often subject to attack through several disease processes, the most notable being atherosclerosis or hardening of the arteries. Throughout the life of the patient, multiple factors contribute to the development of microscopic and/or macroscopic vascular lesions known as plaques.

The development of a plaque lined vessel typically leads to an irregular inner vascular surface with a corresponding reduction of vessel cross-sectional area. The progressive reduction in cross-sectional area compromises flow through the vessel. For example, the effect on the coronary arteries, is a reduction in blood flow to the cardiac muscle. This reduction in blood flow, with corresponding reduction in nutrient and oxygen supply, often results in clinical angina, unstable angina or myocardial infarction (heart attack) and death. The clinical consequences of the above process and its overall importance are seen in that atherosclerotic coronary artery disease represents the leading cause of death in the United States today.

Historically, the treatment of advanced atherosclerotic coronary artery disease i.e. beyond that amenable to therapy via medication alone, involved cardiothoracic surgery in the form of coronary artery bypass grafting (CABG). The patient is placed on cardio-pulmonary bypass and the heart muscle is temporarily stopped. Repairs are then surgically affected on the heart in the form of detour conduit grafted vessels providing blood flow around obstructions. While CABG has been perfected to be quite effective it carries with it inherent surgical risk and requires a several week, often painful recuperation period. In the United States alone approximately 150-200 thousand people are subjected to open heart surgery annually.

In 1977 a major advance in the treatment of atherosclerotic coronary artery disease occurred with the introduction of a technique known as Percutaneous Transluminal Coronary Angioplasty (PTCA). PTCA involves the retrograde introduction, from an artery in the arm or leg, up to the area of vessel occlusion, of a catheter with a small dilating balloon at its tip. The catheter is snaked through the arteries via direct fluoroscopic guidance and passed across the luminal narrowing of the vessel. Once in place the catheter balloon is inflated to several atmospheres of pressure. This results in "cracking", "plastic" or otherwise mechanical deformation of the lesion or vessel with a subsequent increase in the cross-sectional area. This in turn reduces obstruction, and trans-lesional pressure gradients and increases blood flow.

PTCA is an extremely effective treatment with a relatively low morbidity and is rapidly becoming a primary therapy in the treatment of atherosclerotic coronary disease throughout the United States and the world. By way of example, since its introduction in 1977, the number of PTCA cases now exceeds 150,000 per annum in the United States and, for the first time in 1987, surpassed the number of bypass operations performed. Moreover, as a result of PTCA, emergency coronary artery bypass surgery is required in less than four percent of patients. Typically, atherosclerosis is a diffuse arterial disease process exhibiting simultaneous patchy involvement in several coronary arteries. Patients with this type of widespread coronary involvement, while previously not considered candidates for angioplasty, are now being treated due to technical advances and increased clinical experience.

Despite the major therapeutic advance in the treatment of coronary artery disease which PTCA represents, its success has been hampered by the development of vessel renarrowing or reclosure post dilation. During a period of hours or days post procedure, significant total vessel reclosure may develop in up to 10% of cases. This is referred to as "abrupt reclosure". However, the more common and major limitation of PTCA, is the development of progressive reversion of the vessel to its closed condition, negating any gains achieved from the procedure.

This more gradual renarrowing process is referred to as "restenosis." Post-PTCA follow-up studies report a 10-50% incidence (averaging approximately 30%) of restenosis in cases of initially successful angioplasty. Studies of the time course of restenosis have shown that it is typically an early phenomenon, occurring almost exclusively within the six months following an angioplasty procedure. Beyond this six-month period, the incidence of restenosis is quite rare. Despite recent pharmacologic and procedural advances, little success has been achieved in preventing either abrupt reclosure or restenosis post-angioplasty.

Restenosis has become even more significant with the increasing use of multi-vessel PTCA to treat complex coronary artery disease. Studies of restenosis in cases of multi-vessel PTCA reveal that after multi-lesion dilatation, the risk of developing at least one recurrent coronary lesion range from 26% to 54% and appears to be greater than that reported for single vessel PTCA. Moreover, the incidence of restenosis increases in parallel with the severity of the preangioplasty vessel narrowing. This is significant in light of the growing use of PTCA to treat increasingly complex multi-vessel coronary artery disease.