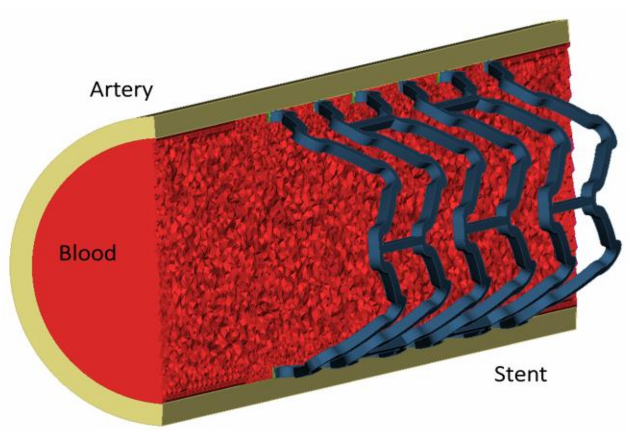
Advanced Multiphysics in Virtual Stent Implantation

Specific problem

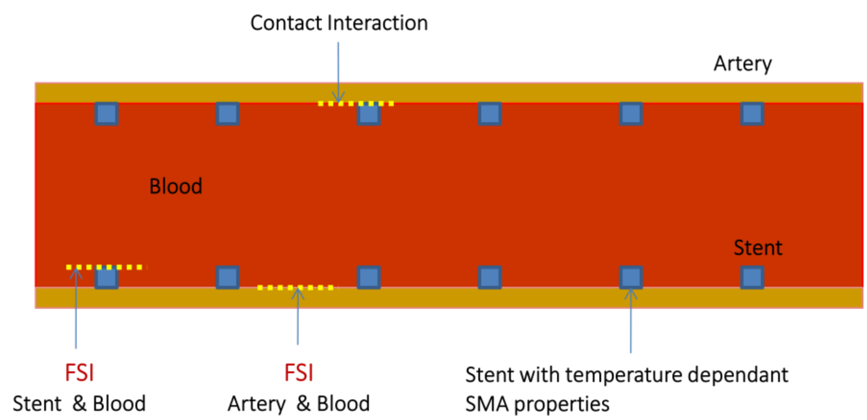
Atherosclerosis or arteriosclerotic vascular disease (ASVD), in which plaque builds up inside arteries, is currently the most common cause for mortality in the developed world. Endovascular procedures like angioplasty for atherosclerosis treatment provide an alternative to open-surgery and require minimal invasion into the human body. Angioplasty is the technique for treating occlusion (blockage) or stenosis (narrowing) of a blood vessel or heart valve. It is used extensively for the treatment of peripheral vascular disease to restore correct blood flow and for the treatment of coronary heart disease and involves stent insertion. However, in-stent restenosis, a repeated narrowing of artery post stent implantation, limits the clinical success of angioplasty, which is caused by mechanical factors, such as wall strain distribution and blood flow induced wall shear stress and local arterial wall stress. Considering the huge expense for the experimental evaluation of stent deployment, we used an alternative route of computational numerical methods to understand the mechanical behavior of stent implantation.

Solution

Using Finite Element approach we demonstrated quantitatively the stent migration and hemodynamic changes such as wall strain distribution and wall shear stress in artery post stent implantation, taking into consideration the non-Newtonian characteristics of blood. The results were arrived performing complex Multiphysics simulation involving fluid-structure interactions between blood and stent by proper coupling of structural and fluid solvers.



Strong FSI coupling for stent & blood flow



Bottom-line Results

The study dealt with aspects different from the conventional hemodynamic analyses that were carried out in the past. Moreover the study concerned with shape memory alloy Nitinol that has gained wide acceptance in medical field. Nitinol (NiTi), a Nickel-Titanium shape memory alloy (SMA) has excellent biocompatibility. Nitinol stents are mostly self-expanding stents which expands by itself into the artery when the enclosing sheath is retracted. NiTi stents are famous for their pseudo-elasticity and also accomplish the biomechanical requirements like kink resistance, flexibility and low delivery profile.

All the former studies were carried out with stents made of alloys without shape memory like stainless steel, cobalt chromium etc. However this approach proved to be computationally expensive and more time consuming compared to the conventional hemodynamic studies, which could be overcome with the use of high performance computing.