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Mathematical Modeling on Capturing of Magnetic Nanoparticles in an Implant Assisted Channel for Magnetic Drug Targeting

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Abstract : The ability to manipulate magnetic particles in fluid flows by means of inhomogeneous magnetic fields is used in a wide range of biomedical applications including magnetic drug targeting (MDT). In MDT, magnetic carrier particles bounded with drug molecules are injected into the vascular system up-stream from the malignant tissue and attracted or retained at the specific region in the body with the help of an external magnetic field. Although the concept of MDT has been around for many years, however, wide spread acceptance of the technique is still looming despite the fact that it has shown some promise in both in vivo and clinical studies. This is because traditional MDT has some inherent limitations. Typically, the magnetic force is not very strong and it is also very short ranged. Since the magnetic force must overcome rather large hydrodynamic forces in the body, MDT applications have been limited to sites located close to the surface of the skin. Even in this most favorable situation, studies have shown that it is difficult to collect appreciable amounts of the MDCPs at the target site. To overcome these limitations of the traditional MDT approach, Ritter and co-workers reported the implant assisted magnetic drug targeting (IA-MDT). In IA-MDT, the magnetic implants are placed strategically at the target site to greatly and locally increase the magnetic force on MDCPs and help to attract and retain the MDCPs at the targeted region. In the present work, we develop a mathematical model to study the capturing of magnetic nanoparticles flowing in a fluid in an implant assisted cylindrical channel under the magnetic field. A coil of ferromagnetic SS 430 has been implanted inside the cylindrical channel to enhance the capturing of magnetic nanoparticles under the magnetic field. The dominant magnetic and drag forces, which significantly affect the capturing of nanoparticles, are incorporated in the model. It is observed through model results that capture efficiency increases from 23 to 51 % as we increase the magnetic field from 0.1 to 0.5 T, respectively. The increase in capture efficiency by increase in magnetic field is because as the magnetic field increases, the magnetization force, which is attractive in nature and responsible to attract or capture the magnetic particles, increases and results the capturing of large number of magnetic particles due to high strength of attractive magnetic force.

Keywords : capture efficiency, implant assisted-magnetic drug targeting (IA-MDT), magnetic nanoparticles, modelling
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