Ultrasonic Angioplasty: Assessing the Risk of Arterial Perforation

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Atherosclerosis is a cardiovascular disease that affects large and medium muscular arteries (such as coronary and iliac) and also large elastic arteries (such as aorta) [1]. It causes thickening of the arterial wall and over time can result in a completely blocked artery or atherosclerotic lesions. Typically, Percutaneous Transluminal Coronary Angioplasty (PTCA) such as balloon and stent implantation, is required to implant the balloon and stent. Excessive guidewire pushing force may result in arterial perforation with calcified CTOs often requiring invasive by-pass surgery. An alternative method proposes the use of low frequency high power ultrasound transmitted through wire waveguides for the removal of the calcified material from advanced atherosclerotic lesions. This type of energy manifests itself as a mechanical vibration to 100 microns and frequencies ranging between 20-45 kHz commonly reported. The ultrasound acts to disrupt calcified diseased tissue by means of direct contact ablation, cavitation, acoustic steaming and other pressure wave components while the elastic tissue remains largely unaffected [2]. In this study the effects of this form of ultrasound on healthy arterial tissue (porcine aorta) is examined. Experiments were carried out to determine the force required to perforate healthy porcine arterial tissue both with and without ultrasound at various distal tip displacements.

Results and Discussion:
At the constant feed-rate the reduction in maximum force required to perforate the artery wall with ultrasound and increasing wire tip displacements can be seen below (Figure 1). The tests revealed a distinct two-stage penetration.

![Figure 1, Max perforation Force vs ultrasonic wire tip displacements peak-to-peak. Freq = 22.5 kHz](image)

Conclusion:
The two-stage penetration recorded may be associated with the composition of the arterial wall, namely the two structural layers of varying elasticity (intima-media and adventitia). It has been reported that the intima-media region can sustain trauma while arterial integrity is still maintained [4]. It is therefore important to define the penetration force for both layers to establish safety thresholds both with and without ultrasonic energy.

References: