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# On the Onset of Cracks in Arteries

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**Abstract**: We present a theoretical approach to study the onset of failure localization into cracks in arterial wall. The arterial wall is a soft composite comprising hydrated ground matrix of proteoglycans reinforced by spatially dispersed elastin and collagen fibers. As any material, the arterial tissue cannot accumulate and dissipate strain energy beyond a critical value. This critical value is enforced in the constitutive theory via energy limiters. The limiters automatically bound reachable stresses and allow examining the mathematical condition of strong ellipticity. Loss of the strong ellipticity physically means inability of material to propagate superimposed waves. The waves cannot propagate because material failure localizes into cracks perpendicular to a possible wave direction. Thus, not only the onset of a crack can be analyzed but also its direction.

We use the recently developed constitutive theories of the arterial wall including 8 and 16 structure tensors to account for the fiber dispersion. We enhance these theories with energy limiters. We examine the loss of strong ellipticity in uniaxial tension in circumferential and axial directions of the arterial wall. We also study the effect of the incompressibility constraint on the analysis of strong ellipticity in uniaxial tension, pure shear and equibiaxial tension. We find that the enforcement of the incompressibility constraint can significantly affect the crack direction.

**Keywords:** Cracks; artery; energy limiter; strong ellipticity

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