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Modeling on Monitoring the Growth and Rupture Assessment of Saccular Aneurysms

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Highlights

1. A new strategy of using dielectric elastomer sensors to monitor the growth of saccular aneurysms.
2. The correlation between the output capacitance and the growth state of the saccular aneurysm is established.
3. A method of multiple indicator (size and wall stress) is demonstrated more reliable for evaluating the rupture risk of saccular aneurysms.

Abstract

The unpredictable rupture of saccular aneurysms especially of the intracerebral aneurysm is a knotty problem that always results in high mortality. Traditional diagnosis of medical images, which gives the aneurysm size and compares with a speculated critical size from clinical statistics, was demonstrated inadequate to forecasting rupture. Here, we propose a new detecting strategy that uses a dielectric elastomer (DE) capacitance sensor to monitor the growth of saccular aneurysms and deliver both the wall stress and geometric parameters. Based on the elastic growth theory together with the finite deformation analyses, the correlation between the real-time output capacitance of the DE sensor and the wall stress and/or geometry of an aneurysm is derived. Compared to clinic statistics and biomechanics simulations, the wall stress and geometric size may be used as combined indicators to assess the rupture risk of a saccular aneurysm. Numerical results show that an output relative capacitance of 30 indicates a high risk of rupture. Finally, the sensitivity and resolution of the DE sensor are proved adequately high for monitoring the growth state and evaluating the rupture risk of a saccular aneurysm.

Keywords: Saccular aneurysms; Rupture risk; Dielectric elastomer capacitance sensor; Elastic growth theory; Finite deformation

Saccular aneurysms are abnormal asymmetric dilation most commonly in the apex of cerebral bifurcations. Ruptured intracranial aneurysms always result in spontaneous subarachnoid hemorrhage (SAH) which has the mortality rate of about 35% – 50% [1-3]. In clinic, there are two main methods to treat this aneurysm, one the intracranial surgery that uses a metal clip or metallic coils to isolate the aneurysm from the blood flow, the other the conservative management assuming that the