FINITE ELEMENT STRESS ANLYSIS OF AN ARTERIAL FILTRATION DEVICE CROSSING A BIFURCATION FOR THE PURPOSE OF EMBOLIC STROKE PREVENTION

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ABSTRACT

A new filtering device (*the Diverter*) was designed to prevent embolic stroke from proximal sources, by implantation at the carotid bifurcation (Fig. 1). It diverts emboli away from the internal carotid artery (ICA) into the external carotid artery (ECA). The diverter, which is a stent like device, is made of fine structure. Our aim was to evaluate the stresses in a Diverter implanted in an arterial bifurcation. In order to solve the artery-device coupling problem, we have developed a new approach based on a 3-D finite element model that takes into account the load and movement of the artery-device mechanism in order to evaluate the device's fatigue resistance.
Keywords: Finite Element Model, Stents-Implantation, Fatigue, Arterial-Blood-Filtration

INTRODUCTION

Implantable devices that permanently filter arterial blood flow have not been previously reported to the best of our knowledge. Filtration of blood can prevent emboli originating proximal to the filter from entering the cerebral circulation and could significantly reduce the burden of embolic stroke.

The main objective of the study is mechanical behavior of the self expandable *Diverter*. Our aim was to evaluate the stresses in a Diverter implanted in an arterial bifurcation. In order to solve the artery-device coupling problem, we have developed a new approach based on a 3-D finite element model that takes into account the load and movement of the artery-device mechanism in order to evaluate the device's fatigue resistance.

MATERIALS AND METHODS

The part of the Diverter in contact with the intima was modeled as an equivalent shell (Fig. 2, Fig. 3), while the part covering the ostium of the internal carotid artery, thus filtering the blood, was modeled as beam elements. We assumed physiological conditions, considering mean loading superimposed by bending, torsion and blood pressure waves, based on a quasi-static analysis. An in-vitro test was conducted to calibrate and check the finite element model.

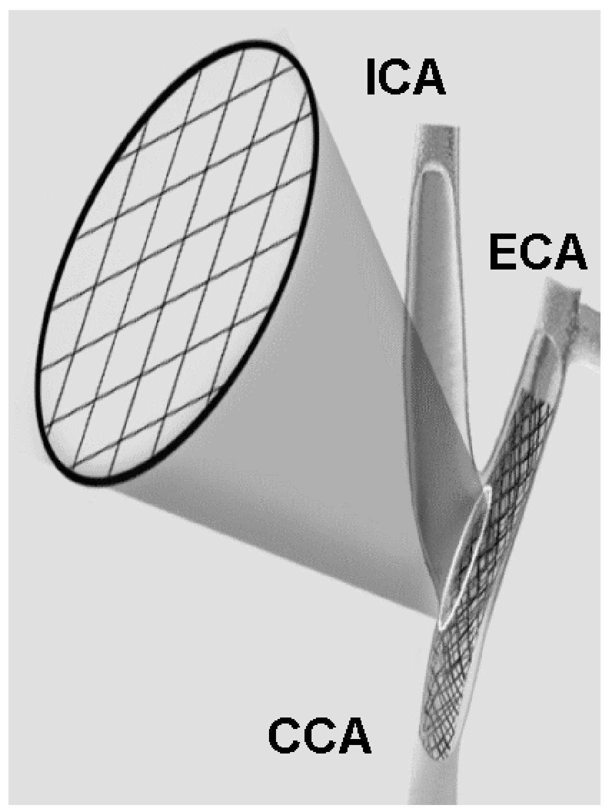

Fig. 1, The Diverter implanted from the CCA to the ECA in the carotid bifurcation. The filtered ICA ostium prevents emboli from reaching the brain.

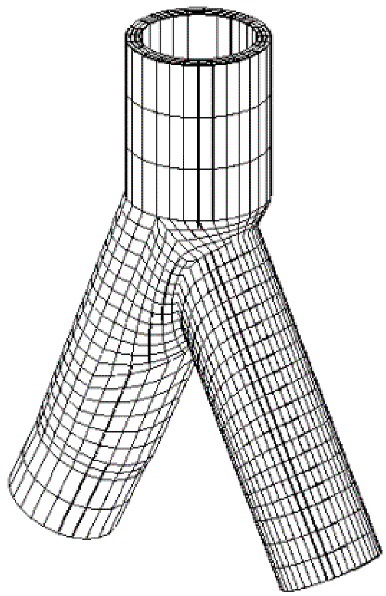

Fig. 2, FE Model of the carotid bifurcation with details of splitting area.

RESULTS

Each increment of 10 mm Hg, 20 mm Hg, 30 mm Hg and 40 mm Hg. Maximum stresses in the beam elements during the cycle of loading, the amplitude and the mean stress of the cycle for the two considered types of strut-to-artery connections and different strut were calculated. There was agreement between the numerical analysis and the in-vitro test results. The stresses in the artery due to pressure showed much smaller values (a factor of 100 at peak value) at the non-filtering area contacting the intima then the stresses at the part filtering the ostium of the internal carotid artery.

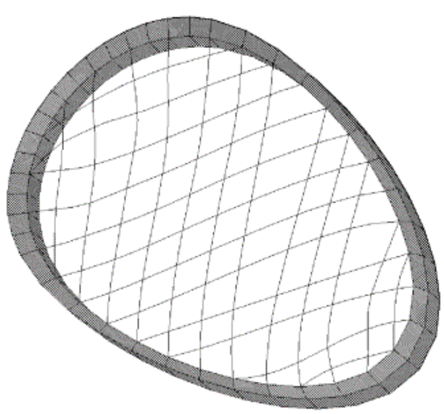

Fig. 3, A case of Strut-to-Artery connection along the inner contour of the filtering area (in conjunction with Fig. 1).

CONCLUSIONS

A finite element based numerical method was developed and used to assess the stresses in a fine structure based device, implanted in an arterial bifurcation. We showed that this numerical method has an agreement with in vitro test. From the results we conclude that the peak stresses in the device implanted in a bifurcation will be at the part crossing the ostium.

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