Classification of Aneurysm Morphology

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I. Introduction

A cerebral aneurysm is an abnormal enlargement of any artery located at or near bifurcations of the arteries in the Circle of Willis. Accompanied with subarachnoid hemorrhage (SAH), aneurysm rupture is quite a serious complication. Due to intracranial bruise, it would cause 32% to 67% fatality and 10.9% morbidity, followed by recurrent bleeding, stroke, hydrocephaly and vessel spasm [1][2]. Symptoms are rare with this disease: about 95% of patients find the first symptom to be death. Rupture and dissection can be avoided through elective surgical repair. However, identifying individuals at risk is still challenging.

Computed Tomography Angiography (CTA) is one of the most commonly used diagnostic images for vessel examination and aneurysm detection. The segmentation of aneurysm and the surrounding vascular structure on CTA images plays an important role in diagnosis and treatment planning. Despite the large amount of specialized research, automatic vascular segmentation on CTA images remains challenging because of noise, inhomogeneous image intensity and gradient, and the presence of bone tissues adjacent to vessels and having similar intensity values as vessels [3].

Currently, the clinical decision whether to electively repair an ascending aortic aneurysm (AsAA) is mainly based on the aortic size, where intervention is typically recommended if the maximum diameter of the ascending aorta exceeds 5.5 cm. It is supported by the positive correlation between the size and rupture or dissection [4]. A relative aortic size index (ASI) normalized by the patient body surface area has also been used for clinical assessment of risk [5]. However, the maximum aortic diameter may not accurately reflect the AsAA patient's risk, since aneurysms at small diameter (e.g., 3.5 cm) have been known to rupture [6]. There are several studies that have investigated the impact of AsAA geometric features, in addition to diameter, on patient risk. Celi and Berti performed finite element analysis of TAA and showed that some morphological parameters such as maximum diameter ratio, lesion extension ratio and eccentricity ratio could significantly affect the wall stress but did not provide any predictive model for risk assessment [7]. What is more, there are many studies applying geometric features for risk analysis of abdominal aortic aneurysms (AAA). However, they only take intuitive geometric parameters such as asymmetry, aspect ratio, curvature, torsion and tortuosity into consideration, which could not clearly describe the variations of AAA geometrics. Liang and Liu proposed a machine learning approach to establish the relationship between shape features and AsAA risk predicted by FE analysis to find the relationship between shape features and the risk [8].

In this study, we are trying to apply the 3D shape contexts to describe the 3D shape of the aneurysm. Then we present a machine learning approach to establish the classification of aneurysm morphology. Support vector machine (SVM) would be used to determine the classification.

[1] Guidelines for the Management of Aneurysmal Subarachnoid Hemorrhage. Stroke. 2012 Jun;43(6):1711-37

[2] J. Huang, J. M. vab Gelder. The Probability of Sudden Death from Rupture of Intracranial Aneurysms: A Meta-Analysis. J. Neruosurg. 2002. 51(5), 1101-1105.

[3] Xin Yang, K. T. Tim Cheng, Aichi Chien. Geodesic Active Contours with Adaptive Configuration for Cerebral Vessel and Aneurysm Segmentation

[4] Coady MA, Rizzo JA, Hammond GL, Mandapati D, Darr U, Kopf GS, Elefteriades JA (1997) What is the appropriate size criterion for resection of thoracic aortic aneurysms? J Thorac Cardiovasc Surg 113:476–491

[5] Davies RR et al (2006) Novel measurement of relative aortic size pre- dicts rupture of thoracic aortic aneurysms. Annal Thorac Surg 81:169–177

[6] Elefteriades JA (2002) Yearly rupture or dissection rates for tho- racic aortic aneurysms: simple prediction based on size. Annal Thorac Surg 73:17–28

[7] Choke E, Cockerill G, Wilson WRW, Sayed S, Dawson J, Loftus I, Thompson MM (2005) A review of biological factors implicated in abdominal aortic aneurysm rupture. Eur J Vasc Endovasc Surg 30:227–244

[8] Liang L1, Liu M1, Martin C1, Elefteriades JA2, Sun W. A machine learning approach to investigate the relationship between shape features and numerically predicted risk of ascending aortic aneurysm.

[9] Doyle BJ, Callanan A, Burke PE, Grace PA, Walsh MT, Vorp DA, McGloughlin TM (2009) Vessel asymmetry as an additional diag- nostic tool in the assessment of abdominal aortic aneurysms. J Vasc Surg 49:443–454

[10] Georgakarakos E, Ioannou CV, Kamarianakis Y, Papaharilaou Y, Kostas T, Manousaki E, Katsamouris AN (2010) The role of geometric parameters in the prediction of abdominal aortic aneurysm wall stress. Eur J Vasc Endovasc Surg 39:42–48