



Title	Topological Analysis for Arteriovenous Malformations via Computed Tomography Angiography Part 1 : Mathematical Concepts & Part 2 : Practical Application
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論文内容の要旨

Synopsis of Thesis

氏 名 Name	波多 祐紀
論文題名 Title	Topological Analysis for Arteriovenous Malformations via Computed Tomography Angiography Part 1: Mathematical Concepts & Part 2: Practical Application (動静脈奇形の3D血管造影CT像に対する位相幾何学的解析手法 第一部 数学的原理 および 第二部 臨床応用)
論文内容の要旨 (Abstract of thesis)	
<u>Part 1</u> [Purpose] Evaluating the progression of soft-tissue arteriovenous malformation (AVMs) is still problematic. To establish a quantitative method, we took a morphological approach. [Methods] Normal blood vessels in early-phase 3D-computed tomography angiography images are theoretically expected to be tree-like structures without loops, whereas AVM blood vessels are expected to be mesh-like structures with loops. Simplified to the utmost limit, these vascular structures can be symbolized with wire-frame models composed of nodes and connecting edges, in which making an extra loop always needs one more of edges than of nodes. [Results] Total amount of abnormal vascular structures is estimated from a simple equation: Number of vascular loops = 1 - ([Number of nodes] - [Number of edges]). [Conclusion] Abnormalities of AVM vascular structures can be mathematically quantified using computed tomography angiography images.	
<u>Part 2</u> [Purpose] In a previous study, the authors outlined a technique for calculating the number of abnormal vascular loop structures described in 3-dimensional computed tomography angiography. To be developed into a quantitative evaluation method for soft-tissue arteriovenous malformations (AVMs), the concept needs assessment of validity. [Methods] Computed tomography angiography results of 19 soft-tissue AVMs and 18 control abdominal vessels are utilized. Enhanced vascular lumen regions over 120 IU were extracted by a region growing method and skeletonized into wire frame graph models. The number of vascular loop structures in graphs is calculated as 1 - [Number of nodes] + [Number of edges], and results are compared between AVM/control groups, pre-/postprogression, and pre-/posttreatment. [Results] Average vascular lumen capacity of AVMs was 57.5 ml/lesion, and average number of vascular loops was 548 loops/lesion. Loop density of AVMs (weighted average, 9.5 loops/ml) exhibited statistically significant ($P < 0.001$) greater value than normal abdominal blood vessels (weighted average, 1.3 loops/ml). In all 4 cases without treatment, number of loops and loop density both increased. Particularly, number of loops increased greatly by 2 times or more in 3 cases. In all 7 cases with treatment, number of loops and vascular lumen capacity significantly ($P = 0.0156$) decreased. Particularly, number of loops showed clearer decrease in cases with entire lesion treatment than partial treatment. [Conclusion] Total number of described vascular loop structures and their density or volume well reflected the existence, progression, and remission of soft-tissue AVMs. Topological analysis can be expected to be developed into a quantitative evaluation for AVMs.	

論文審査の結果の要旨及び担当者

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論文審査の結果の要旨 一連の研究を経て申請者は以下の二点を明らかにした。 1. 軟部組織動静脈奇形（AVM）の造影像を単なる血管の量的過剰ではなく、「異常なつながりの過剰」と捉えることで定量的な進行度指標に変換する手法を開発した。 2. 放置例・治療例の蓄積データを用いて上記指標の妥当性を実証した。 本研究は血管構造の解析に位相幾何学という異分野の知識を導入したという点で独自性に優り、その実行と成果の発表は科学的に正当な方法で行われている。 さらに、本研究は今後も予後判断・治療部位選択の探求に継ぎ得る十分な将来性を有する。 以上の理由を以て、申請者の能力は本学が求める医学博士としての資質を満たし学位授与に値するものとする。			