DEVELOPMENT OF A PLANNING TOOL FOR ROBOT-ASSISTED PARTIAL NEPHRECTOMY SURGERY BASED ON 3D RECONSTRUCTIONS OF KIDNEYS

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1. INTRODUCTION

Renal cell carcinoma is the most common type of kidney cancer accounting for 2-3% of all cancers worldwide with the highest incidence in western countries. For small renal tumors, the treatment of choice is partial nephrectomy, a surgical procedure that involves tumor resection from the kidney. This treatment allows part of the kidney to remain functional without increasing the risk of cancer recurrence [1]. Selective clamping of the tumor supplying arteries avoids excessive bleeding with minimal healthy tissue ischemia but requires a profound knowledge of the patient-specific vasculature and the perfusion of the surrounding parenchyma [2]. Here, we present a model that determines the theoretical perfusion areas per vessel based on anatomical information derived from pre-operative CT scans. Our model should provide the optimal clamping locations for bloodless tumor resection with minimal healthy tissue ischemia and thus enable adequate planning through 3D visualization of these perfusion zones.

2. MATERIALS AND METHODS

The model outcome is a map of the perfusion regions in the kidney using a workflow that exists

volume reconstructions of the renal parenchyma, the arterial tree, and the tumor. These volumes are obtained by segmentation of preoperative CT scans. For analysis, the arterial tree is converted into a graph structure (skeleton) containing only the centerlines of the arterial segments. Once the anatomical data is stored in an adequate format, some patient-specific settings are adjusted to load the anatomical data into the model. The perfusion regions are constructed by assigning each point of the parenchyma to the arterial branch that has the highest probability to supply this point. Therefore, we developed an algorithm in Python that selects the branch that is the closest to that specific point using two different approaches: (i) The *direct distance approach* simply determines for each point the distances to all branches and then selects the branch at minimum distance; (ii) The *region growing method* involves growing of the arterial branches. Each skeletonized branch expands at the same speed until the end of the tissue or until it meets another growing branch. Finally, both methods result in an arterial perfusion map and the outcomes are visualized in 3D in Mimics®.

3. RESULTS AND DISCUSSION

The model was applied to four patient cases. The outcomes were compared to perfusion maps provided by a commercially available software package. The comparison showed that our model overall predicts the perfusion zones in accordance with the available software, though also suggested more arteries perfusing the tumor. We conclude that our results are promising, but optimizations of the model and especially its input data are necessary to increase the accuracy, and in vivo validation is warranted.

References

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