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The development of a 3D anatomical atlas of the pelvis: taking the next step in enhancing surgical anatomical education and clinical guidance

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Background

The surgical anatomy of the pelvis is very complex. Due to the funnel-shaped pelvis there is an intricate anatomical arrangement. In case of rectal cancer, surgeons are challenged to perform a total mesorectal excision (TME), involving radical *en-bloc* removal of tumour and surrounding structures, and preservation of autonomic nerves. Excellent anatomical knowledge of the pelvis is essential to obtain good oncological and functional results in TME. However, contradicting descriptions on the arrangement of fasciae and nerves create confusion. As incomplete mesorectal excisions and iatrogenic nerve disruption are still reported, there is a need to optimise treatment by enhancing the anatomical knowledge among surgeons. We aimed to develop the Virtual Surgical Pelvis (VSP): an anatomical atlas representing the female pelvis in a virtual 3D context. Cadaveric specimens were histologically analysed to reveal the precise arrangement of fasciae and autonomic nerves.

Methods

910 slices comprising the whole pelvis from the Visible Korean Female (VKF) dataset were selected and anatomy of interest was manually segmented using Amira. Additionally, two female cadaveric pelvic exenteration specimens were obtained through the Leeds GIFT Research Tissue Programme, sliced at 1 cm intervals and dissected to fit into mega blocks. These were sectioned at 5 µm and stained histologically. All stained glass slides were digitally scanned with an Aperio XT slide scanner at 200x magnification. The Unified Anatomical Human software was used to integrate 2D and 3D anatomical data in one single atlas and allow registration of anatomical content onto patient-specific radiologic images.

Results

Microscopic analysis of the cadaveric specimens revealed that autonomic nerves ran laterally to the mesorectal fascia. The autonomic nerves were segmented as risk zones in the VKF. The VSP is an anatomical atlas of various synchronously linked 2D anatomical data and a 3D pelvic reconstruction. Currently, the relationship between risk zones, fasciae and other surgically relevant structures are shown, but the VSP can be constantly enriched with new heterogeneous anatomical data. Risk zones that were visible in the VSP can be mapped onto patient-specific MR images. The Online Anatomical Human (OHA) was developed, allowing online interactive exploration of the VSP.

Conclusions

The VSP can be of great value in surgical education by interactive (online) exploration of the 3D female pelvis, showing fasciae and risk zones where nerves are prone to damage. Patient-specific registration onto MR images helps surgeons to focus on specific anatomy that is not visible in MR images. The VSP is work in progress, but has great potential in education, surgical planning, and providing an anatomical context for image-guided surgery and radiotherapy.