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Original article

Organs at risk in the brain and their dose-constraints in adults and in children: A radiation oncologist's guide for delineation in everyday practice

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A B S T R A C T

Purpose: Accurate organs at risk definition is essential for radiation treatment of brain tumors. The aim of this study is to provide a stepwise and simplified contouring guide to delineate the OARs in the brain as it would be done in the everyday practice of planning radiotherapy for brain cancer treatment.
Methods: Anatomical descriptions and neuroimaging atlases of the brain were studied. The dosimetric constraints used in literature were reviewed.
Results: A Computed Tomography and Magnetic Resonance Imaging based detailed atlas was developed jointly by radiation oncologists, a neuroradiologist and a neurosurgeon.
For each organ brief anatomical notion, main radiological reference points and useful considerations are provided.
Recommended dose-constraints both for adult and pediatric patients were also provided.
Conclusions: This report provides guidelines for OARs delineation and their dose-constraints for the treatment planning of patients with brain tumors.

The delineation of intracranial OARs is one of the most crucial points in the planning of brain tumors because radiotherapy (RT) to the brain can lead to visual and hearing deficits, hormonal impairment and neurological and neurocognitive alterations.

Moreover, accurate delineation of OARs is essential for the inverse-planning process of intensity modulated radiation treatment.

Although cerebral normal structures are not always easily recognizable on the imaging used for RT planning, to date, the anatomic delineation of these structures has not been standardized for planning purposes.

This guide might be a tool for daily practice and for decreasing the discrepancies in intracranial OARs delineation between radiation oncologists.

Methods

Anatomical descriptions and neuroimaging atlases of the brain were studied [1–9].

A simplified but detailed anatomy atlas on Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) of the brain has been developed in order to significantly improve the contour accuracy and concordance. For each organ at risk we added some main notions of neuroanatomy, we also defined structures that are easy to identify to be used as landmarks; lastly, we stated some useful considerations for helping in contouring. The atlas was then critically reviewed, discussed, and edited by radiation oncologists, a neuroradiologist and a neurosurgeon.

The following regions of interest were defined: optic chiasm, cochlea, hippocampus, brainstem, pituitary gland, circle of Willis, retina, lacrimal gland and lens.

This report also provides for all the above-mentioned OARs a brief review for the recommended dosimetric constraints both for adult and pediatric patients.

Results

Optic chiasm

Anatomical notions

The optic chiasm, probably the most crucial intracranial organ at risk is the convergence of the optic nerves in front and the

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divergence of the optic tracts behind. With conventional CT or MRI, the optic tracts are visible for only 1–2 cm posterior to the optic chiasm before the fibers spread and blend into the rest of the brain parenchyma.

The optic chiasm lies below the hypothalamus, the third ventricle and its optic recess. It rests upon the tuberculum sellae, in the so-called chiasmatic groove. The chiasm is surrounded by the cerebrospinal fluid contained in the chiasmatic cistern. The anterior cerebral arteries and the anterior communicating artery are located ventral to the chiasm. Lateral to the optic chiasma are the internal carotid arteries. The crossing of the optic fibers occurs just anterior to the pituitary stalk.

Landmarks

The structures that need to be identified in order to have a correct contouring are the optic canals (Supplementary Fig. sI: sIa, sIb, sIe, sIf) from which optic nerves originate (Fig. 1a and b), the anterior clinoid processes of the sphenoid bone (Supplementary Fig. sI: sIa, sIb, sIe, sIf) and the internal carotid arteries (Fig. 1a and b) on each side (Fig. 1g), and, posteriorly, the pituitary stalk (Fig. 1a) or the infundibular recess (Fig. 1c and d).

Both CT (Supplementary Fig. sI) and MRI images (Fig. 1) are useful to identify these reference structures.

The pituitary stalk is the most important landmark because it lies just behind the crossing of the fibers. It is not difficult to be found because it is hyperintense in T1-weighted images, but also slightly hyperdense in CT images, even when the contrast is not used.

In the superior slices, behind the chiasma the infundibular recess (Fig. 1c and d) can be found instead of the pituitary stalk (that is caudally placed). This structure is well-recognizable because it lies in the same median position as the pituitary stalk but it is ring-shaped.

Useful considerations

The optic chiasm measures about 14 mm in its transverse width, with an antero-posterior width of about 8 mm and a thickness of only 2–5 mm.

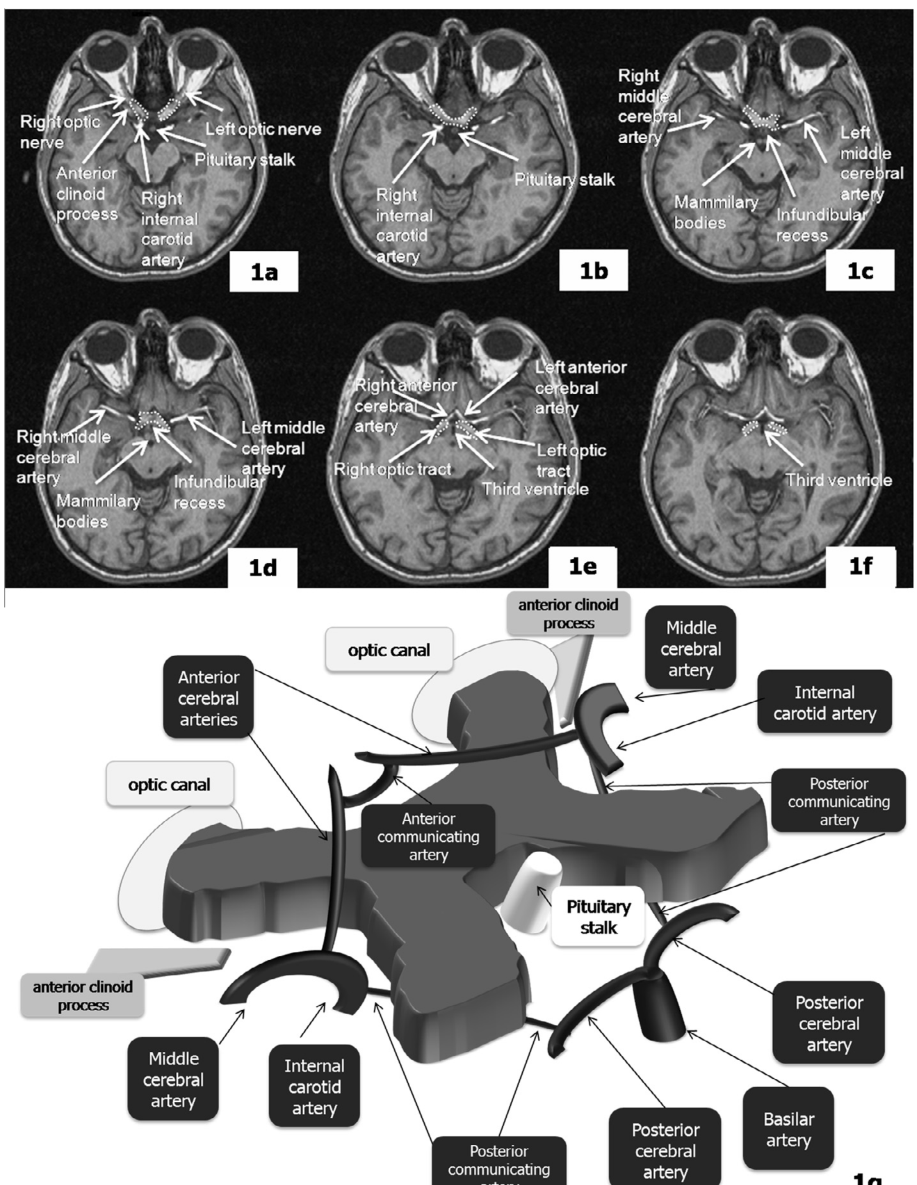

Fig. 1. Region of the optic chiasm as it appears on axial T1-weighted MRI scan with contrast. Optic chiasm is contoured as a dotted line. (g) Anatomy of the optic chiasm and its relationship to the circle of Willis.

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