Brain Tumors, what the radiologist provides

Brain tumours are among the top causes of cancer related deaths both in Europe and North America.

They are categorized into primary versus secondary tumours based on the tissue origin and intra-axial versus extra-axial tumours based on the origin of growth. The most common primary intra-axial tumours are of neuroepithelial origing including astrocatomas, oligodendrogliomas, mixed gliomas and other more rare neuronal – glial tumours with the glioblastoma multiforme as the most common of all primary intraaxial lesions. Meningeomas are the most common primary extraaxial tumours and account to about 20% of all brain tumours.

Secundary, metastatic brain lesions far outnumber the primary tumours with a high incidence in systemic cancer such as lung and breast cancer.

The goals and requirements for neuroimaging in brain tumours are multiplex and involve making a diagnosis and a differential diagnosis, while accurate lesion grading is needed in the case of the overall patient management. Imaging is also involved in the decision-making process for therapy and later for precise planning of surgical or radio-therapeutic interventions. After therapy neuroimaging techniques have shown to be mandatory for monitoring of disease and detection as well as management of possible therapy related side effects.

Independent from the pathology of the lesion neuroimaging is an essential part of the decision-making process for therapy and later for precise planning of surgical or non-surgical interventions. In the case of neurosurgery, neuroimaging can precisely define the location and accurately delineate the lesion. In the case of radiotherapy it assists in the definition of the treatment volume and enables to demarcate the margins for targeted interventions.

Of all diagnostic imaging methods, computed tomography (CT) and magnetic resonance (MR) imaging are accepted as the most sensitive methods for diagnosing brain tumours.

CT is often used as the primary diagnostic step in patients with unknown or acute onset of neurological symptoms. The method is because of its geometric accuracy a mandatory element for treatment planning in radiotherapy.

MRI, due to its high tissue contrast and its non-invasiveness, however, enables to recognize and determine accurately the dimensions of a tumour and its surrounding affected or non-affected tissue. This requires a high a CNS-to-lesion contrast, which depends on the signal intensity of the lesion relative to that of the surrounding normal tissue. Furthermore, detailed information on the internal morphology of the lesion is essential for differential diagnosis, grading, and for the selection and planning of therapy. For most diseases and for many of the currently available functional MR imaging methods, the use of MR contrast media is mandatory. The standard dose employed for MR imaging of the CNS is 0.1 mmol/kg bodyweight although numerous studies have shown that lesion detection may be improved with the use of higher doses and dedicated sequences. Contrast enhanced MRI also helps in distinguishing tumours from other pathologic processes, and depicting basic signs of tumour response to therapy, such as change in size, morphology and degree of contrast material enhancement.

Neuroimaging initially focused on the superb contrast and spatial resolution of neuronal tissue to enable a detailed morphological analysis. Recent developments, however, have focused on evaluating these in conjunction with additional functional assessments. The characterization of neoplasm using physiologic or pathophysiologic characteristics has long been the domain of positron emission tomography (PET).

While PET has significantly improved our pathophysiological understanding of the CNS, the availability of contrast agents and improve rapid imaging methodologies, both in CT and MRI are now enabling further non-invasive characterization of physiologic tissue and diseases. Functional information can reflect macrovasculature, the breakdown of the blood brain barrier (BBB) with resulting permeability for the contrast agent, and tissue perfusion. Neurofunctional magnetic resonance imaging (nfMRI) is a recently established technique which increases our diagnostic potential in neurosciences, while MR-spectroscopic techniques such as chemical shift imaging (CSI) allow a detailed metabolic analysis of the neuronal or pathologic tissue.

The overall diagnostic aim of functional neuroimaging of CNS neoplasm is to optimize tumour characterization, with an emphasis on improved specificity to separate benign from

malignant features. Specific characterization facilitates planning of the most appropriate treatment. Furthermore, functional neuroimaging of CNS neoplasms can be expanded to the monitoring of ongoing therapy and for early detection of therapeutic side effects. The predictive assessment of therapy response and the monitoring of ongoing therapy to guide therapeutic intervention, are major challenges in the current treatment of CNS neoplasms.