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Case studies of AI segmentation and MRI spectroscopy of gliomas

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In this project we wanted to check the usefulness of AI segmentation in voxel selection in magnetic resonance spectroscopy (MRS). We wanted to show the advantage of an AI solution in reporting tumor size.

Six cases of brain gliomas were analyzed based on MRI examination. Glioma segmentation was performed in DeepBraTumIA software based on T1w, T2w, FLAIR and T1w post contrast images. Brain metabolite concentration rates were calculated in syngo. *via* software based on chemical shift imaging. The voxel was selected based on glioma segmented maps (edema, tumor, contrast-enhancing tumor compartment). We prepared an automatic measurement of the longest diameter of glioma. The results of segmentation were used for precise voxel selection in MR spectroscopy. See graphical abstract of one of the cases. In each case it was easier to differentiate between edema or tumor. Based on segmentation we could separate the cases with a contrast-enhancing compartment.

Automating calculation helps to improve the quality of volumetric measurements. Our findings may contribute to the adoption of AI glioma segmentation in clinical settings and advanced brain research.

Incidence of perineural invasion in resected non-small cell lung cancer – preliminary study

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Introduction: Increasing data suggests a pivotal role of neural microenvironment in cancer development and progression. Perineural invasion (PNI) is defined as neoplastic infiltration of any nerve layer, epineurium, endoneurium or perineurium. In a set of malignancies it was proved to affect patients outcome usually as a predictor of poor prognosis. PNI incidence is various in different tumor types. Little is known about its incidence and role in non-small cell lung cancer (NSCLC).

Material and methods: The study included 124 resected NSCLC cases from the patients operated between 2011 and 2012. Clinicopathological features were reviewed retrospectively. All available H&E sections taken during routine examination from the tumors were thoroughly examined to established pathologic characteristics such as histologic type, grade, pTNM, size of the tumor or vascular involvement.

Results: Out of the all analyzed cases 57 (46.0%) were squamous cell carcinoma and 67 (54.0%) adenocarcinomas. PNI was identified in 17 (13.7%) tumors with at least one nerve affected. In one case more than 10 nerves were infiltrated. Additionally, vascular invasion (VI) was found in 39 (31.5%), spreading through air spaces (STAST) in 36 (29,0%) and pleural involvement (PI) in 66 (23.4%) cases. In a group of PNI positive cases most were squamous cell carcinomas (12/17, 70.6%) from which 5 (5/17, 29.4%), were poorly differentiated tumors (grade 3). In 9 cases (9/17, 53.0%) PNI coexisted with vascular invasion, in 3 (3/17, 17.6%) with STAS and in 8 (8/17, 47.1%) with PI.

Conclusions: The study shows that PNI occurs in these type of tumor together with other features known as the indicators of worse outcome. The role of PNI is NSCLC is still unknown and needs careful investigation.

The promising pathophysiological aspects to better understand and manage the risks of rupture of unruptured cerebral aneurysms

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Introduction: Actuality to deeply understand the underlying mechanisms in the aneurysm wall launching the progression and potentially rupture may be helpful to optimize the clinical decision making process among patients with unruptured cranial aneurysms (totally fast 18 million in Europe), especially asymptomatic with low score according to specific scales such as PHASES und UIATS.

Aim of the study was to gather and analyze the current relevant scientific achievements describing the pathophysiology of inflammatory remodeling of aneu-

rysm wall resulting in the degeneration und poor clinical outcome.

Material and methods: 529 patients with unruptured saccular intracranial aneurysms are being observed and treated during 2013-2023. 19.1% have already been operated (98% endovascular, 2% transcranial approach). Among them 19.8% had multiple, 4.95% – mirror intracranial aneurysms. Primarily we used PHASES and in the last years UIATS Score to estimate and individualize the risk of aneurysm rupture. We conducted also the literature review using the PubMed service.

Results and discussion: Our findings correlate with literature data confirming the thickening of aneurysm wall, myointimal hyperplasia und hypocellularity with accelerated collagen breakdown. The high wall shear stress activates pro-inflammatory signaling thorough macrophage chemoattractant protein 1 (MCP1) promoting the smooth muscle cell proliferation being thus a promising target for drug therapy. This process increases the aneurysm wall permeability, which can be detected using the dynamic contrast-enhanced MR perfusion.

Conclusions: The detection of biochemical markers of aneurysm wall remodeling with modern radiological correlates looks promising to improve the early diagnosis, treatment and prevention of rupture of the cerebral aneurysms.

AI neuroscientist: Current and future prospects of virtual reality environments with machine learning (ML) and artificial intelligence (AI) in neuroscience

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Innovative technologies such as extended reality (XR) in general, and virtual/augmented reality (VR/AR) in particular offer tremendous opportunities for neuroscience research in both healthy and disease conditions. With the extremely rapid development of IT/ICT, various unusual computer (bio)science solutions are being proposed, for example, such as the Metaverse concept for future generations and their activities. This modern approach is based primarily on ML models and AI techniques. ML is a key element of AI that allows computers to learn from and make decisions based on data, and constantly update their "skills" based on new data sets. AI encompasses many different disciplines, from computer science, (intelligent) data analysis/search and (bio)statistics, (bio)(neuro) hardware and software engineering, linguistics, medicine and neuroscience, to philosophy and psychology. This report presents and discusses the prospects and some of the limitations of applications of machine learning and artificial intelligence in the field of basic and clinical neuroscience, particularly neuropsychology, neurology and neurogeriatrics. Achievements to date have shown that ML/AI are promising and effective tools for AI researchers, especially AI neuroscientists, e.g., for diagnosis and prognosis, development of biomarker arrays and evaluation of treatment strategies. Artificial intelligence is expected to be one of the most important technologies in the near future, and thus is likely to have an increasing impact on our lives (e.g., see [1]). This impact includes, but is not limited to, the use of ever-increasing amounts of information (big data), the fusion of AI and VR/AR, and then the emergence of the future Metaverse equipped with AI. The creation and exploration of these new digital worlds and their impact on human societies will be a great challenge for neuroscience.

1. https://www.europarl.europa.eu/news/en/headlines/society/20230601STO93804/eu-ai-act-first-regulation-on-artificial-intelligence

Relevant recent research findings on the relationship between breathing and neural and/or mental activity

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Research on the functioning and plasticity of the body's systems has been conducted on animals, also through model (computational) and experimental studies with humans, as well as clinical observations. These findings, among others, point to the vital importance and connection between respiratory rhythms and brain activity. The current results of these studies demonstrate that breathing can play a pivotal role in coordinating neuronal activity, behavior and emotion. In fact, it has already been shown that: (i) breathing affects neural activity of many different regions in the brain,