CNS imaging techniques
Brain tissue imaging

• Crossections
• Nissl staining – neuron bodies
• Fibres staining
• Histochemistry (enzyme detection - NADPH diaphorase in NOs pozitive neurons)
• Immunohistochemistry
  (antibodies against some substance – P substance, cholin acetyl transferase)
• Tracts tracing studies: antegrade and retrograde methods
In vivo

X-ray
Angiography, DSA
CT – bones, injuries, emergency
MRI
a) T1 weighted
b) T2 weighted
c) proton density weighted
d) diffusion weighted
3D reconstruction of brainstem, cerebellum and diencephalon
Hippocampus a fornix
Ventricles

cornu occipitale

cornu temporale

atrium

cornu frontale

commissura anterior

pars centralis

ventriculus tertius
Nucleus caudatus

Caput

Corpus

Cauda
Capsula interna

corona radiata

capsula interna

pedunculi cerebri
Basal ganglia

- Putamen
- Nucleus caudatus
- Nucleus accumbens
- Amygdala
(A) Skull X-ray - only hard tissues can be observed
(B) one of the first CT scans from AMH in 1971
(C) recently obtained CT scan showing higher resolution and better tissue contrast
(D) T2 weighted brain MRI showing subtle contrast differences with small thalamic abnormalities - extending the cross sectional paradigm
(E) DTI tractographic image with selective depiction of white matter anatomical structures deployed in three dimensions,
(F) fMRI study with individual looking at pictures, making judgments and button-press responses with resultant activation in visual cortex, and prefrontal + SMA (supplementary motor) area.
Intracranial hemorrhage
Transtentorial herniation.

Multifocal but unilateral acute parenchymal hemorrhage.

Subfalcine herniation.

Ipsilateral dilated pupil and contralateral hemiparesis
Decompression craniectomy has been performed.

Uncal herniation with posterior cerebral artery occlusion and resulting infarct.
acute vision loss, confusion, new onset posterior cranium headache, paresthesias,
limb weakness, dizziness, nausea, memory loss and language dysfunction
Mount Fuji sign – tension pneumocephalus
Pneumocephalus při ruptuře sinus frontalis
CT angiography

(Provided by Dr. Raymond F. Garwood.)
Spiral CT: first phase in a healthy adult.
A. Twenty-six seconds after intravenous injection of nonionic contrast medium, all arteries are opacified: anterior cerebral arteries, middle cerebral arteries, posterior cerebral arteries, and superficial temporal arteries.
B. Two seconds later and a section above A: on the midline of the brain, the pericallosal arteries, internal cerebral veins, great cerebral vein, straight sinus, and superior sagittal sinus. Terminal arteries for the cortex are also well opacified.
Brain death.

**A**, The first phase of spiral CT 25 seconds after intravenous injection of contrast medium: the cerebral arteries and the basilar artery are not visible, whereas the **superficial temporal arteries** (*white arrows*) and **superior ophthalmic veins** (*black arrows*) are opacified.

**B**, Three seconds later, neither midline vessels (arteries and veins) nor terminal arteries for the cortex are seen, whereas **superficial artery branches** (*arrows*) are opacified. Note brain swelling.
Brain cyst – 5 year old child
45-year-old patient walking around the ER complaining of a headache

- Transaxial CT scan of the brain. Knife entering the superolateral aspect of the left nasal cavity (blue arrow).
Transaxial CT scan of the brain. Knife traverses the carotid canal with tip at the level of the internal auditory canal (blue arrow). Postoperative pneumocephalus (yellow arrow) and posttraumatic infarction in the distribution of the right middle cerebral artery (green arrow). Knife has been removed.
Angiogram of the right internal carotid artery in an oblique projection. **Knife tip in close proximity to the right internal carotid artery** with little flow seen intracranially (blue arrow). **Spasm** noted at the catheter tip in the internal carotid artery (yellow arrow).

Angiogram of the right internal carotid artery in an AP projection. The knife traverses the midline with the **knife tip in the right carotid canal**.
MRI

T1 weighted

T1 - time constant with which nuclei return to alignment with the static field

T2 weighted

T2 – time constant with which nuclei, all pertubated at the same time by radiofrekvency pulces, lose alignment with each other
MRI

**T1W**
short spin relaxation time (white): fat, methemoglobin
long spin relaxation time (dark): CSF, oedema, most of tumors

**T2W**
short spin relaxation time (dark): deoxyhemoglobin, intracellular methemoglobin
long spin relaxation time (white): CSF, oedema, most of tumors

**FLAIR** (Fluid attenuated inversion recovery) supresses signal of water
   good for finding of demyelinised lesions in sclerosis multiplex

**SPIR** (Spectral Presaturation by Inversion Recovery) supresses signal of fat
MR s kontrastem neurinomom VIII.n
Brain microbleeds on MRI. Numerous lobar microbleeds with sparing of the basal ganglia and thalamus, suggestive of severe cerebral amyloid angiopathy in a 71-year-old patient with dementia with Lewy bodies. Image obtained using susceptibility-weighted imaging at 3T.

http://www.3t-mri.net/9.html
Diffusion tensor imaging (DTI)

- is a recent imaging technique that assesses the microstructure of the cerebral white matter (WM) based on anisotropic diffusion (i.e., water molecules move faster in parallel to nerve fibers than perpendicular to them).
- Fractional anisotropy (FA), which ranges from 0 to 1.0, increases with myelination of WM tracts and is sensitive to diffuse axonal injury (DAI) in adults with traumatic brain injury (TBI).
Long association fibres

1- fasciculus uncinatus
2- f. fronto-occipitalis superior
3- f. longitudinalis superior
4- f. occipitalis verticalis
5- sulcus centralis

1- fasciculus uncinatus
2- cingulum
3- f. longitudinalis inferior
4- genu corporis callossi
5- commissura anterior
6- splenium corporis callossi
Long association fibres
• f.longitudinalis superior
• f.longitudinalis inferior
• f.fronto-occipitalis superior
• f.fronto-occipitalis inferior
Directional histograms (rose diagrams) for posterior limb of internal capsule (PLIC), superior longitudinal fasciculus (SLF), and genu of the corpus callosum (CC) in a normal subject. Note the unique distributions characterizing each of these major tracts. These distributions can be subjected to statistical analysis seeking changes related to pathology.
Three large frontal-temporal fiber tracts are visualized: the cingulum bundle in red, the fornix in yellow, and the uncinate fasciculus in green.
Fibers traced from Turboprop-DTI data appear to be anatomically accurate representations of the corresponding fiber cingulum (A), fornix (B), corpus callosum (C), inferior longitudinal fasciculus (D), corticospinal tract and corona radiata (E), and anterior commissure (F).
Fiber tracking images of a control subject (A) and ALS patient (B). Descending fibers connecting the cortex and brain stem are shown in purple. CSTs are in green. The CST fiber density is diminished in ALS patients (B).
FIGURE 4. Fiber tractography in an MS patient. Fixed-size seeds are placed symmetrically in both sides of frontal white matter regions. The number of fibers in the left side is significantly decreased with a lesion (arrow) on the affected tracks.
Major white matter fiber tracts in a 3-month-old infant

- spino-thalamic tract
- cortico-spinal tract
- uncinate fascicle
- inferior longitudinal fascicle
- corpus callosum
DTI fiber tracking of projections emanating from the total corpus callosum overlaid on a $b=0$ image.

Green color indicates fibers traveling in an anterior-posterior direction, red color indicates fibers traveling in a lateral (right-left) direction, and blue color indicates fibers traveling in an inferior-superior direction. DTI fiber tracking maps are then used to calculate mean FA within the fiber system.
(A) Focal lesion in the splenium of the corpus callosum for a 10.8-year-old boy with TBI on conventional T1-weighted MRI midsagittal image.

(B) Fiber systems projecting from the corpus callosum using DTI with fiber tracking. Note the absence of identifiable fiber tracks in the posterior regions corresponding to the focal lesion evident on the midsagittal T1 slice as well as other more lateral intercallosal posterior body abnormalities visible on conventional imaging (not shown here).

(C) Corpus callosum fiber system using DTI with fiber tracking of a demographically matched, uninjured child. Interestingly, the TBI patient had no focal lesions or obvious white matter atrophy in the frontal, temporal, or anterior parietal regions on conventional imaging, which also corresponds to the normal appearing fiber tracking of regions coursing through the anterior and mid regions of the corpus callosum.
Limbic association pathways: inferior longitudinal fasciculus (blue), uncinate (yellow), inferior frontal occipital fasciculus (orange) and cingulum (red). The fornix (light blue) belongs to projection system fibers. On the left hand side, lateral view of the limbic pathways, is easily to detect the most lateral tracts: inferior longitudinal fasciculus, uncinate and inferior frontal occipital fasciculus. The right hand side represents the middle view of the brain, where cingulum and fornix are easily to detect. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)
Functional techniques reveal the activity

- Functional magnetic resonance imaging (fMRI) reveals the active areas by comparison of deoxyhemoglobin and oxyhemoglobin content.

- SPECT single photon emission computed tomography (radioactive tracer iodine or technecium nebo technecium) – blood supplying.

- Positron Emission Tomography (PET) – (with fluor deoxy glucose) – when the short-lived radioactive material undergoes radioactive decay a positron is emitted, which can be picked up be the detector.
Broca and Wernicke areas in fMRI
„Hand knob“

Bartoš, Neurochirurgická klinika UJEP, Masarykova nemocnice, Ústí nad Labem
Navigation
Stimulation of the primary motor cortex

- bipolar electrode
- 60 Hz
- 0.2ms
- 2-10mA
Extra surgery mapping
Boston test - speech
Registration of MEP

- Monitored muscles:
  - small muscles with a lot of motor units
  - mimetic muscles: orbicularis oris, orbicularis oculi
  - upper limb: ADM, APB
  - lower limb: Abd. hallucis, tibialis anterior
Lokalisation of the stimulating electrodes
Sources

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