Imaging the ageing brain: iron accumulation across the adult lifespan

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BACKGROUND

MRI techniques currently allow in vivo characterization of iron deposits in brain tissue. Understanding the age-related changes in iron content is key to identify abnormal patterns of iron deposition and their connection to pathological changes.

IRON IMAGING

Magnetic susceptibility → property of matter that distorts an applied magnetic field, resulting in field inhomogeneities. Iron imaging is based on the ability to distort the magnetic field (paramagnetism), and is therefore dependent on $B_0$.

There are several sequences sensitive to brain iron, namely T2*, Relaxometry and Susceptibility-weighted imaging (SWI), that combines magnitude and phase information, increasing the sensitivity for iron detection. Quantitative Susceptibility Mapping (QSM) is a novel technique that allows a more accurate quantification of brain iron content.

IRON IN NORMAL AGEING

MRI measures compound iron and not unbound forms. Ageing associates with increased non-heme iron (mostly ferritin). Heme iron deposits (e.g. hematomas; microbleeds; siderosis) do not take part on healthy ageing. Iron deposition seems to be sex independent.

Iron deposition with ageing has been shown to be spatially selective, with predilection for movement associated circuits. Basal ganglia have the largest iron concentrations. Globus pallidus has the highest concentration, with age independent levels which plateau around the 5th-6th decades.

IRON DEPOSITION WITH AGE (highest to lowest):

- Putamen
- Red Nucleus
- Caudate Nucleus
- Substantia Nigra
- Dentate Nucleus

MAGNITUDE OF INCREASE WITH AGE (highest to lowest):

- Red Nucleus
- Dentate Nucleus
- Putamen
- Substantia Nigra
- Caudate Nucleus

IRON IN BRAIN PATHOLOGY

Abnormal iron deposits have been linked to inflammation, neurodegeneration and cognitive decline, although the precise mechanisms remain unknown.

KEY MESSAGES

MRI is increasingly sensitive and accurate for brain iron detection, especially with the development of SWI and QSM.

There is an exponential number of studies focusing on brain iron and neurodegeneration. However, the value of brain iron as a biomarker still remains to be established. Recognition of normal age brain iron deposition patterns and standardization of iron imaging are crucial to increase the diagnostic value of MRI for neurodegenerative diseases.

REFERENCES

5. www.mriquestions.com