POTENTIAL OF USING ARTERIAL SPIN LABELING(ASL) IN PARKINSON DISEASE(PD) DIAGNOSIS

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INTRODUCTION: Parkinson's disease is a chronic progressive neurodegenerative disorder primarily induced by loss of dopamine producing nerve cells(Lewy bodies) PD is characterised by motor symptoms like tremors, rigidity, gait disturbances, sleep disorders, depression, dementia and hallucination, dopaminergic neuronal loss alters the microvascular environment which affects cerebral blood flow(CBF). Reduced CBF in PD important to assess motor symptoms, non- motor symptoms and dopamine treatment. with standard structural MRIs often showing no gross abnormalities. Quantitative perfusion MRI modality Arterial Spin Labelling (ASL) is helpful in identifying PD specific perfusion patterns. CBF and arterial arrival time (AAT) values derived from ASL can potentially be used as biomarkers to discriminate PD from similar brain-related disorder.(Joshi et al 2022) making this research timely.

OBJECTIVE: This poster is designed to discuss the principle of arterial spin labelling, limitations of ASL, clinical advantages and application of arterial spin labelling in Parkinson disease, critical analysis of arterial spin labelling as an advanced functional MRI neuro perfusion weighted imaging technique while comparing it to other imaging modalities essential in PD diagnosis, recommendation and conclusion.

PRINCIPLE OF ASL

Arterial spin labeling (ASL) is a magnetic resonance (MR) imaging technique used to assess cerebral blood flow noninvasively by magnetically labeling inflowing blood Physical principle of arterial spin labelling.(Haller et' al 2016)

Using an EPI sequence, 2 images are produced of same area, 1st the controlled image then the "tagged" image in which arterial blood water have been labelled with a radiofrequency pulse as it enters the area of interest. The images are subtracted to get the perfusion information which can also be colour mapped as shown in fig: 1 below.

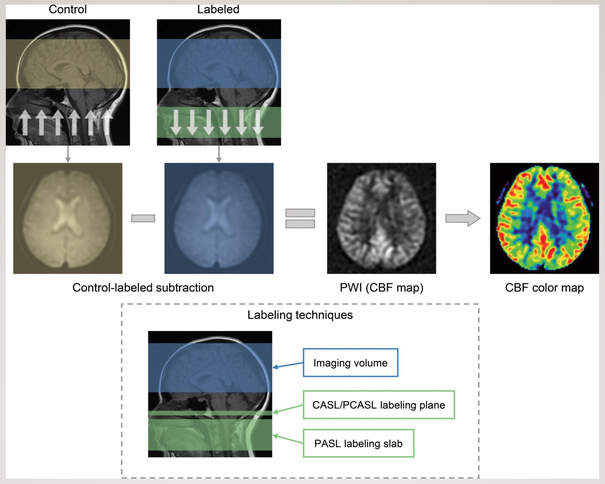


Fig 1: showing the principle of ASL and labelling technique . Source: radiographic.rsna.org(2023)

Ways of tagging a spin

1. Pulsed ASL: Uses a pulsed inversion/sat RF pulse with less power deposition. High labelling efficiency, Low SNR and higher transit delay.
2. Continuous ASL: Has high SNR, short transit delay but with lower labelling efficiency, high absorption rate and RF hardware needed.
3. PCASL: intermediate between PASL and CASL, clinically used with high SNR, lower absorption rate and high labelling frequency.
4. Velocity selective ASL: inverts spin based on blood velocity. short and uniform transit delay, low SNR and difficult to optimize the velocity rate.

Why perfusion MR imaging

Perfusion Studies look at blood flow/supply through a body of tissue which is critical for cell viability and function
3 main types of perfusion in MRI:

- DSC - Dynamic susceptibility contrast
- DCE - Dynamic contrast enhanced
- ASL – Arterial Spin Labelling

In PD, hypoperfusion is Predominant in brain regions such as basal ganglia sub regions, globus pallidus frontoparietal network, praecuneus, occipital lobe, sensory motor area regions, visual network which are associated with motor and non motor symptoms in PD, were identified with cerebral blood flow hypoperfusion, indicating neuronal loss and cerebrovascular dysfunction (Joshi et'al 2022)

Limitation of arterial spin labelling

- Due to its complex post processing, its use have been majorly in research.
- Hardware complications: ASL is feasible in low field strength but has high signal to noise ratio in high field scanners.
- It has long acquisition time which makes the scan long
- Asl signal is affected by labelling efficiency, blood transport time, magnetisation transfer effect, T1 relaxation in arterial blood. (Iutaka et'al 2023)
- Arterial spin labelling is susceptible to artefact which makes interpretation difficult. some of the artefacts can provide additional information to diagnosis as shown in diagram below. E.g. motion artefact or Intraarterial transit artefact as shown in the fig below which is good in identifying delayed arterial transit time for possible Cardiovascular disorder.

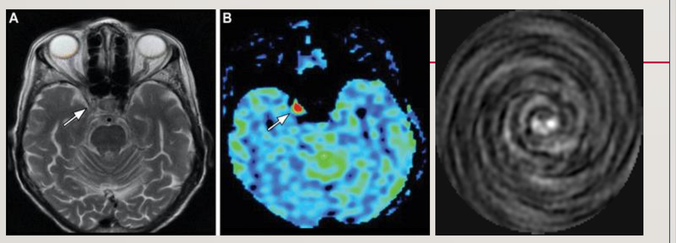


Fig 2: (A,B) arterial transit artefact due to stenosis in ax T2 image and an ASL with flow void. C showing motion artefact. Source: radiographic.rsna.org(2023)

Clinical Advantages of ASL

- ASL is non-invasive, no radiation or radioactive element required
- ASL does not require an exogenous tracer or contrast.
- It is used in patient with low Egfr, renal failure, patients with unknown egfr value.
- Can be used repetitively for follow up without the need for contrast.
- It can be repeated over a short period of time
- ASL can be quantitative e.g. in longitudinal studies and recognise of global hypo and hyper perfusion state. (Iutaka et'al 2023)

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Clinical application of ASL on Neuro degenerative disease e.g. Parkinson

- Shows hypoperfusion and hypometabolism proceeding atrophy or loss of volume as shown in fig 3 which matches with FDG PET. And both modality has similar diagnostic performance.(Haller et' al., 2016: Iutaka et' al., 2023)
- ASL also reflects neuronal activity which and may demonstrate similar findings to PET or SPECT in patients with neurodegenerative disease. (Iutaka et'al 2023)
- ASL can also be used as a complimentary diagnosis due to levels of signal intensity as in dementia. Needs further research
- ASL can also be used to discriminate PD or for differential diagnosis as is used in Alzheimer disease just as in FDG PET.(Joshi et al., 2022: Iutaka,2023)

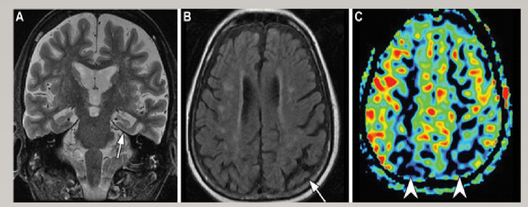


Fig 3: (A,B) Cor T2 weighted and axial FLAIR MR images showing loss of volume in temporal and parieto-occipital region.C is ASL image showing matched hypoperfusion. Source: radiographic.rsna.org (2023)

Clinical Limitation of ASL on PD

- Reproducibility: Standardisation
- Specificity and sensitivity: ASL shows reduced CBF in posterior cingulate gyrus and praecuneus with sensitivity of 91% and specificity of 80% (Iutaka et'al 2023) .further research for PD.
- Interpretation unfamiliarity: by Radiologists relating to author's trust.
- Lack of research materials especially in the role of ASL in PD diagnosis may explain why the possibility of using ASL in PD diagnosis e.g author's trust have not been implemented.

Critical discussion

In a study by kamagata et' al (2011)35 PD patients, 11 psrkinson disease with dementia (PDD) 35 normal controls were scanned using ASL. Result shows that PD and PDD patients has lower regional regonal cerebral blood flow in the posterior cortex as shown in the diagram below. Although lower in PD than PDD, this study should have isolated PD in this case, which is in line with previous PET and SPECT studies used to know functional abnormality in PD and PDD.

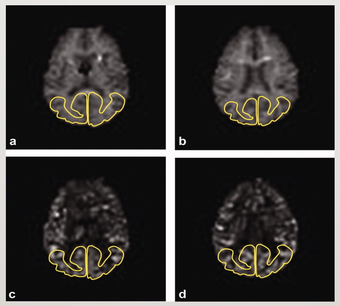


Fig 4: posterior cortex hypoperfusion in ASL map. Sources: journal of magnetic resonance imaging (2011)

There are several imaging approaches for screening PD including PET, SPECT, MRI and CT. SPECT or PET has an important role but requires radioactive tracers. CT is no specific but useful in ruling out atrophy, hidden lesions and vascular disease, PET has 90% accuracy in diagnosis of PD, limited due to high cost, radiochemical lab etc. F-deoxy-glucose PET/CT as showm below has also bean limited due to low special resolution and image quality though can differentiate PD from other neurodegenerative diseases as shown below. It seems that advanced MRI techniques are like ASL, DWI, DTI, MRS, ASL, MTI are more delicate in PD diagnosis. (Mortezazadeh et'al 2021)

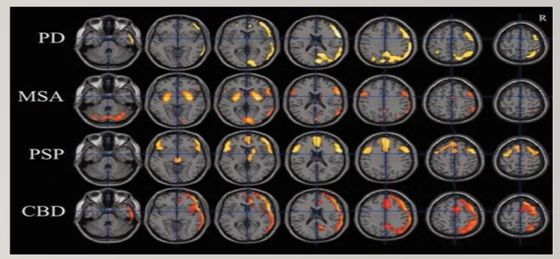


Fig 5:PET image with f-deoxy-glucose showing hypometabolism posterior cortical regions compared to other neurodegenerative diseases. Sources: Egyptian journal of radiology and nuclear medicine.(2021)

Combined pre-and postsynaptic SPECT with clinical criteria could improve diagnosis of PD as shown below in early stages but still expensive to maintain and needs a radioactive element.

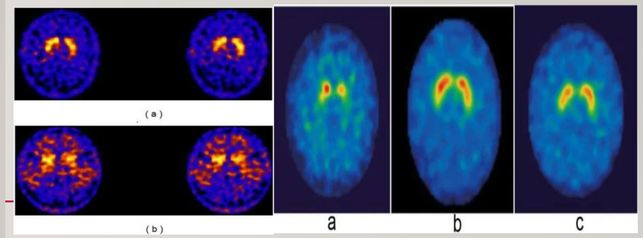


Fig 6:SPET image with Trodat -1 in normal patient (a) and early PD (b) and dopamine transporter SPECT in PD(a), tremor(b), and control (c). Sources: Egyptian journal of radiology and nuclear medicine.(2021)

Recommendations.

- More research should be done geared toward ASL finding in Parkinson without categorising them under Neurological condition.
- Combination of ASL and functional MRI will be an interesting area to explore in PD diagnosis and monitoring

CONCLUSION

ASL has great potential for diagnosis and monitoring PD patients, further research and implementation of new advances can be used to remedy the limitations and artefact associated with ASL. The advantages of using ASL compared to other imaging modalities like FDG PET etc offers patients easier way of diagnosis and monitoring to enhance their management and treatment. There is also great need for standardisation of ASL finding in PD. Radiologist should also get familiar with ASL findings in PD to enhance development of practical guidelines which will enable integration of ASL into clinical practice.

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