

Cerebral Atrophy vs. INPH Evaluation via Infusion Test

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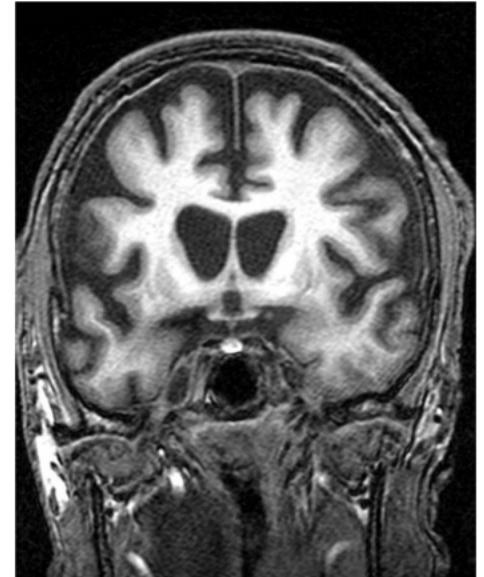
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Every Day, A New Discovery

What is cerebral atrophy?

- Cerebral atrophy is defined simply as loss of cells in the brain focally or in general.
- More specifically, atrophy is a loss of neurons and the connections between them in brain tissue.
- Possible cause of cerebral atrophy varies such as aging, Alzheimer's disease, stroke, epilepsy, MS, etc.



Cerebral atrophy in NPH patients

- Idiopathic Normal Pressure Hydrocephalus (iNPH) is mostly diagnosed in elderly that includes clinical symptoms of gait disturbance, dementia, and urinary incontinence with the presence of ventricular dilatation and normal CSF pressure .

Cerebral atrophy in NPH patients

- The presence of ventricular dilatation may be sometimes misinterpreted as a result of brain atrophy therefore, iNPH has been misdiagnosed as Alzheimer's or other neurodegenerative diseases.

Cerebral atrophy in NPH patients

- Also, the periventricular white matter changes which are observed in iNPH patients may be as a result of CSF extravasation not as a result of ischemic changes.

Cerebral atrophy in NPH patients

- In addition, atrophic brain is frequently observed in elderly patients as well.

Cerebral atrophy in NPH patients

- Therefore, it is necessary to characterize the iNPH radiological findings and differentiate those from the neurodegenerative diseases and ischemic changes.

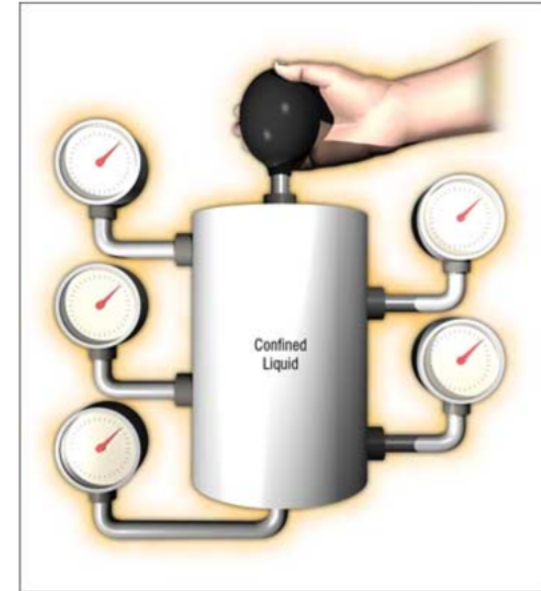
■ CNS is a closed system consists of subsystems:

1. Soft tissue (brain parenchyma)
2. Fluid circulatory systems (CSF and blood).

■ The interplay among abovementioned subsystems is physically characterized by pressure-volume relation:

Pressure-volume relation

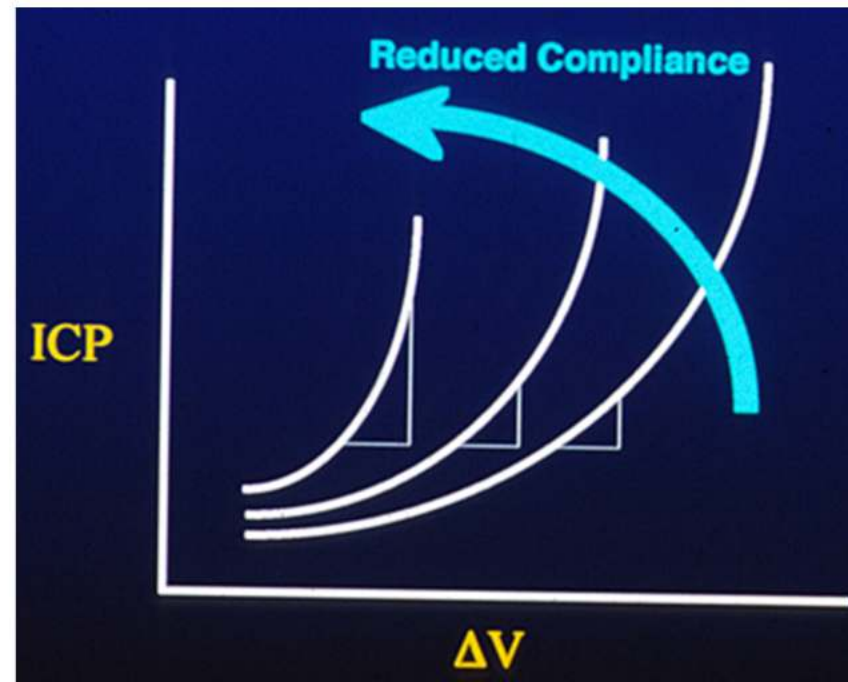
- Pascal's law: Pressure exerted on liquids contained in a closed volume is transmitted to all directions equally.
- This is primarily due to the property of liquids being incompressible.
- The cranium deviates from fitting the incompressibility model due to the elastic behavior of the brain parenchyma.
- Due to this deviation, pressure-volume relation within the brain defined and tested qualitatively within the context of compliance.



Compliance

- As an amount of liquid injected to a closed system (e.g.; the cranium) the pressure response depends on the accommodation level of the enclosure to the addition of extra liquid.
- Compliance can be defined as the change in pressure against addition of liquid into the CSF space (C):

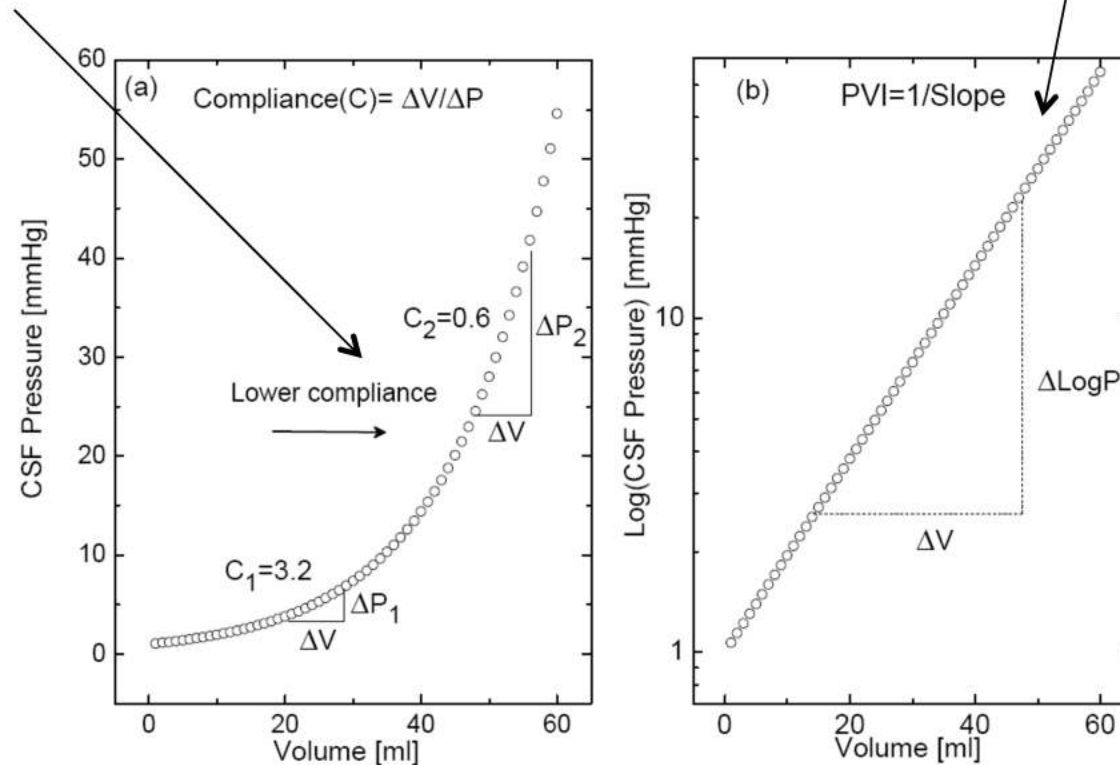
$$C = \Delta V / \Delta P.$$



Compliance vs. PVI

Compliance changes as one moves along the P-V curve.

PVI yields a constant value



$$PVI = \frac{\Delta V}{\log \frac{P_p}{P_r}}$$

ΔV : Amount of volume injected in ml.
(usually a total of 4ml at a rate of 1ml/s).

P_r : Resting /opening pressure for CSF.

P_t : Peak CSF pressure after infusion.

Pressure-volume index

- This constant value is called as “***pressure-volume index (PVI)***”.
- *PVI is defined as the amount of liquid needed to increase the CSF pressure ten-folds within the physiological limits.*
- PVI can be easily calculated using the data obtained from an infusion test.

PVI vs. Atrophy

- Monitoring pressure response to an addition of a liquid into the CSF space that has elastic boundaries can be a good probing tool.
- PVI can be used as parameter of interest because it is a characteristic quantity of the brain in the units of [ml].

How does PVI help to evaluate atrophy?

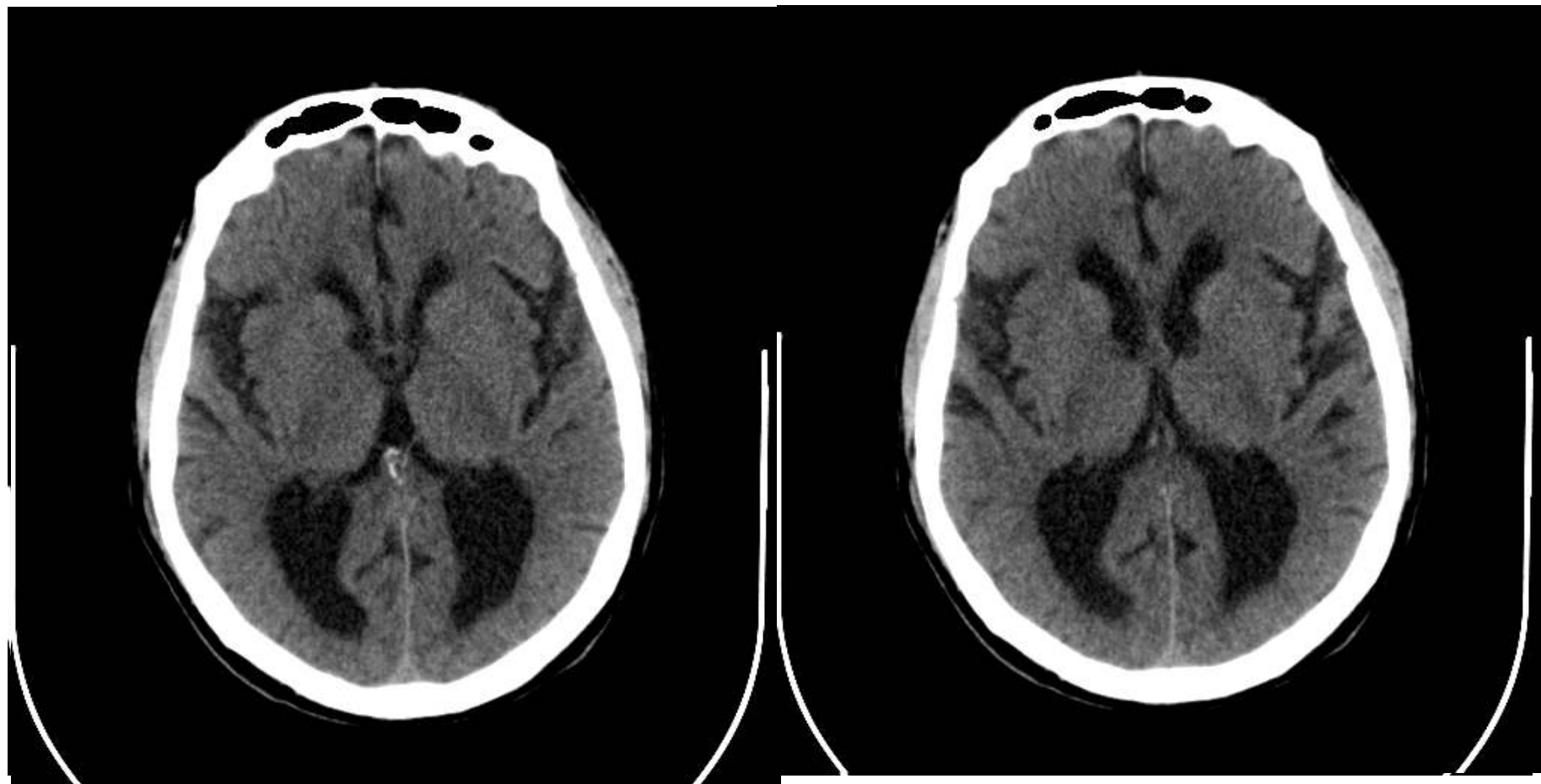
- Low PVI simply implies to a tight brain. (Needs less liquid to increase pressure ten-folds)
- On the contrary, a high PVI means more sponge-like or soft brain (Needs more liquid to increase pressure ten-folds)
- Therefore, high PVI indicates that some degree of cerebral atrophy is present.

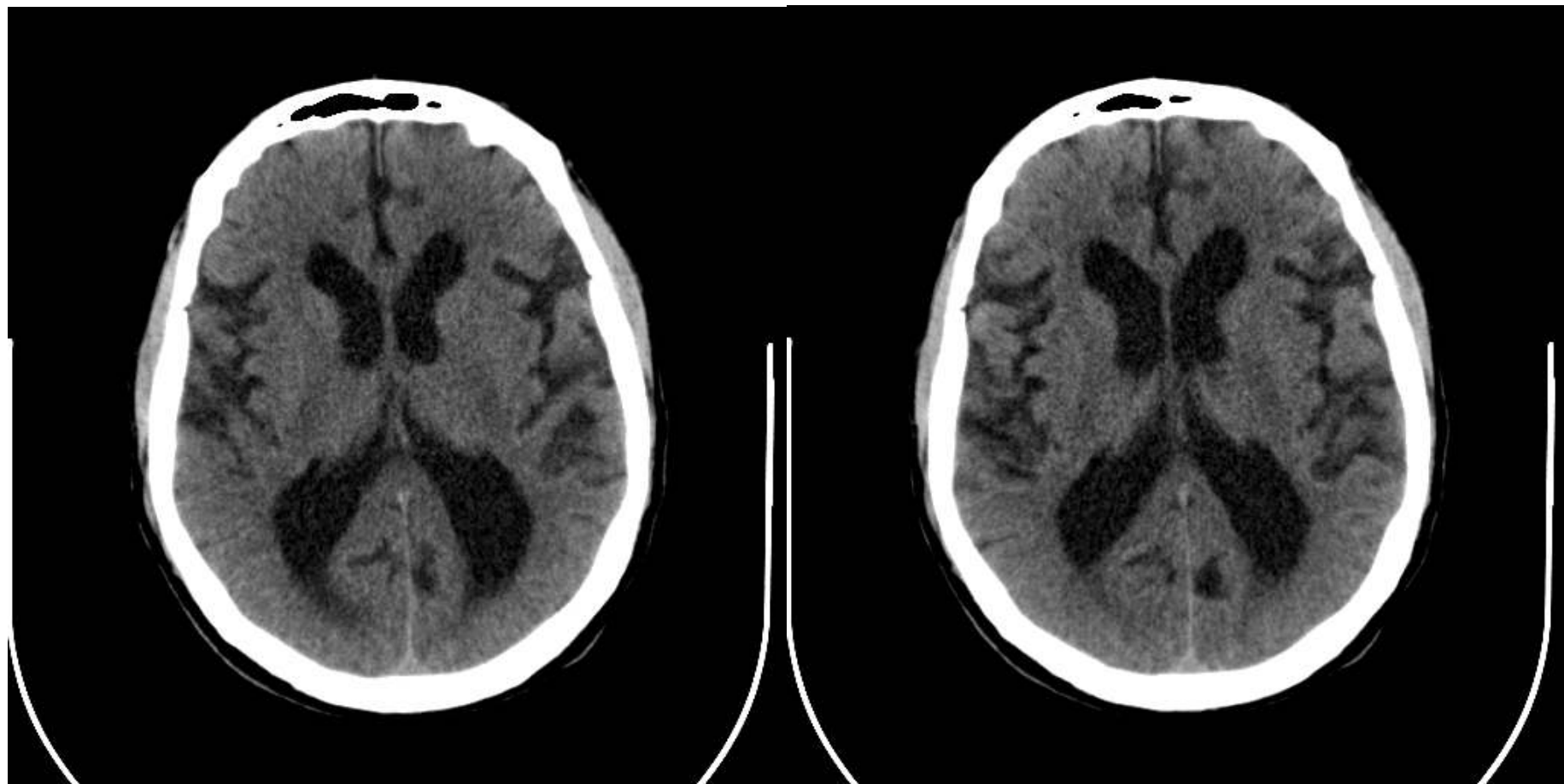
PVI vs. Image results

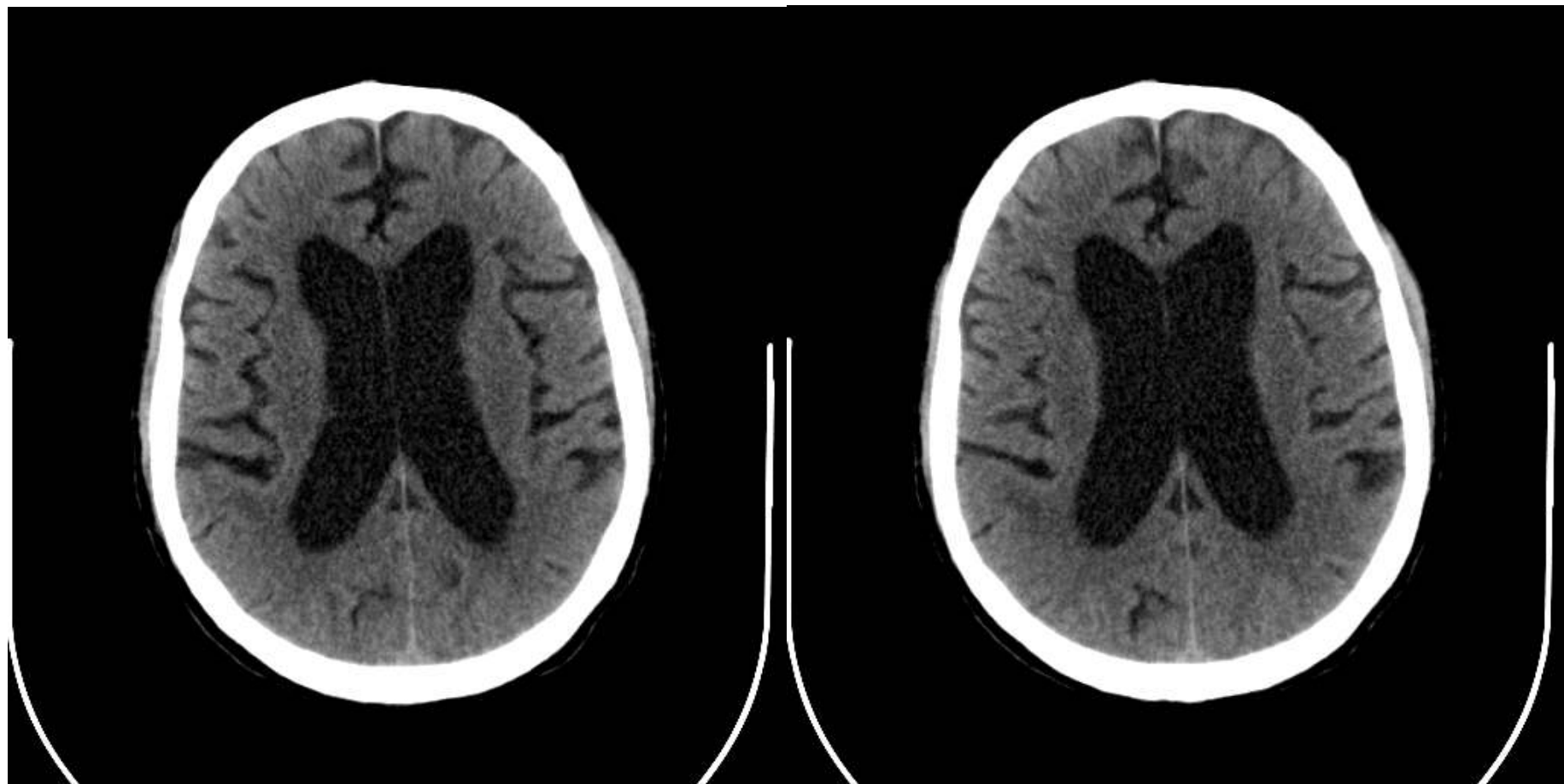
- The radiological findings of our iNPH findings have following statements;
- “Generalized volume loss/atrophy”
- “Extensive periventricular white matter changes”
- “Dilatation of the ventricular system”
- “Disproportionately enlarged subarachnoid space (DESH)”

PVI vs. Image results

- Patient JK; 76 years old male comes to our NPH clinic and presents with the full triad of iNPH symptoms.
- The radiological findings indicates that there is mild generalized volume loss as well as dilatation of lateral ventricles.





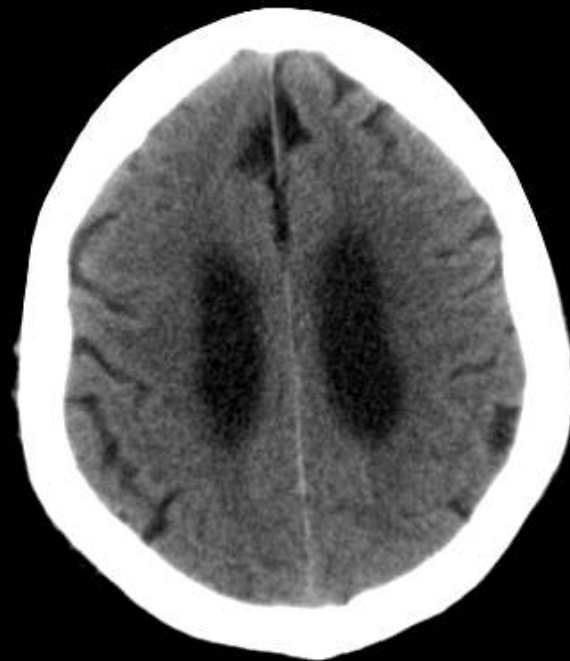
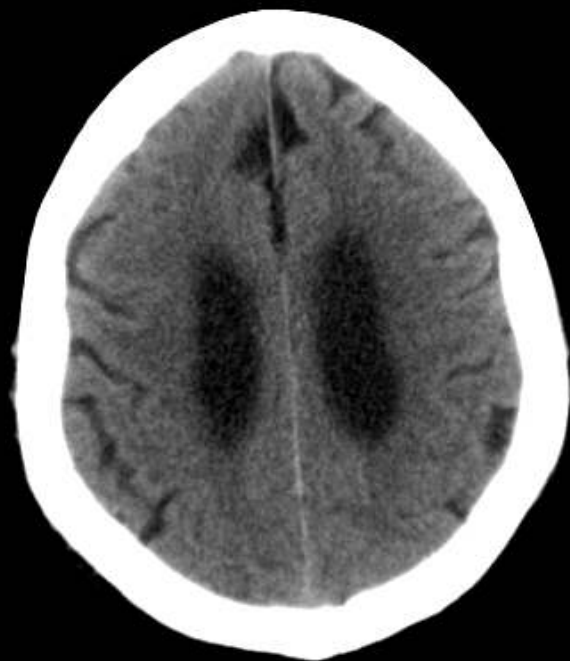


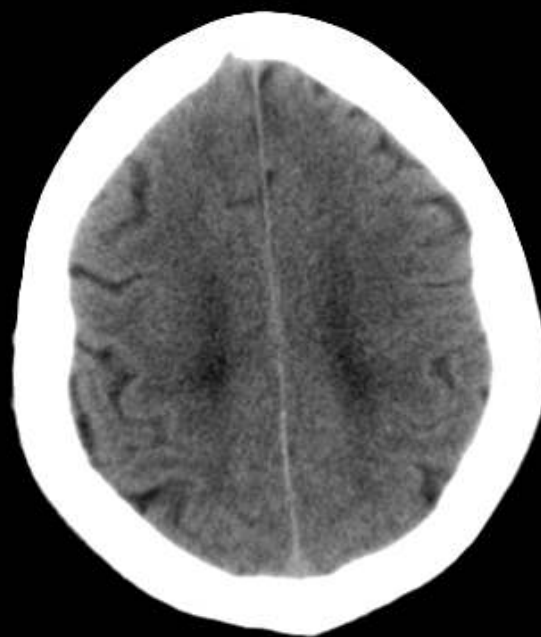
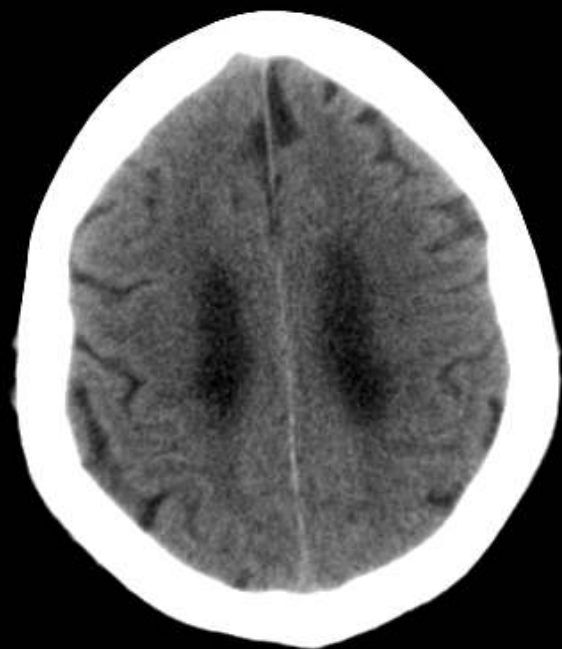


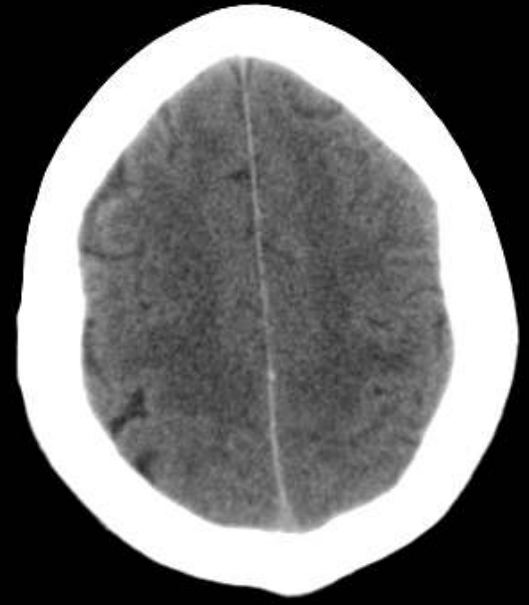
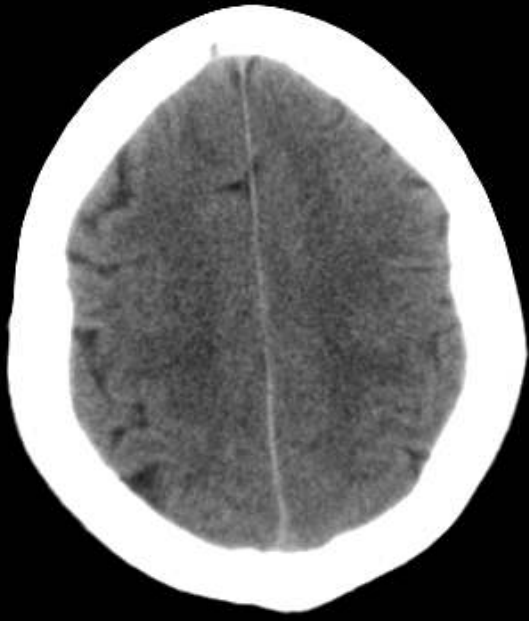












PVI vs. Image results

- Infusion test

OP: 14 mmHg

Ro: 10 (normal is 4)

PVI:20 (normal is 25 ml)

- Large Volume Tap (40 cc)

Marked improvement in gait

- Received a VP shunt

Patient is doing very well. His wife says his balance is "better than ever " and he is fully alert.

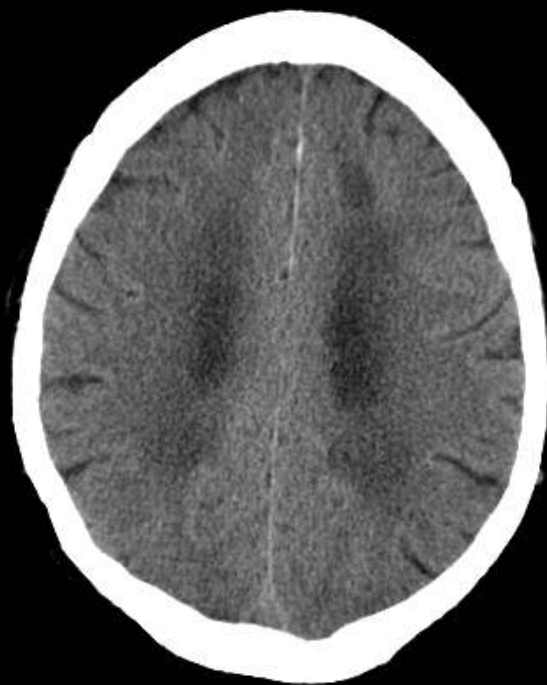
PVI vs. Image results

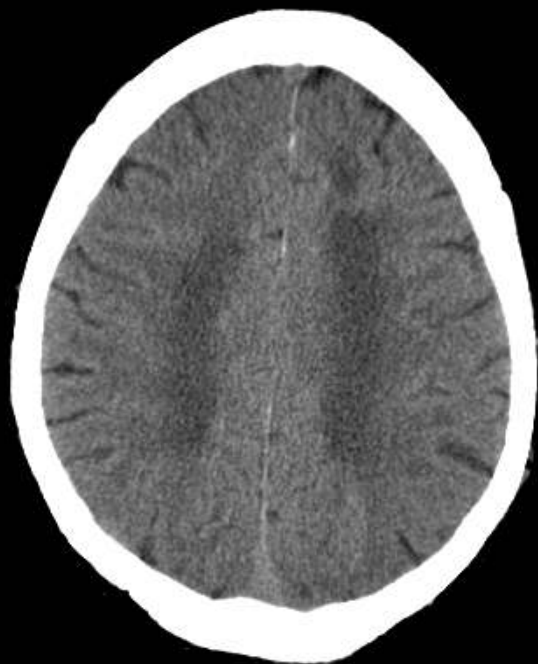
- Patient JB; 82 year old male comes to our NPH clinic and presents with the full triad of iNPH symptoms.
- The radiological findings indicates that there is extensive periventricular and subcortical white matter changes in addition to dilatation of ventricular system.













PVI vs. Image results

- Infusion test

OP: 8 mmHg

Ro: 14 (normal is 4)

PVI:15 (normal is 25 ml)

- Large Volume Tap (40 cc)

Marked improvement in gait

- Received a VP shunt

Patient improved in his gait
however showed the signs of
apathy “ I have no interest in
anything”.

Summary and Conclusions

- If radiological findings of a possible iNPH patient refer to some degree of atrophy and the infusion test results are consistent with “normal or low PVI” ;
- This may indicate that it is not the atrophy, it is the CSF diffusivity through the brain parenchima which plays the major role in the pathophysiology of these iNPH patients.

Summary and Conclusions

- If CSF diffuses in the atrophy-like regions, PVI will be significantly lower due to the incompressibility of liquids.
- Versus, PVI will be higher due to atrophic changes since there is a room for external volume addition through the infusion test.

Summary and Conclusions

- Our goal is to establish an algorithm which will include the findings of brain imaging and infusion study in order to differentiate the CSF spaces from atrophy.
- Our results will be presented at the next meeting of Hydrocephalus 2013.