

# MRI for Paediatric Surgeons



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What determines the brightness of a pixel in MRI?



# i.e. What determines the strength of signal in MRI?

Density of Hydrogen Atoms in any structure

In biology the vast majority of Hydrogen is in *water*

The local environment around the  $H^+$  atoms

i.e. the tissue makeup

Strength of the magnetic field

# What are sequences?

A sequence is a series of different radiofrequency pulses designed to return signal from different tissues

Most commonly accentuate 'T1' and 'T2' characteristics of a tissue to varying degrees

# What produces signal in MRI?

Bright on T1

fat

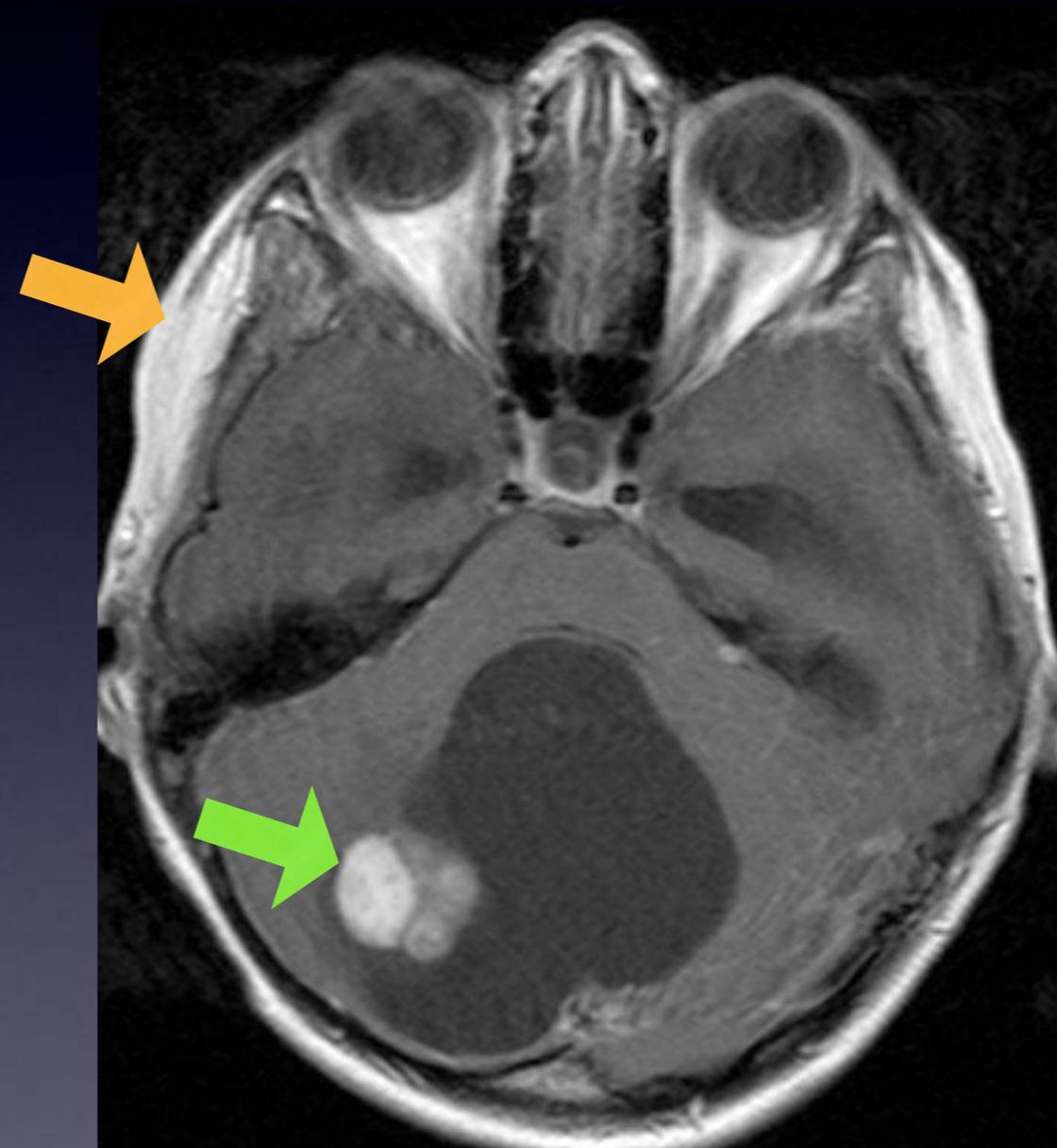
blood products

proteinaceous material

gadolinium contrast

Bright on T2

water



T1

# What produces signal in MRI?

Bright on T1

fat

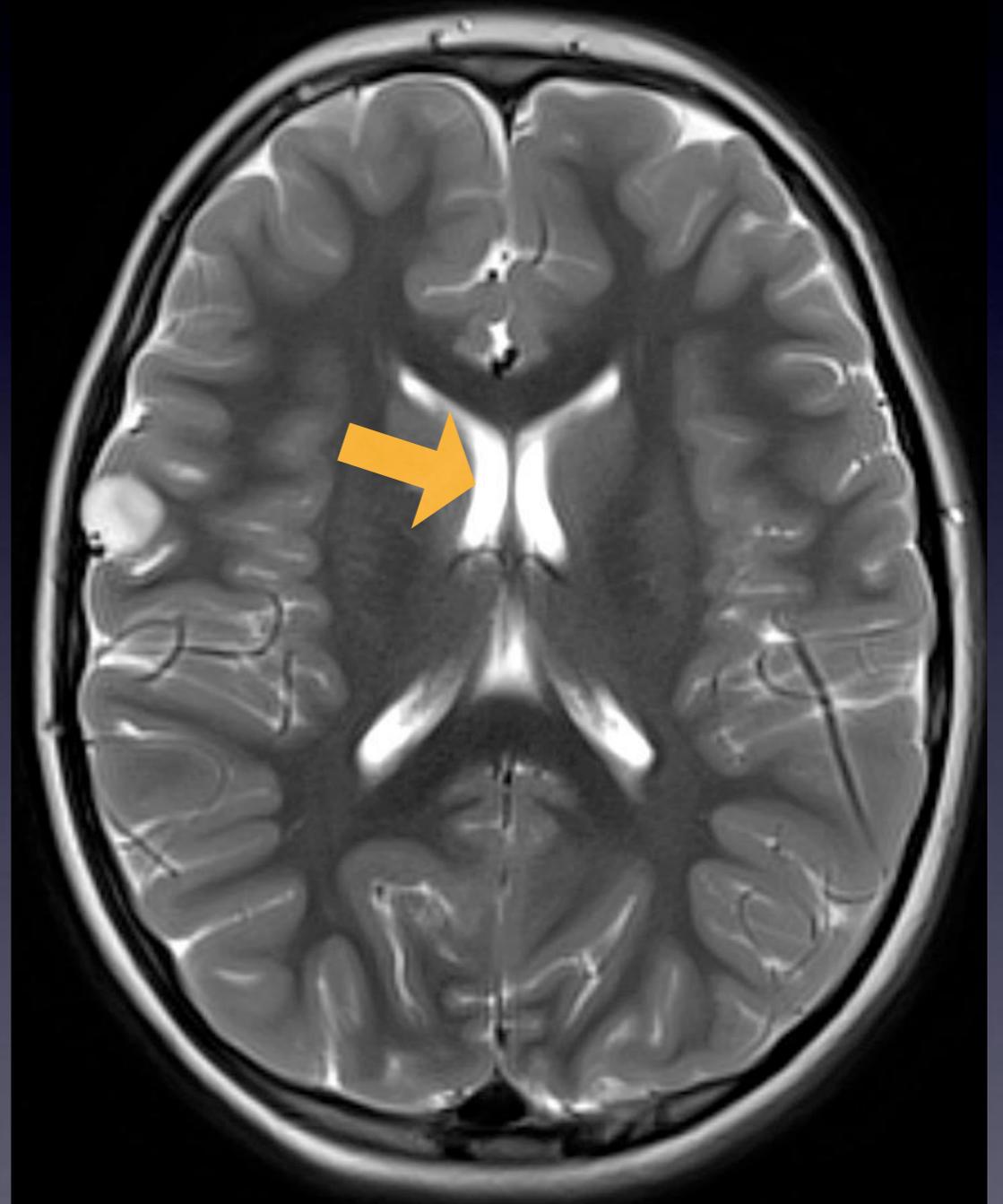
blood products

proteinaceous material

contrast

Bright on T2

water



T2

# What has very low signal in MRI?

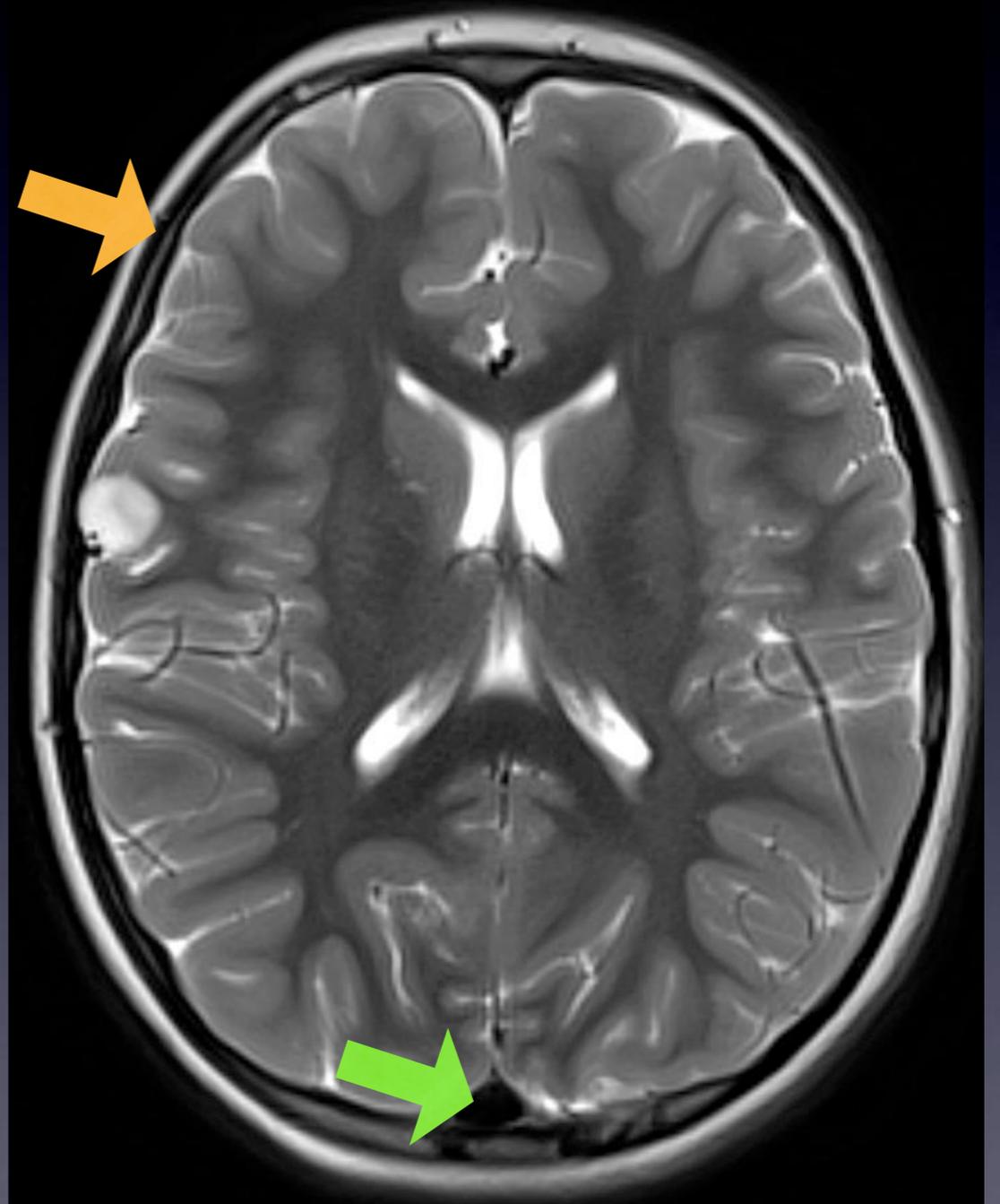
Tissues with low H<sup>+</sup> concentration

Cortical Bone

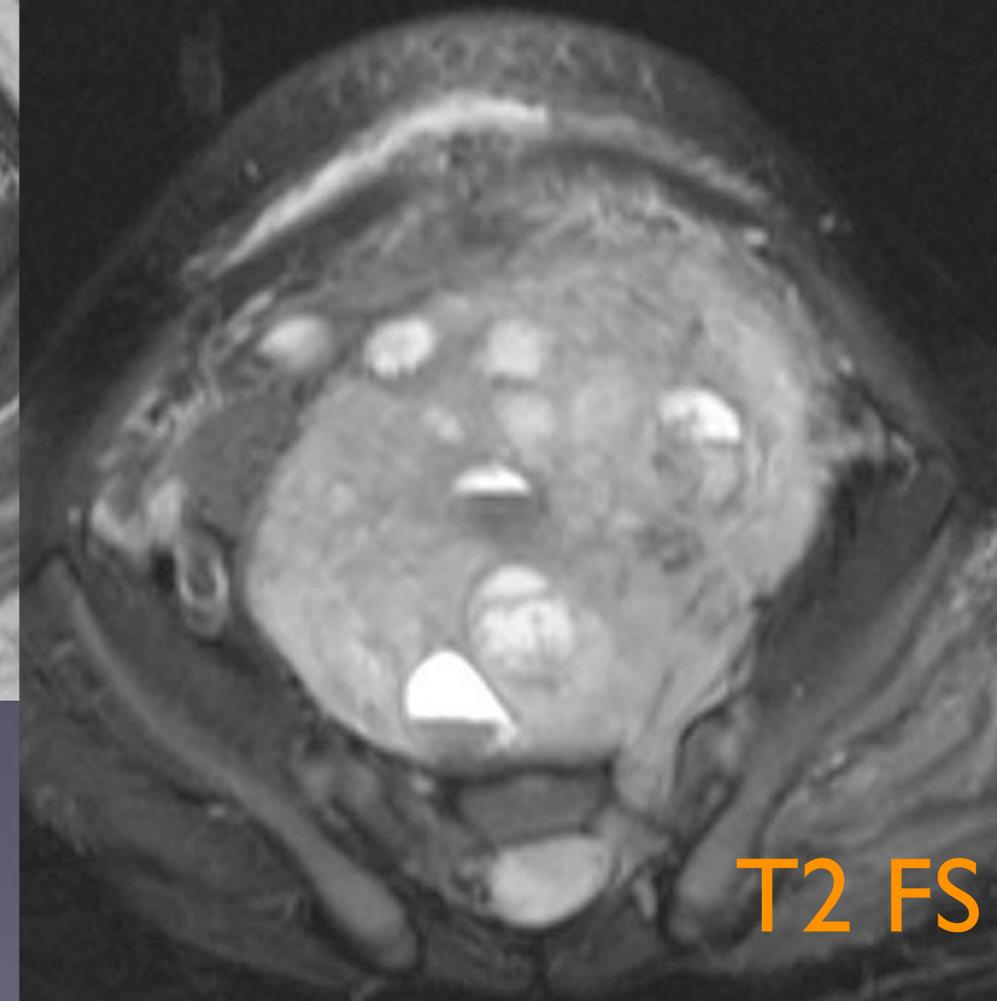
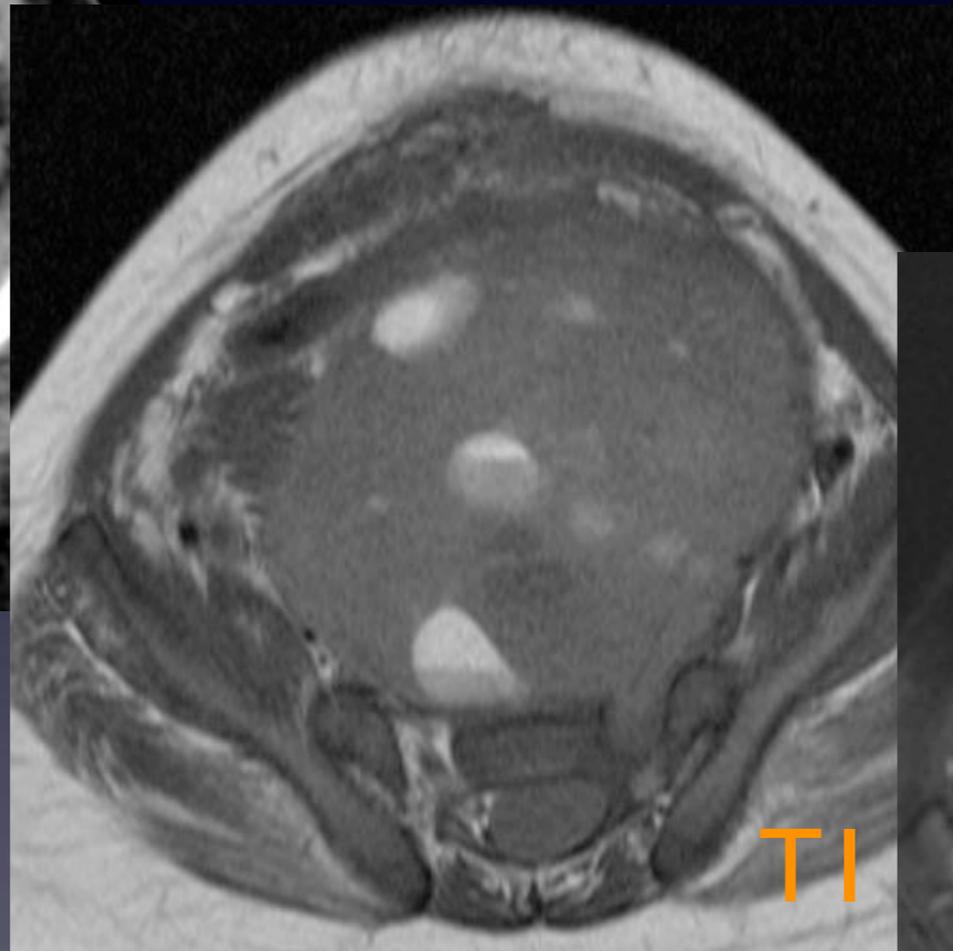
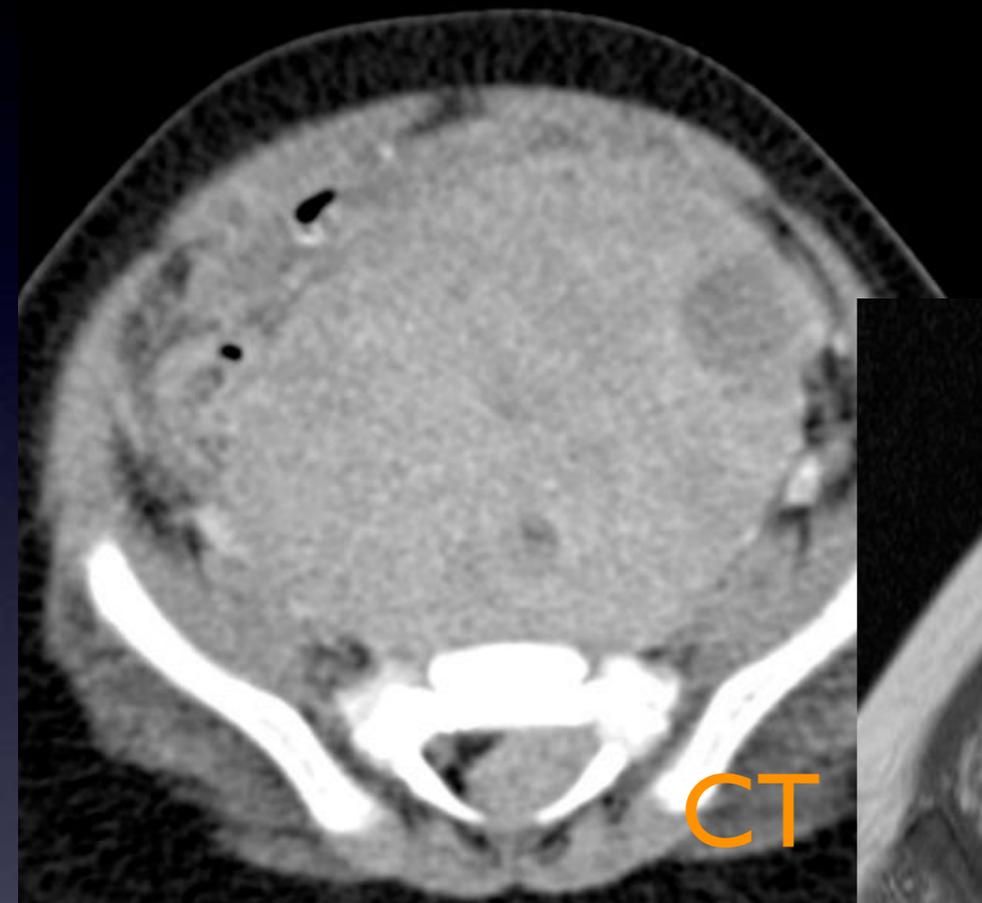
Air

(Flowing blood)

Haemosiderin



# Contrast Resolution



# Spatial Resolution

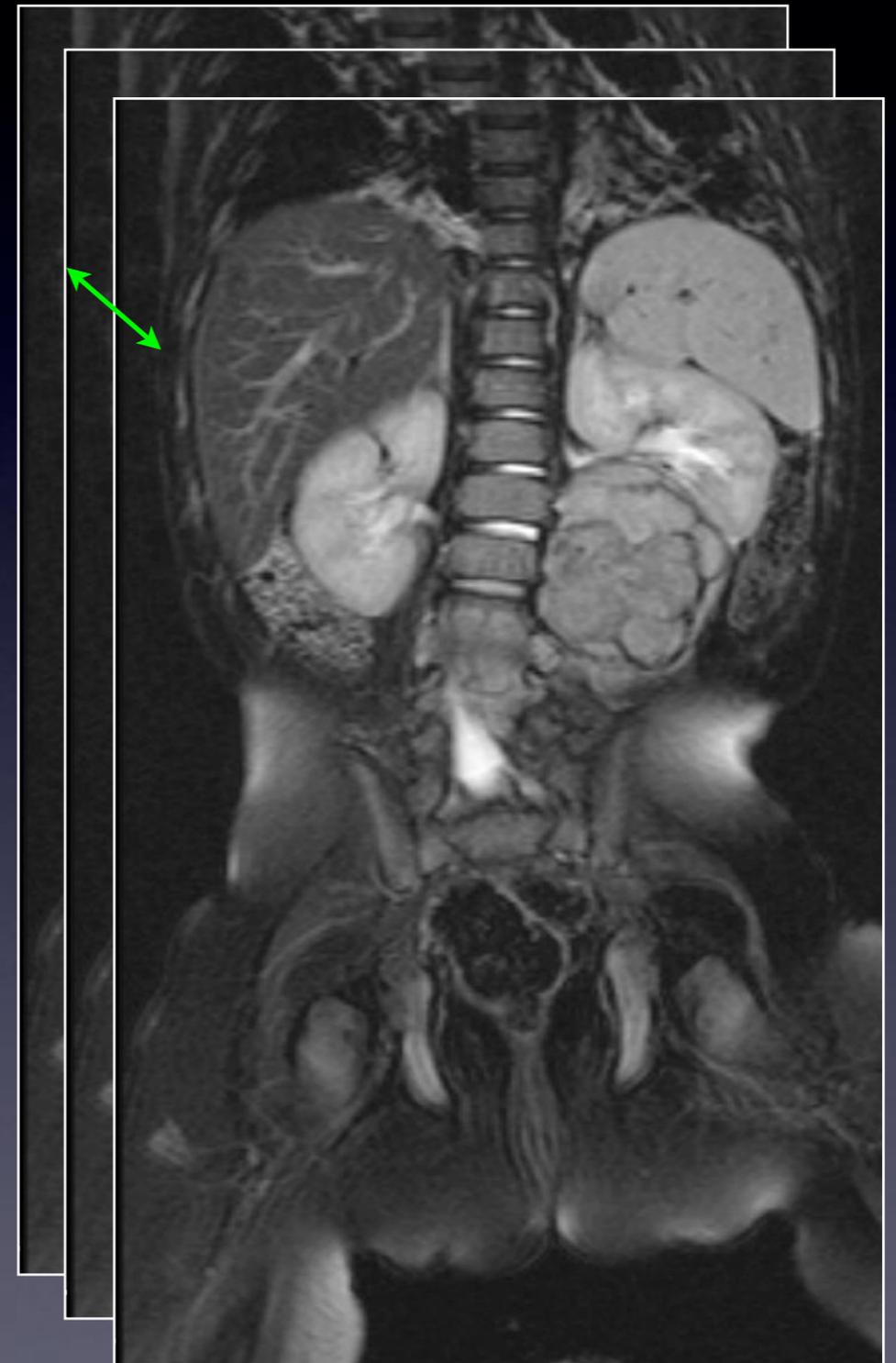
## Slice thickness

Most sequences have a small gap between each slice

Usually  $\sim 10\%$  of the slice thickness

'3D' sequences have no gap and very thin slices  $\sim 1\text{mm}$

z plane



# Spatial Resolution

In plane resolution (pixel size)

field of view

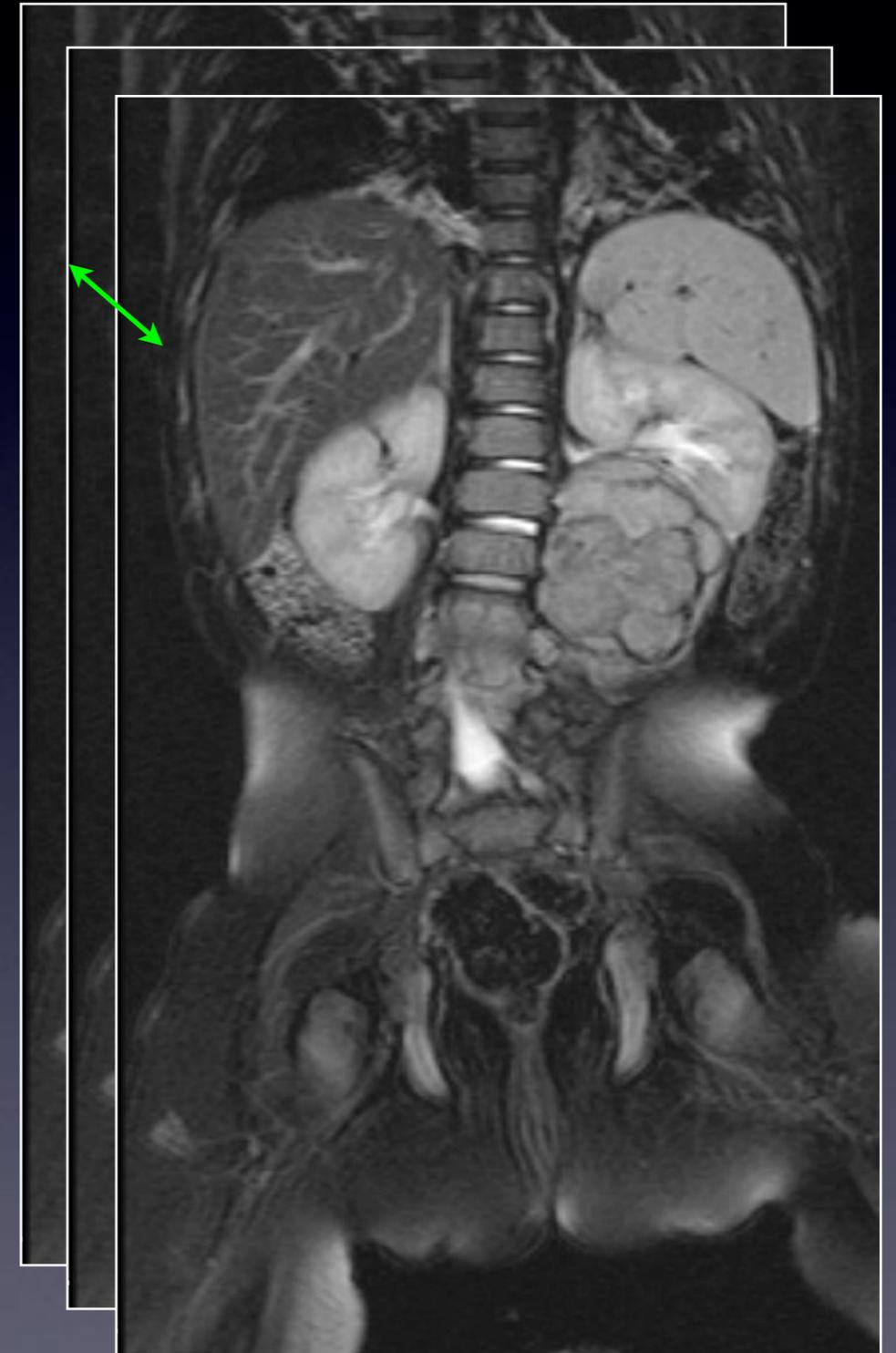
~10 to 50cm

matrix

number of pixels

128 to 512

x and y plane



# Spatial vs Contrast Resolution

Smaller pixels

- = better spatial resolution
- = less tissue per pixel
- = less H<sup>+</sup> per pixel
- = less signal
- = noisy, grainy images
- = less contrast resolution



Contrast Resolution

Spatial Resolution

Time

# High Field Strength (3T)

More signal

Faster imaging

Smaller pixels - more detail

Technically more challenging

Prone to artifacts in body work

Improving all the time

Expensive

# Surface Coils



# T1 Spin Echo

Bright -

*Lipids (adipose, myelin, fatty marrow), gadolinium, blood breakdown product (MetHb), protein, melanin.*

Traditionally for anatomical detail

*Most important role is in post contrast imaging*



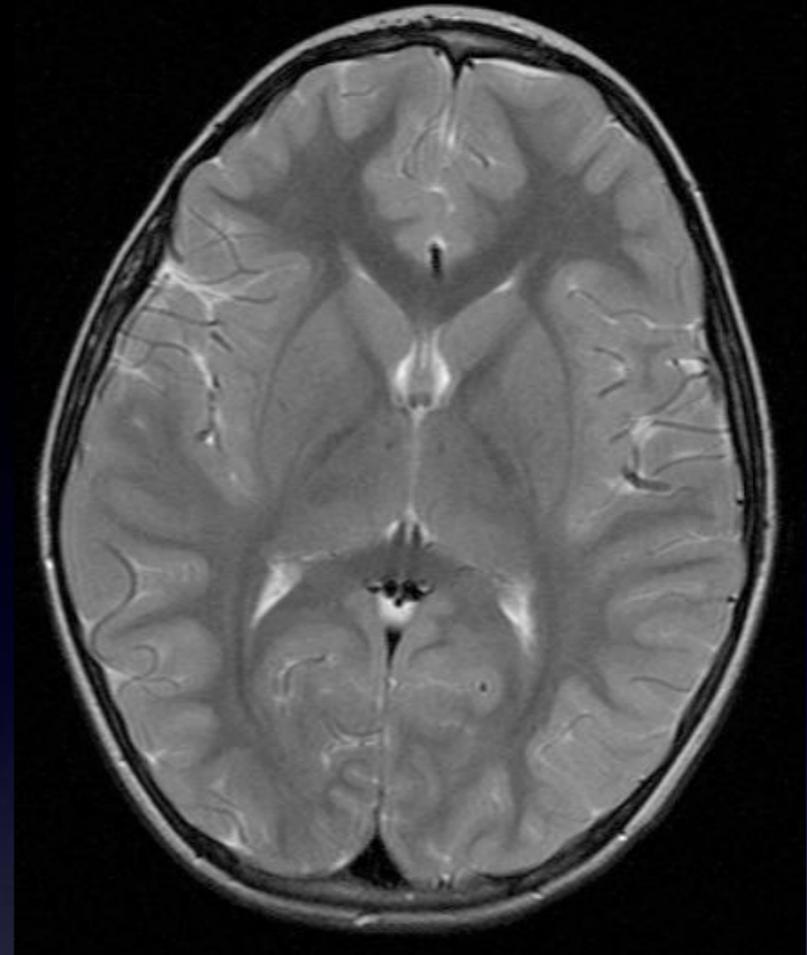
# T2 Spin Echo

Bright -

Fluid (csf, oedema, water in cysts, tumours)

Excellent for pathology

*Mainstay of pre-contrast imaging*



# Why is the fat bright on that T2 sequence?

Because of technical and time limitations, sequences are not usually 'pure' T1 or T2

most sequences are somewhere along a spectrum between T1 and T2

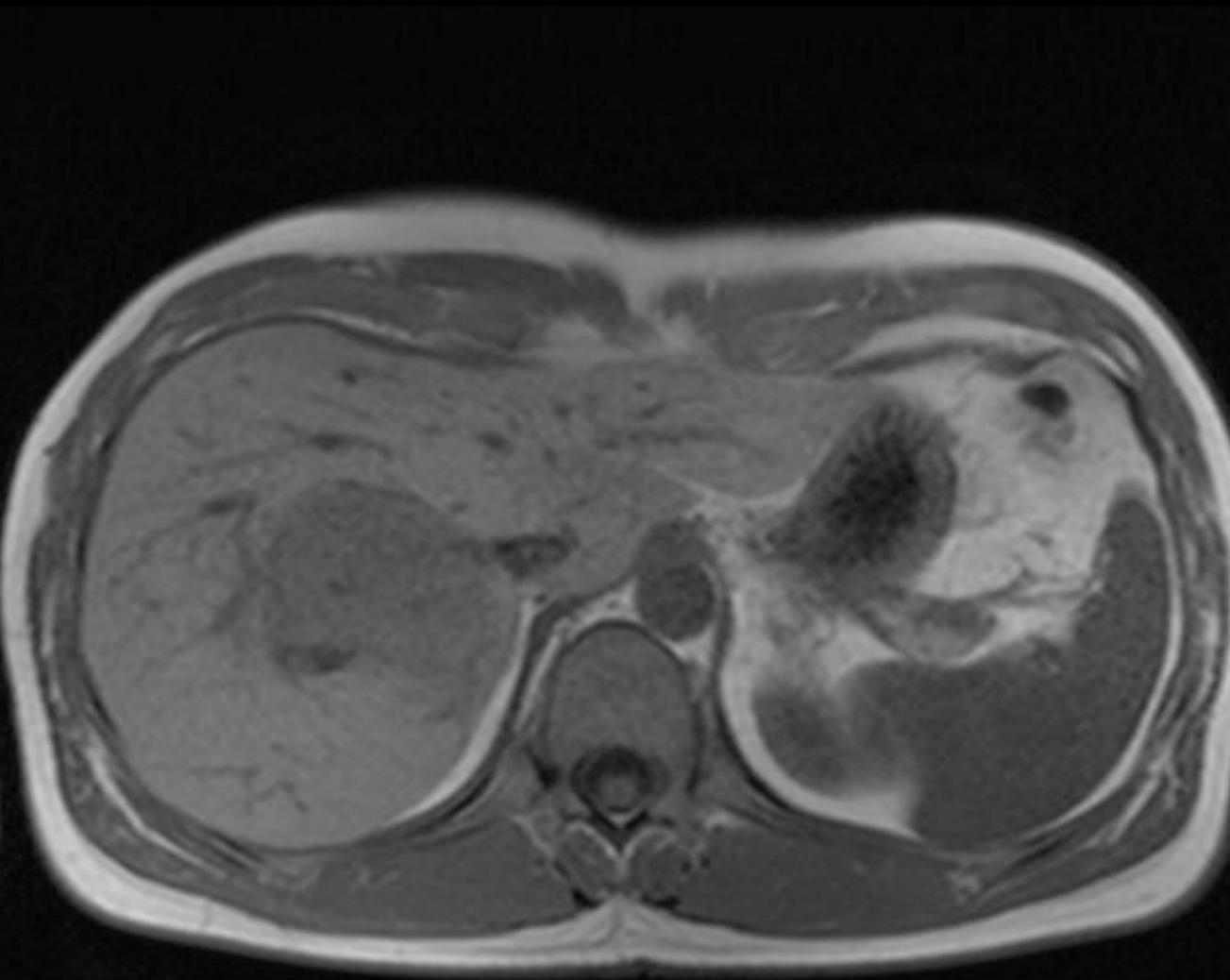
Thus terms like 'heavily T2 weighted' for MRCP sequences



# T1 and T2 Spine



# T1 and T2 Abdomen



25 : L 387

6



W 816 : L 379

Is the fluid bright?

# Fat Suppression

Several techniques with similar goal of removing fat signal so that pathology is more obvious

Oedema on T2 - Enhancement on T1

Common - Fat Saturation pulse, STIR

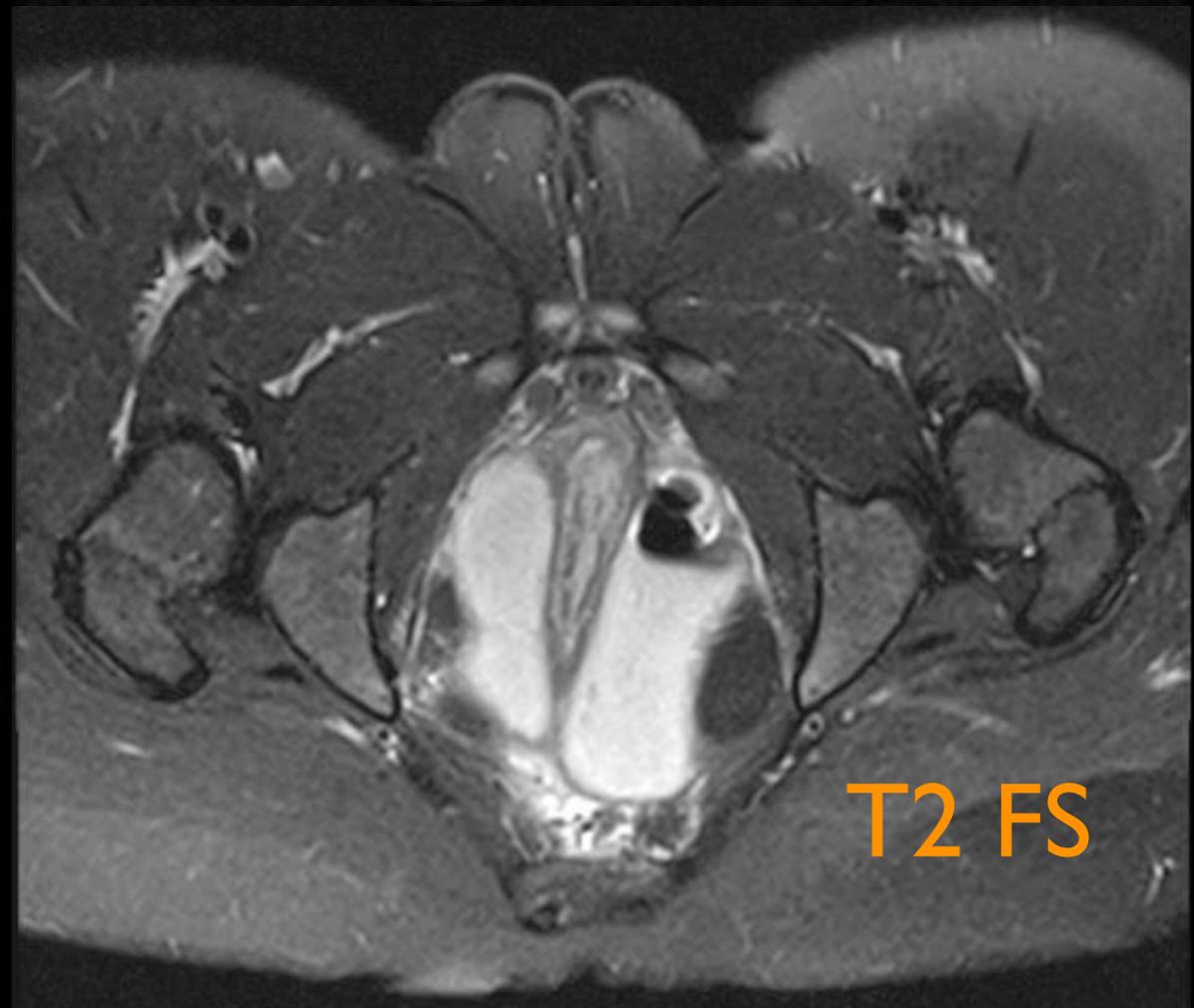
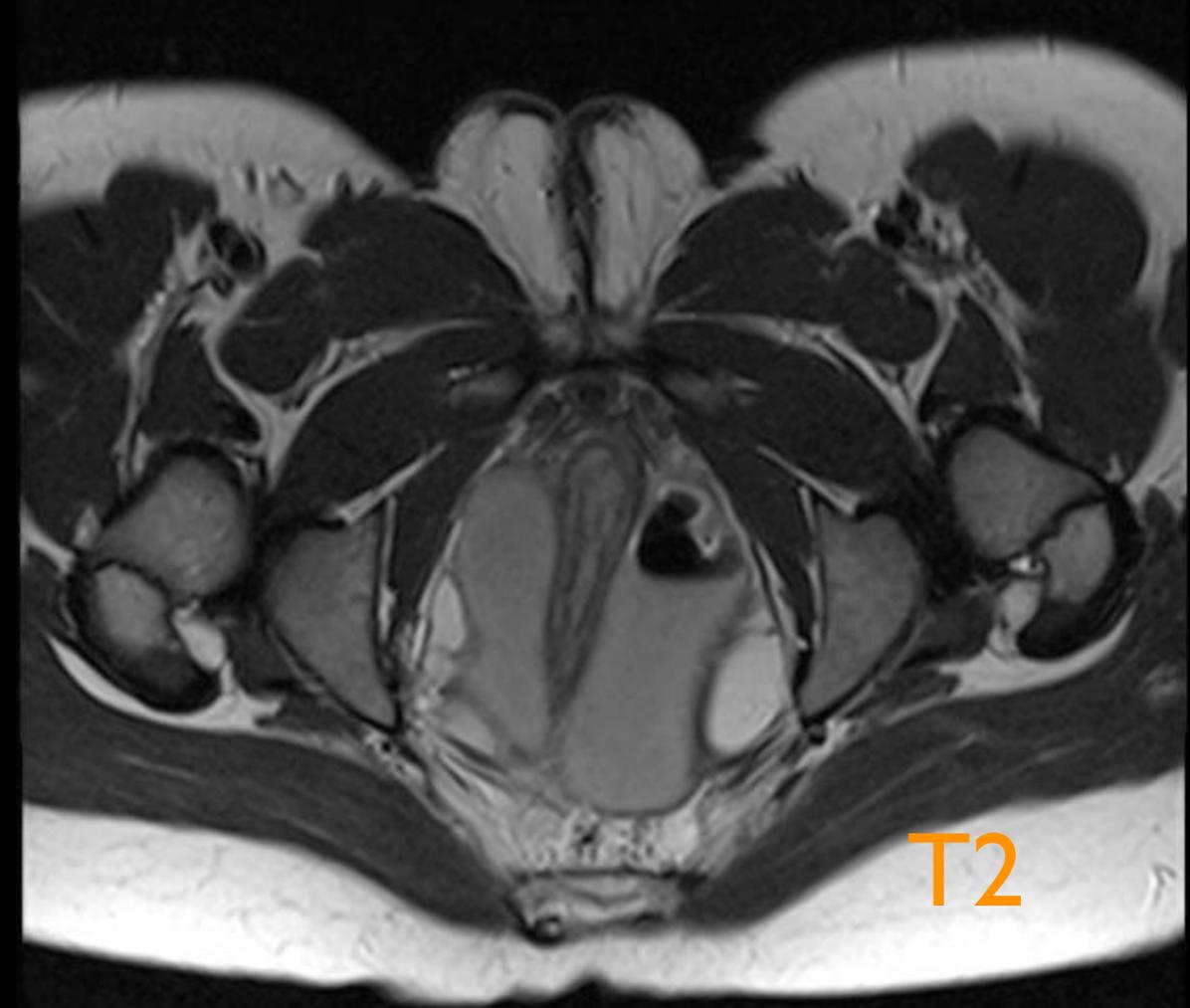
Others - 'IDEAL' - 2 and 3 point Dixon and more

Different advantages and disadvantages

# Fat Saturation

Can be added to most common sequences with a small increase in time and radiographer trickiness

Need an even magnetic field  
i.e. ruined by adjacent metal  
or uneven shaped anatomy



# Fat Sat



# STIR

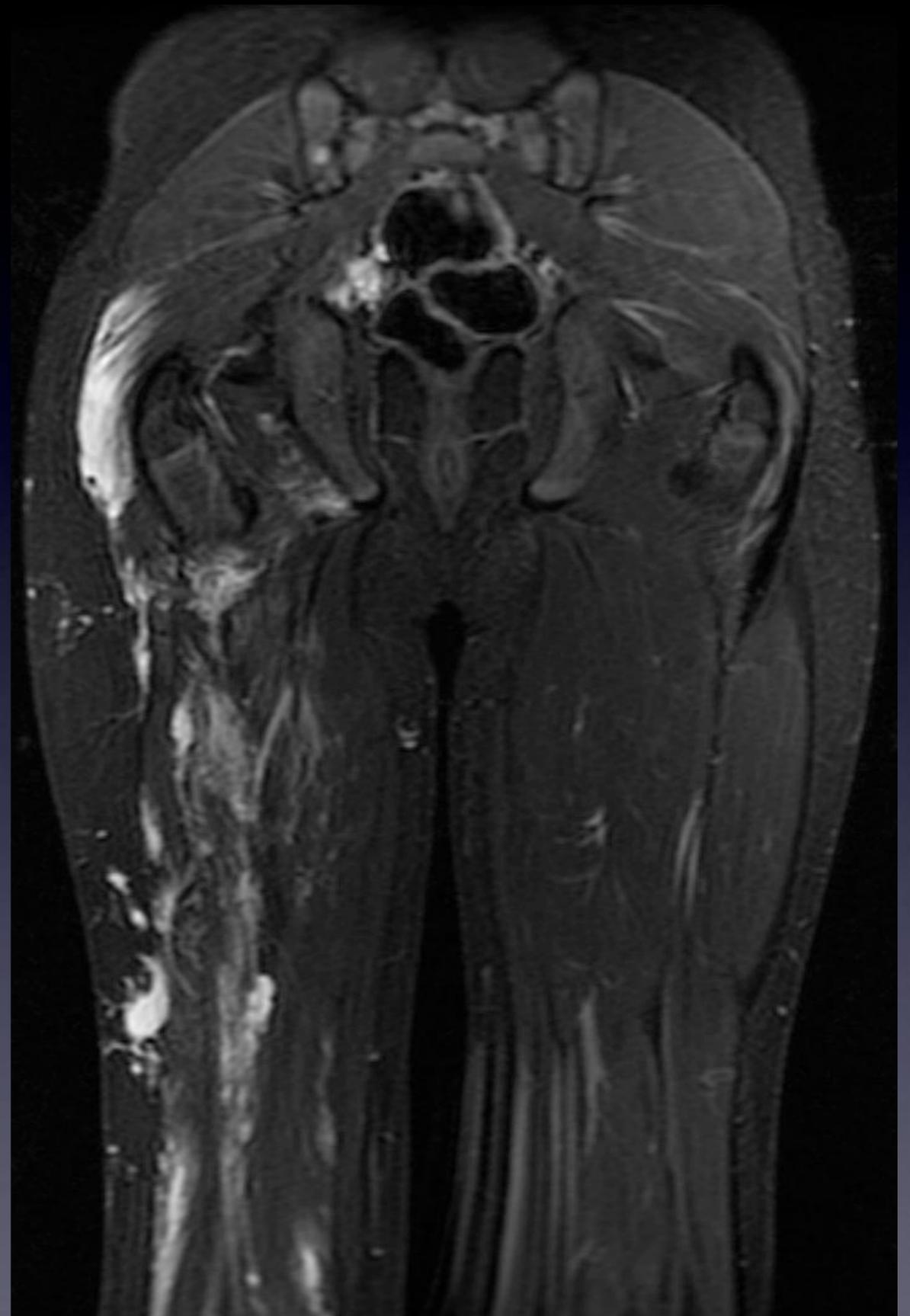
Short Tau Inversion Recovery

Inversion Recovery is a technique to remove signal from a specific tissue

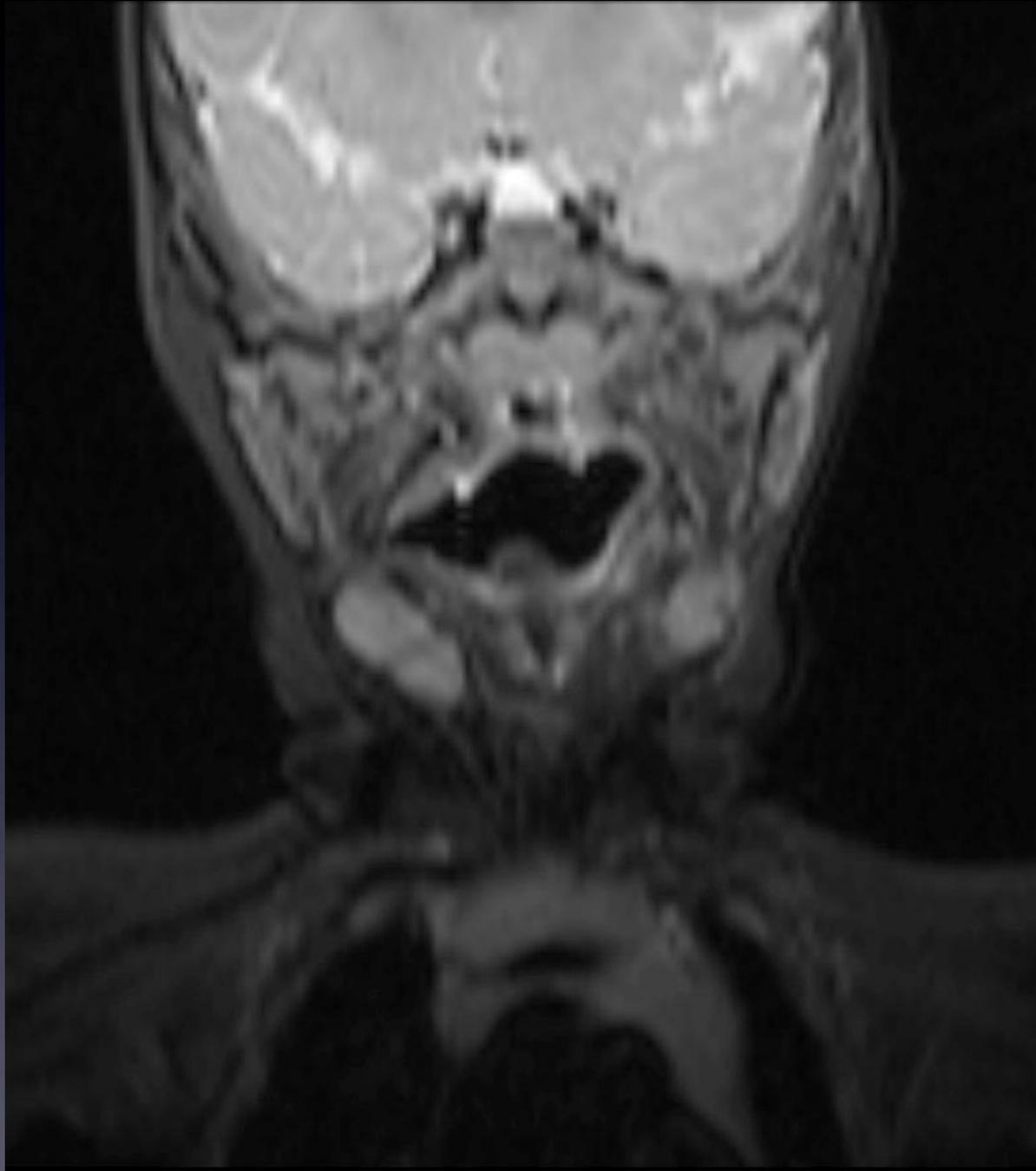
In this case - Fat

Very even fat suppression over large areas but often less sharp

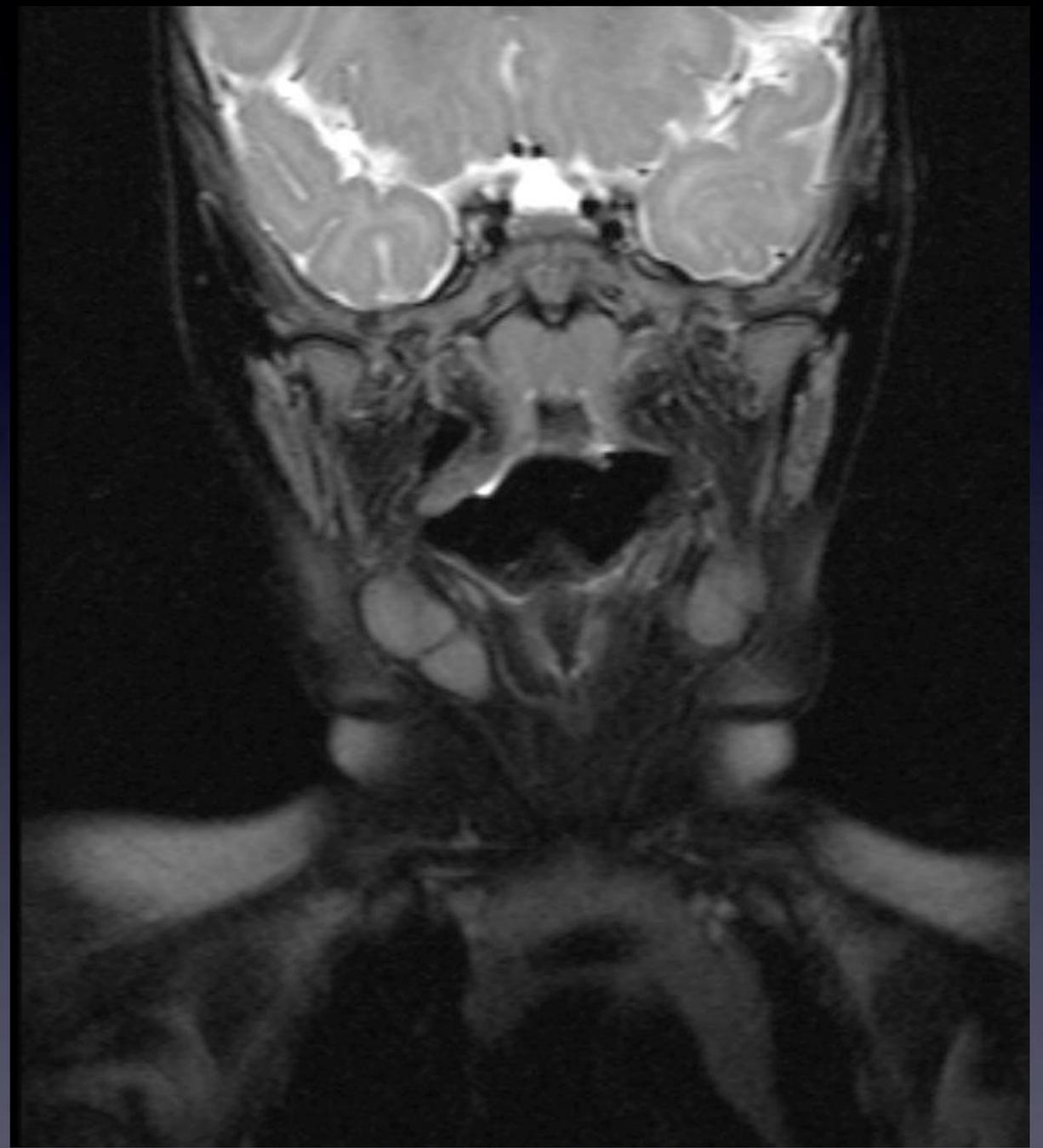
T2 weighted image



# STIR vs. Fat Sat



even but fuzzy



uneven but sharp



T1



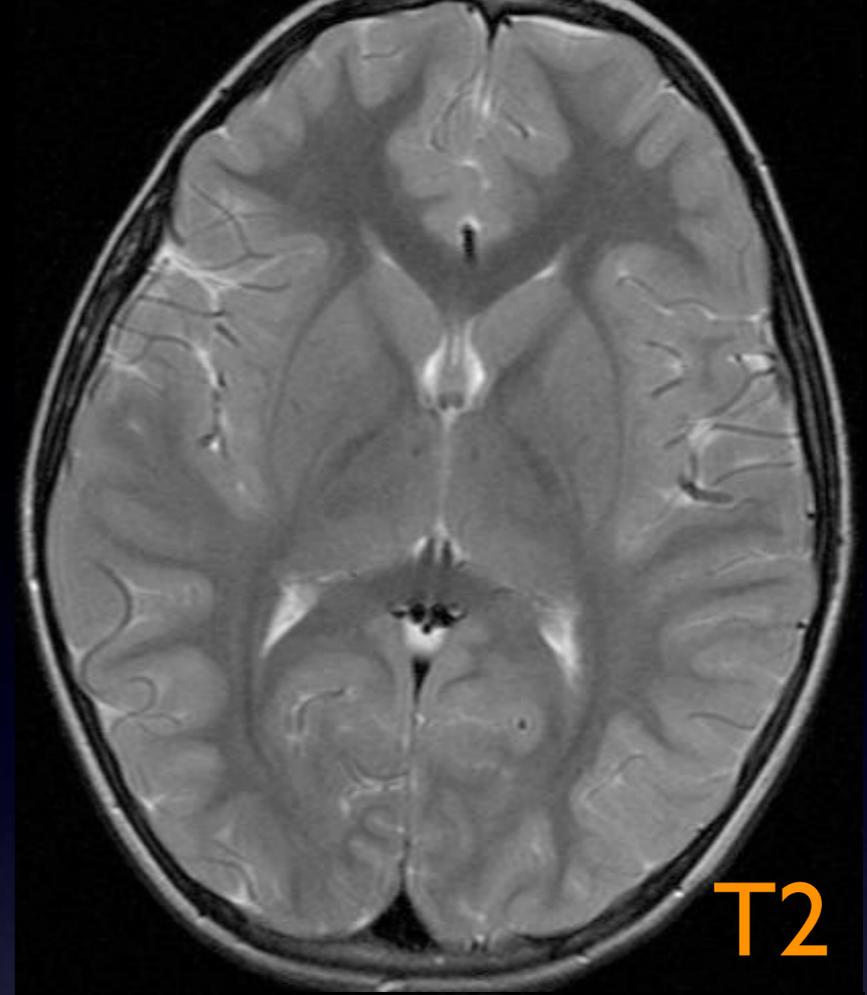
T1 with Fat Saturation

# FLAIR

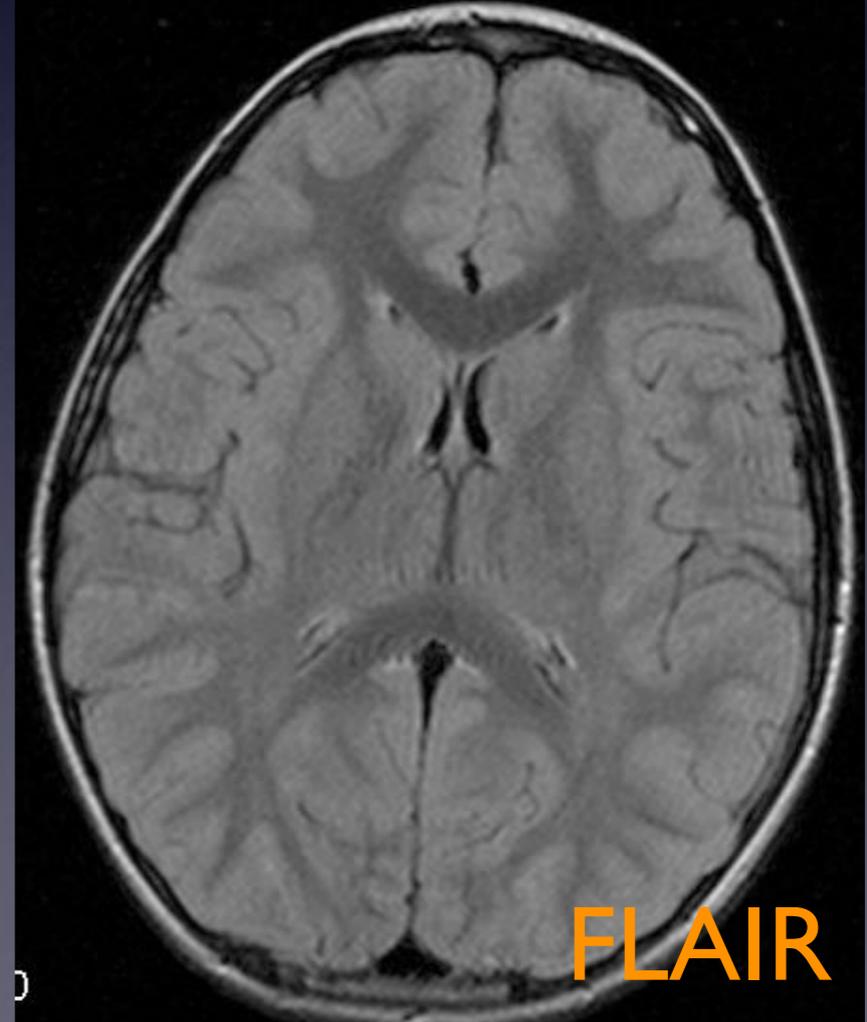
FLuid Attenuated Inversion  
Recovery

Neuroimaging

Removes signal from CSF and  
other simple fluid but leaves  
tissue oedema



T2



FLAIR

# Fast MR Sequences

A range of confusingly acronymed sequences named after marketing brainstorming sessions

Usually variations on gradient echo

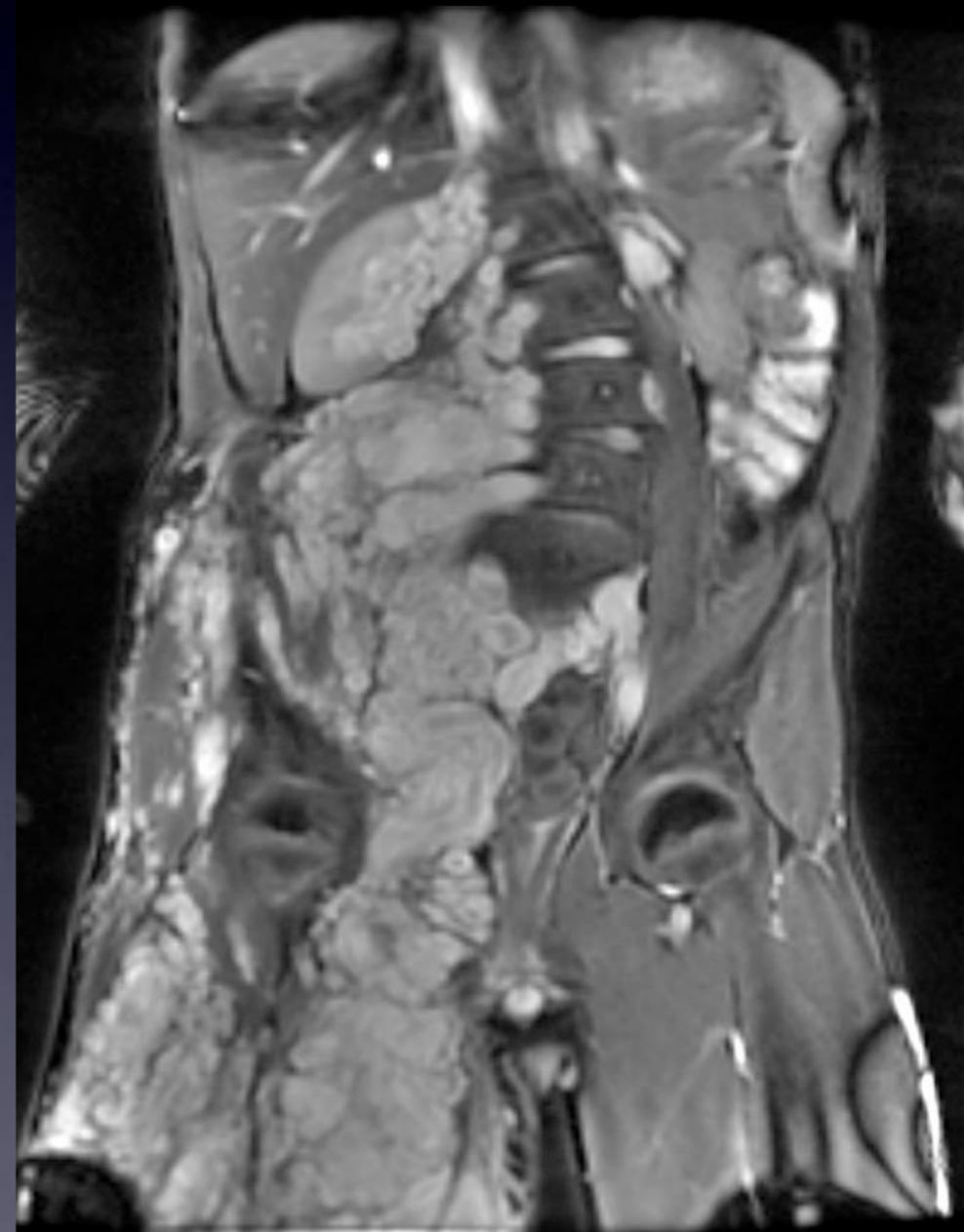
FIESTA / TRUFI

SSFSE / HASTE

VIBE / LAVA

Advantage= speed (e.g. breath-hold)

Disadvantage= signal or resolution

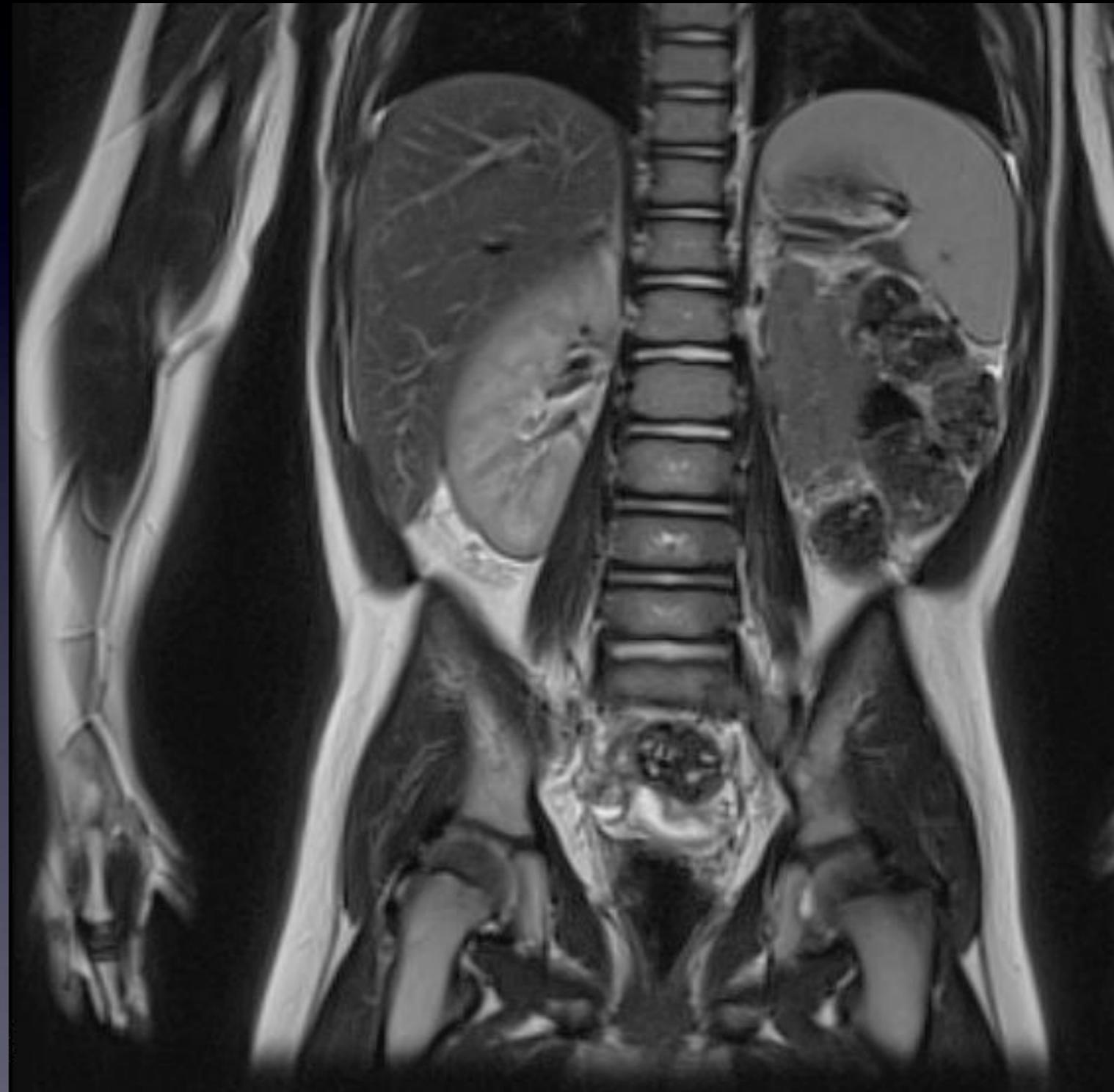


# Motion Suppression

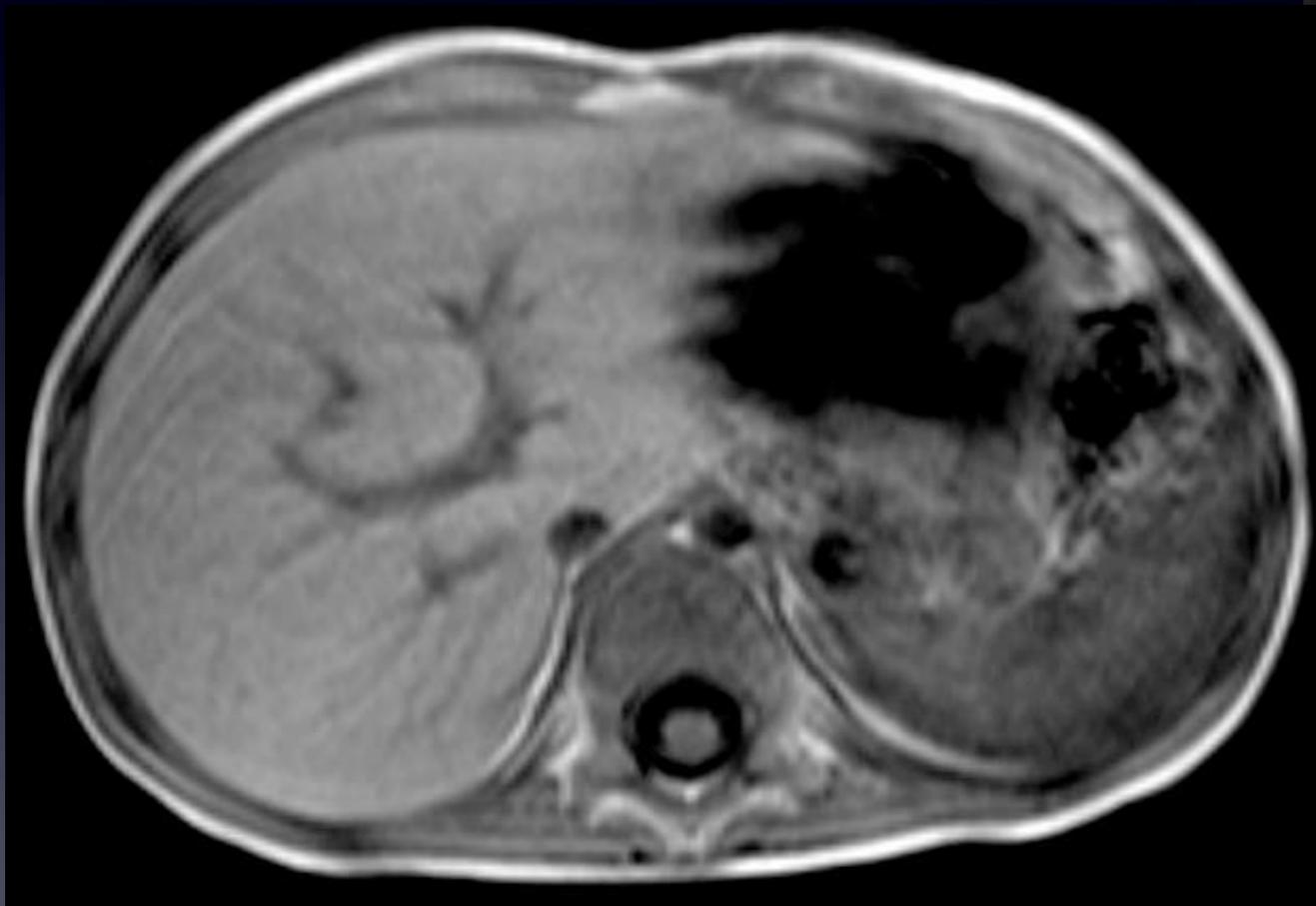
Different techniques  
to suppress patient  
movement

Improving every year

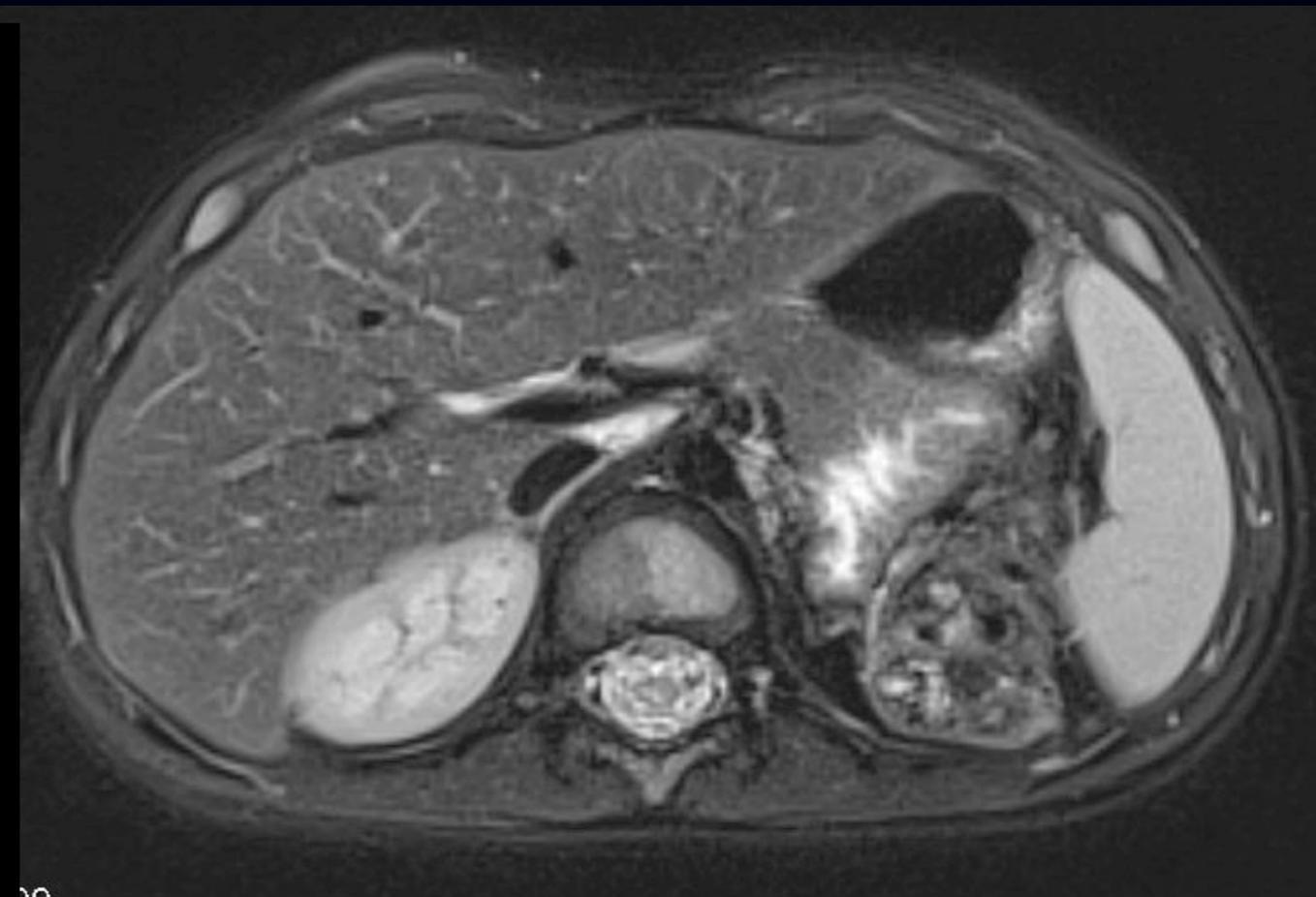
**BLADE / PROPELLER**



# Motion Suppression



Standard T1



T2FS with BLADE

# Whole Body MRI

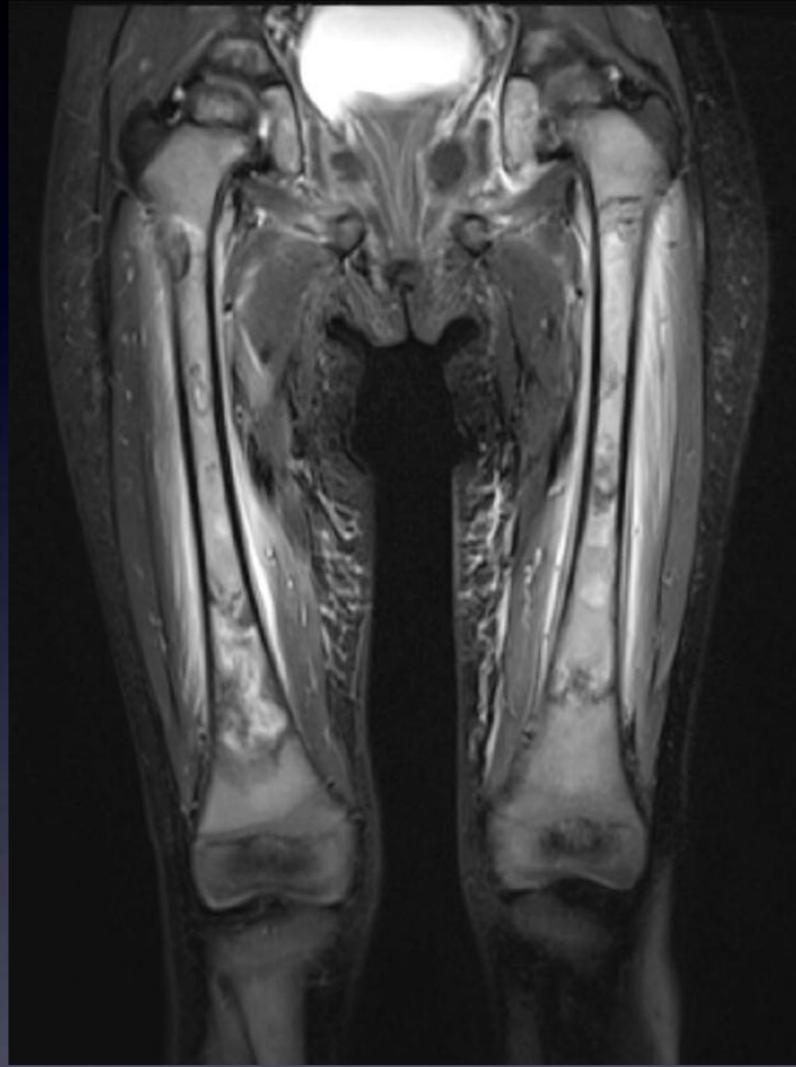
MRI screening studies most commonly for infection or tumour

Performed in sections and commonly combined into a single series

Usually coronal T1 and STIR

Axial STIR +/- Diffusion



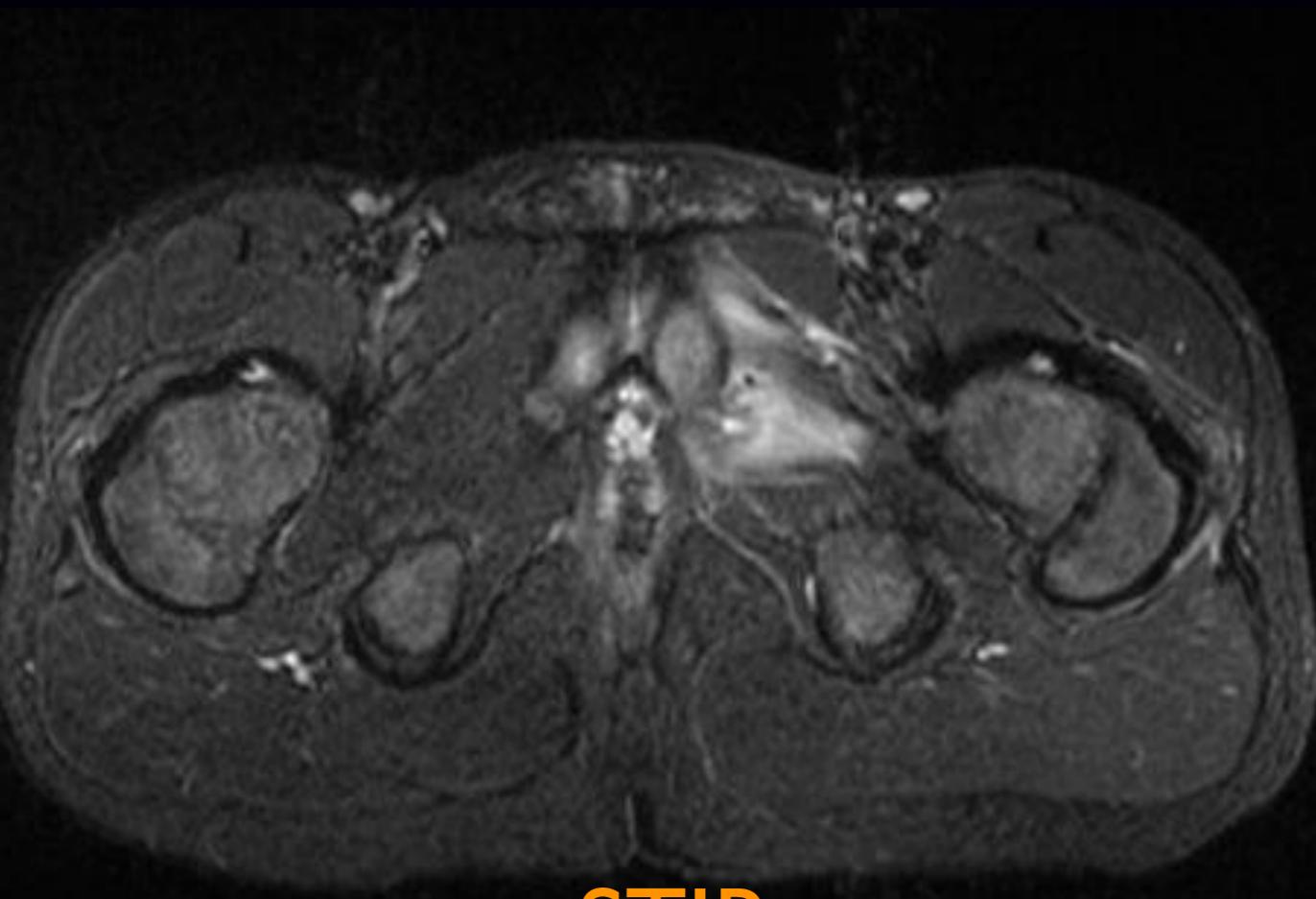


# Gadolinium

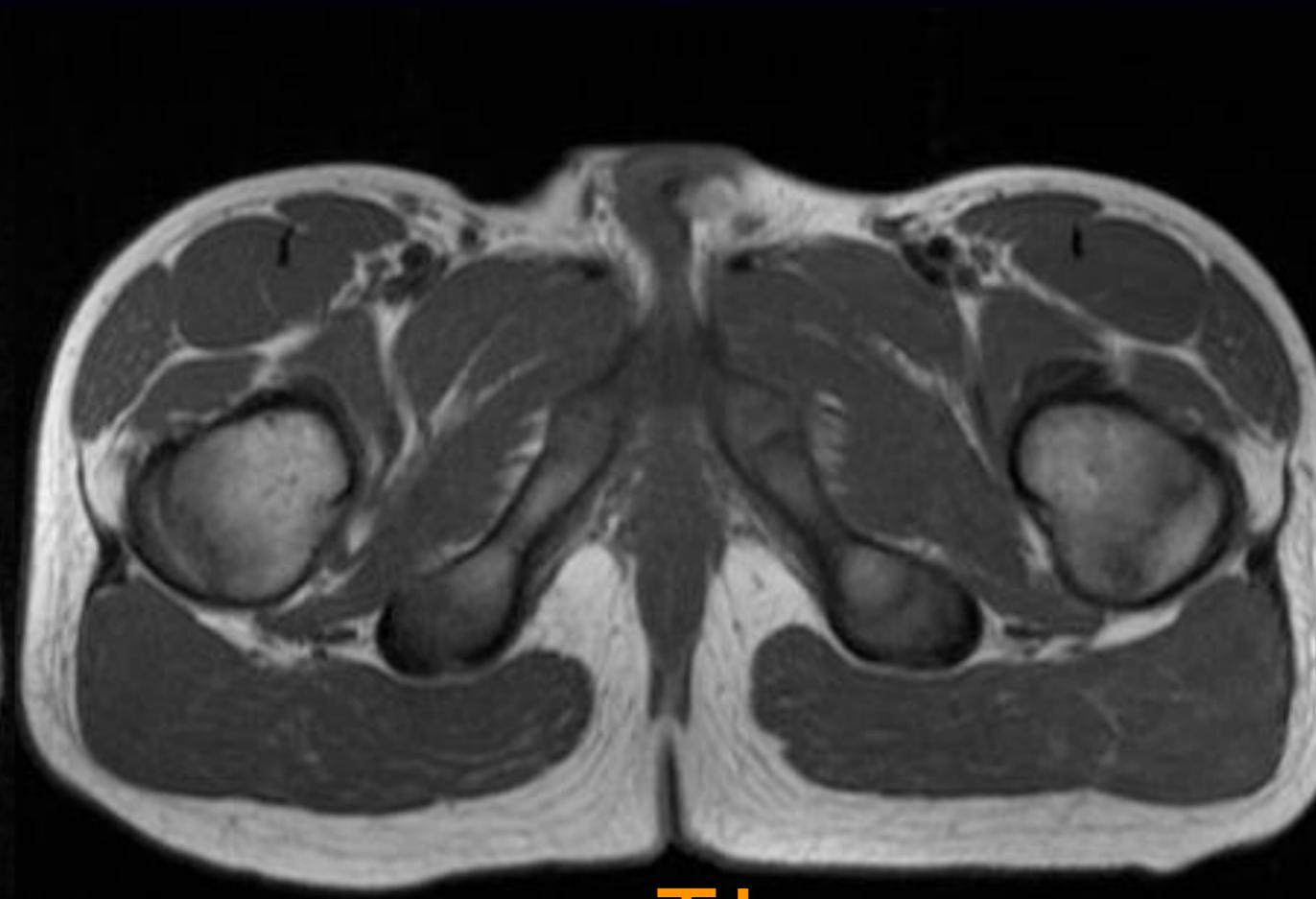
Rare earth metal with paramagnetic effects  
increases signal on T1

In body imaging, is usually imaged with fat saturation

# Pelvic Pain and Fever

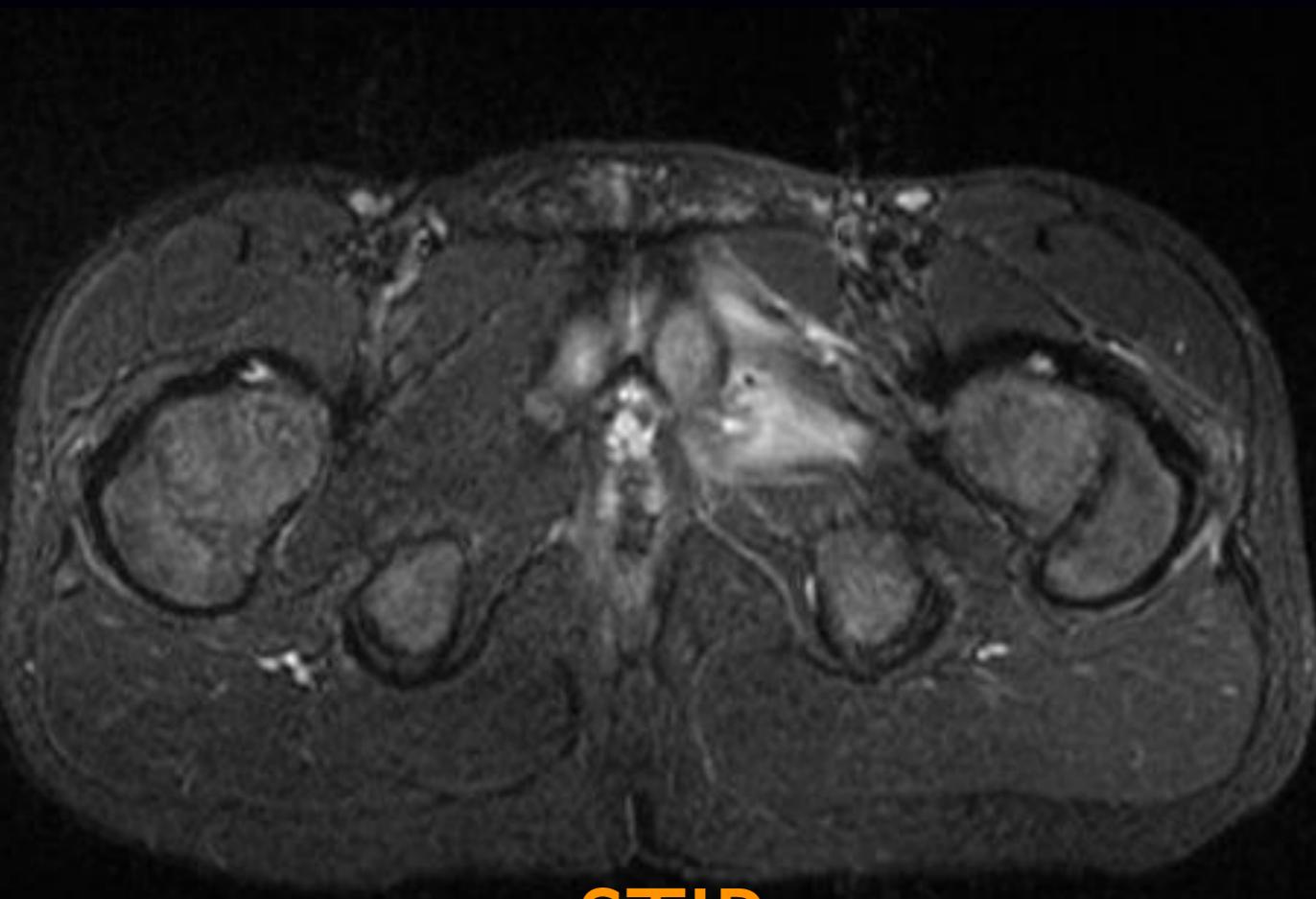


STIR



T1

# Pelvic Pain and Fever

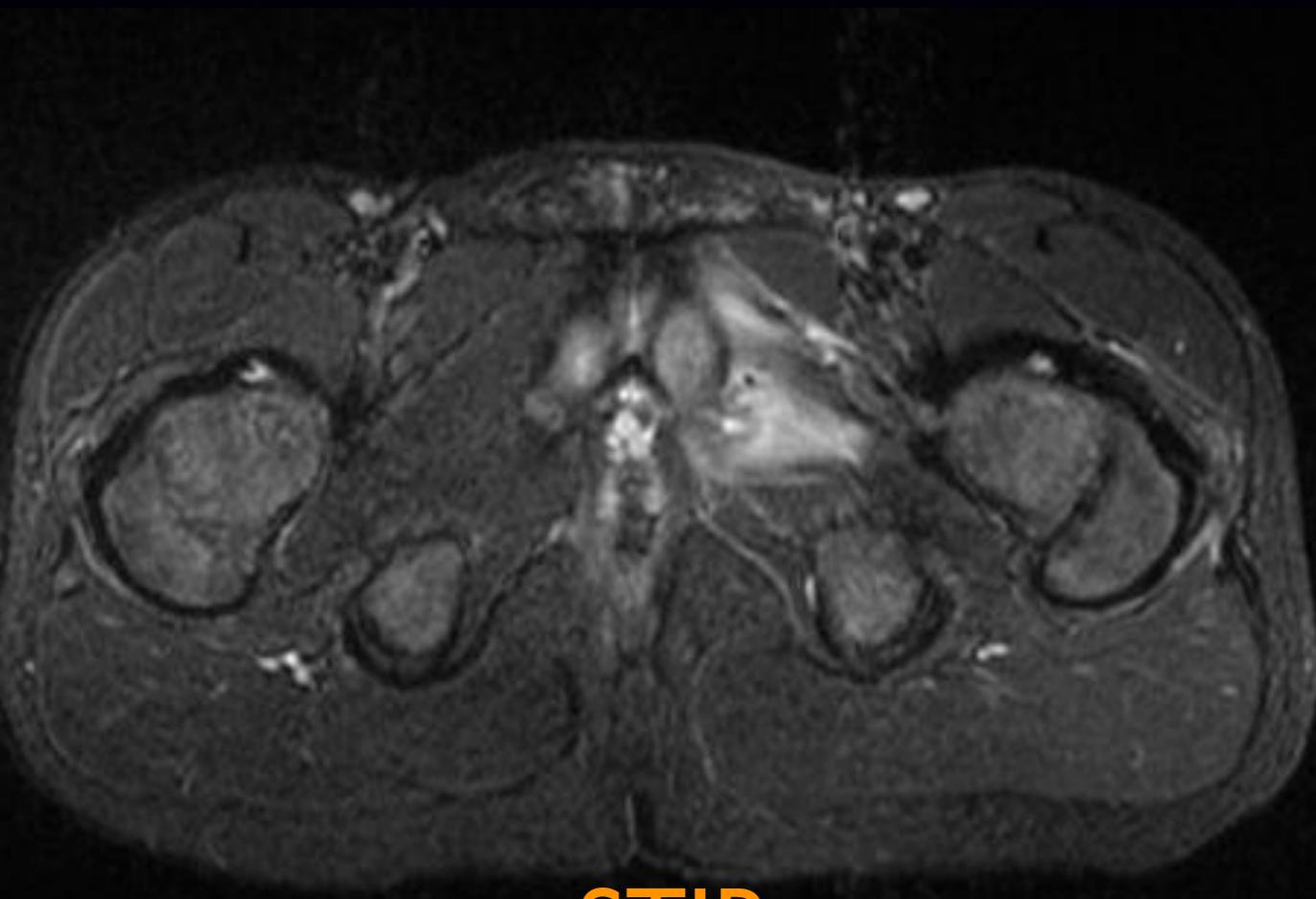


STIR

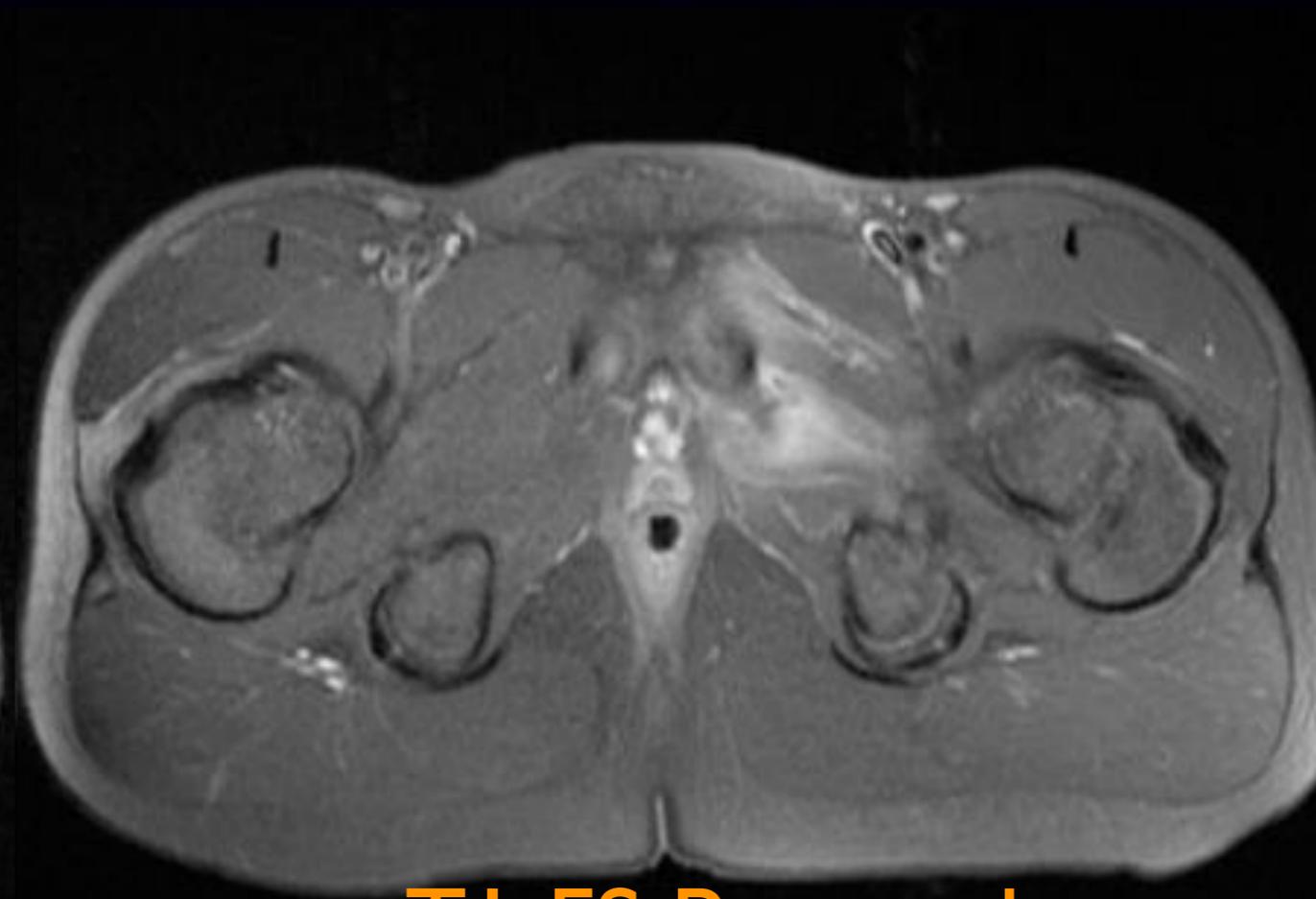


T1 FS Post gad

# Pelvic Pain and Fever



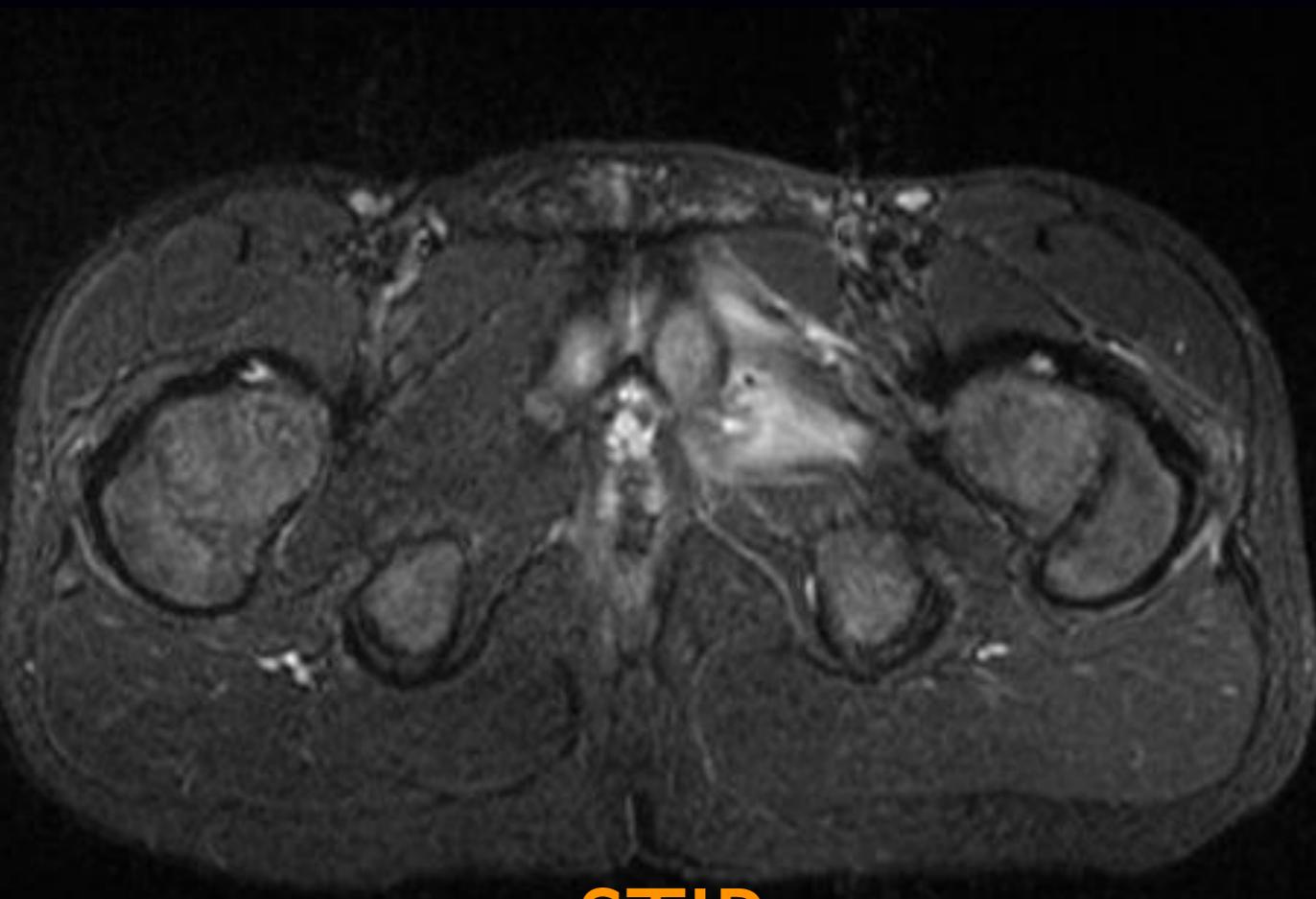
STIR



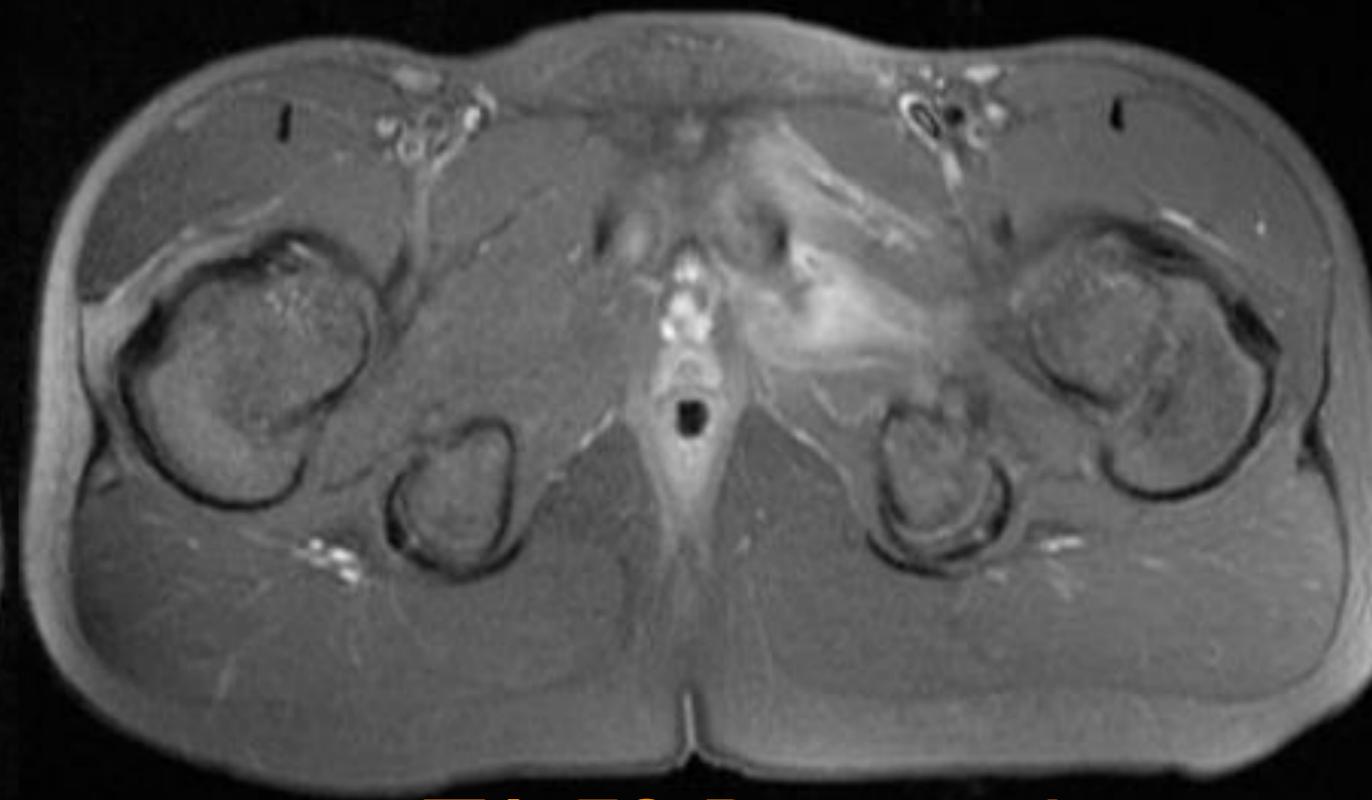
T1 FS Post gad

Ischiopubic Synchondrosis Osteomyelitis

# Oedema / Inflammation



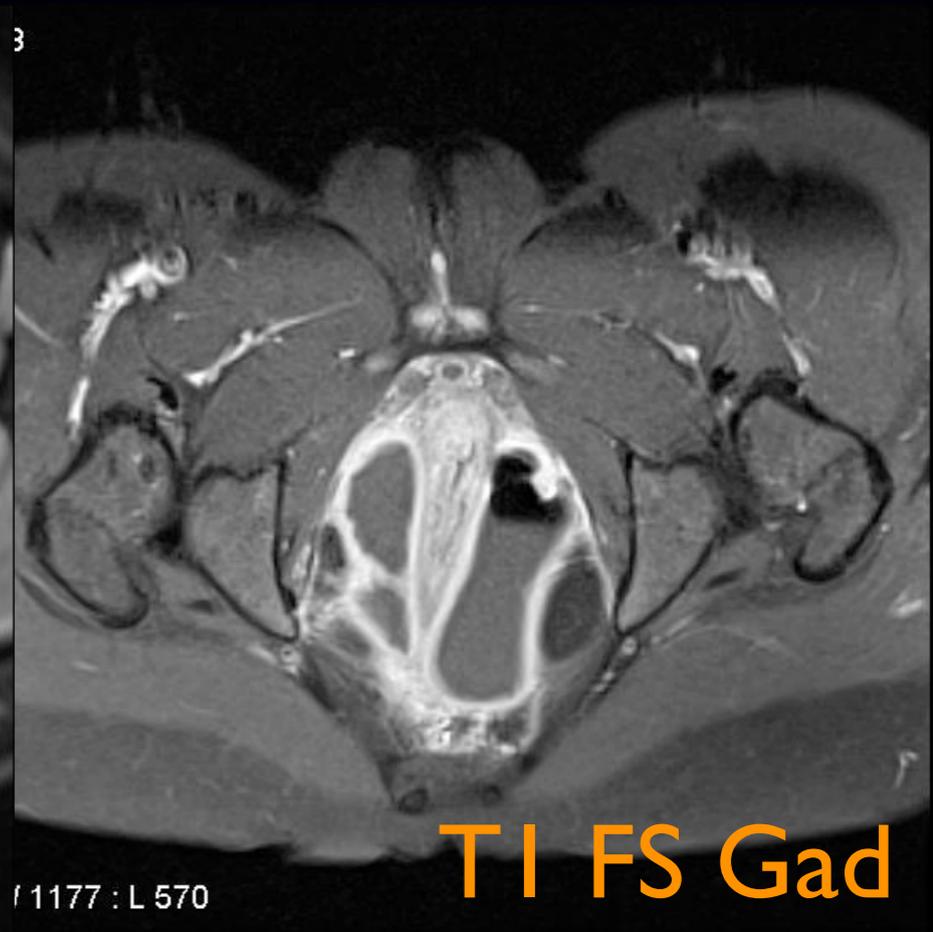
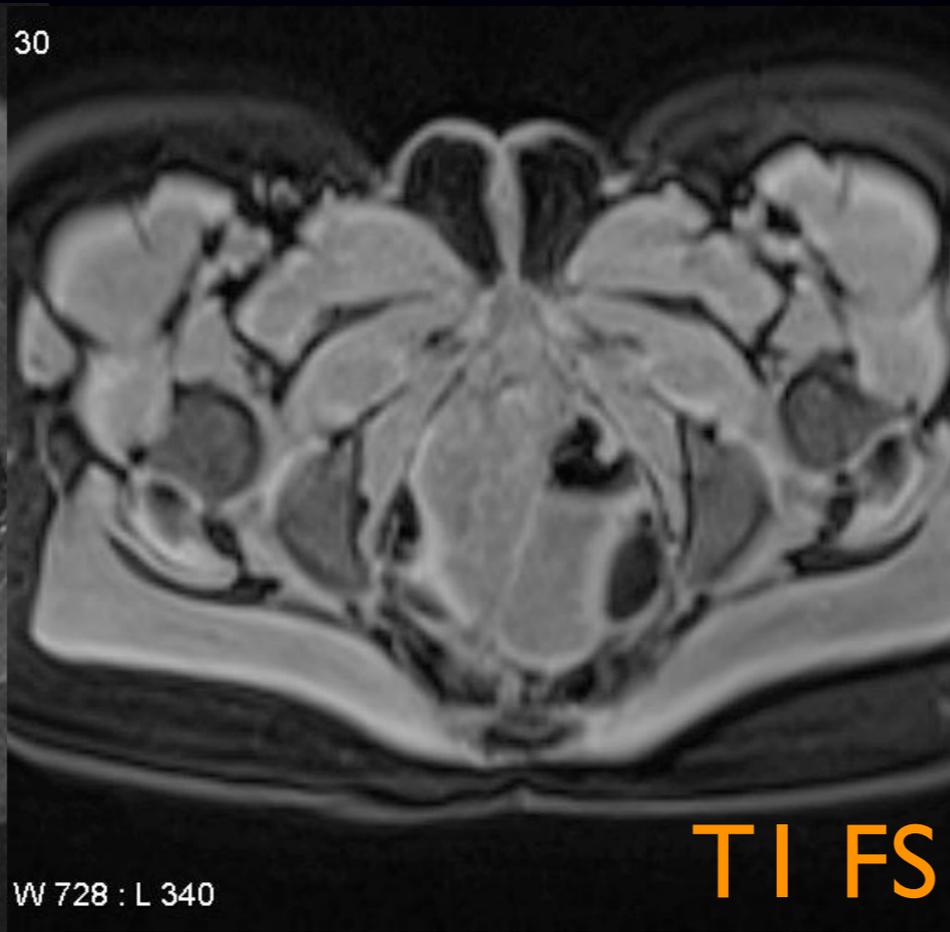
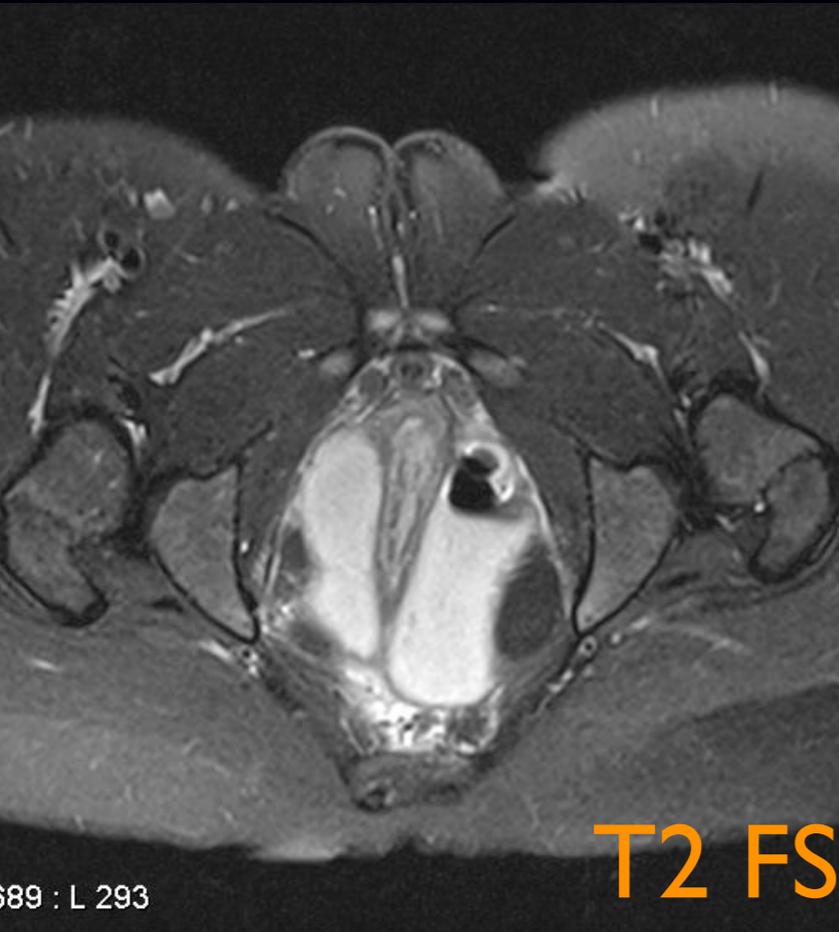
STIR



T1 FS Post gad

Fluid (oedema) is bright on STIR or T2 FS  
Inflammation also enhances

# Pus



T2 Bright

T1 Intermediate

Enhancing  
inflammatory  
rim

# Dynamic Pre/Post Gadolinium

Fast fat suppressed T1

<20 second sequences

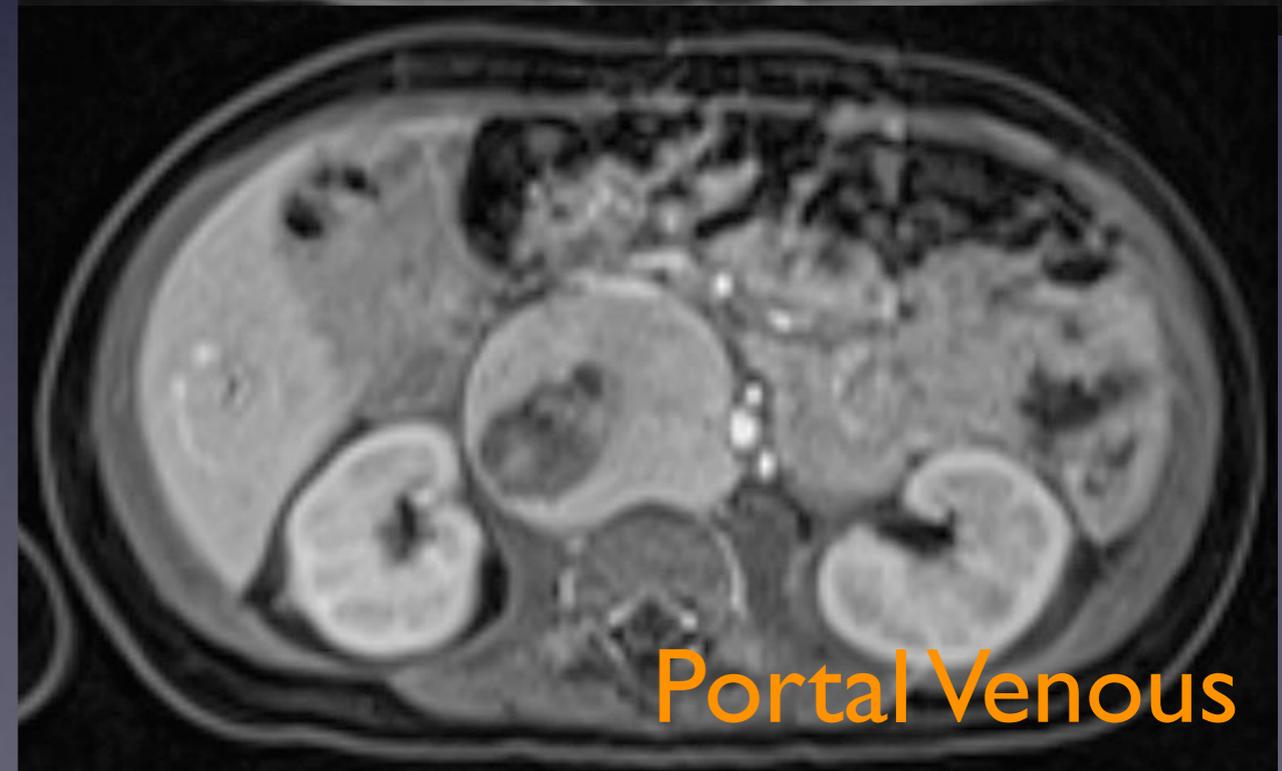
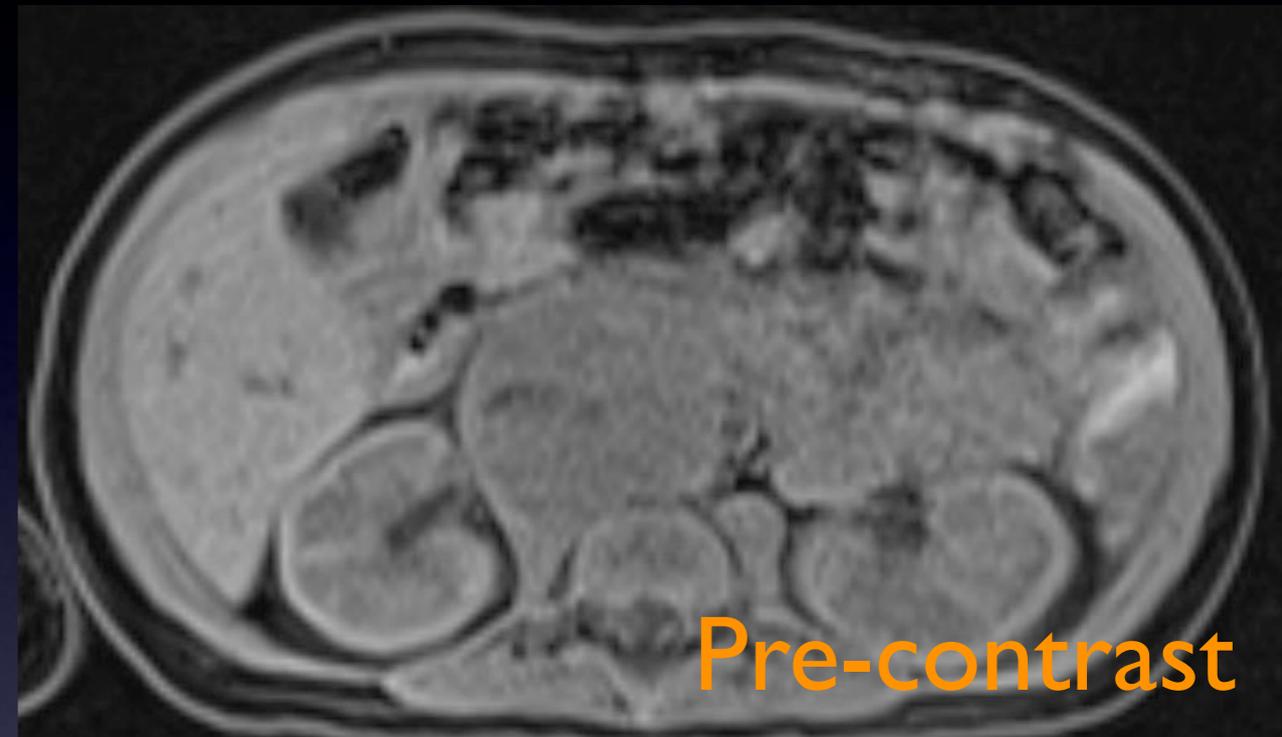
Thin slices (~1-2.5mm)

Similar to a multi-phase CT

Typically 30s, 1m, 2m, 5m

Less in young children

e.g. VIBE / LAVA



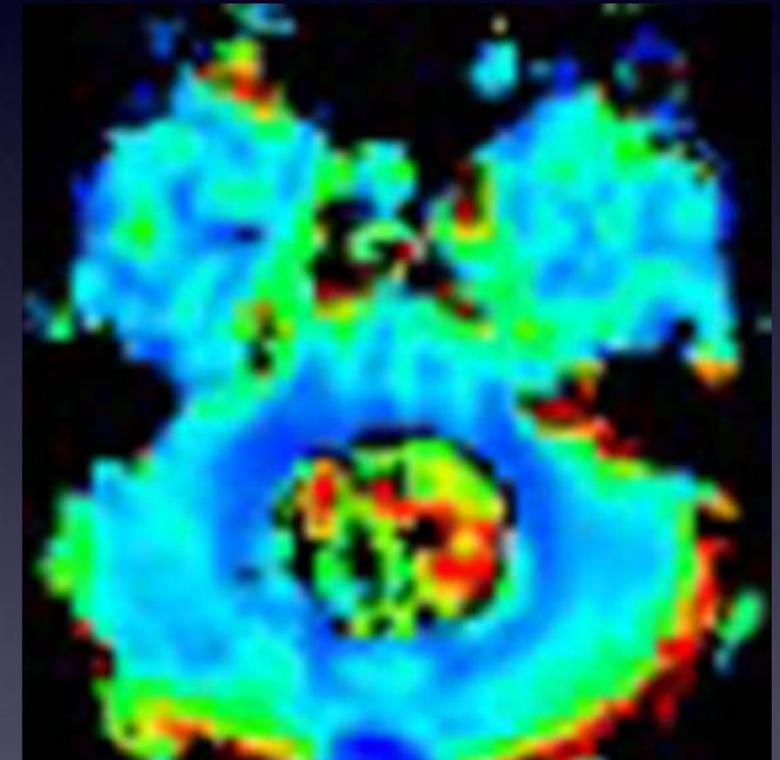
# Perfusion Weighted MRI

Images and measures the rapid signal change associated with the first passage of a bolus of contrast using very fast imaging techniques

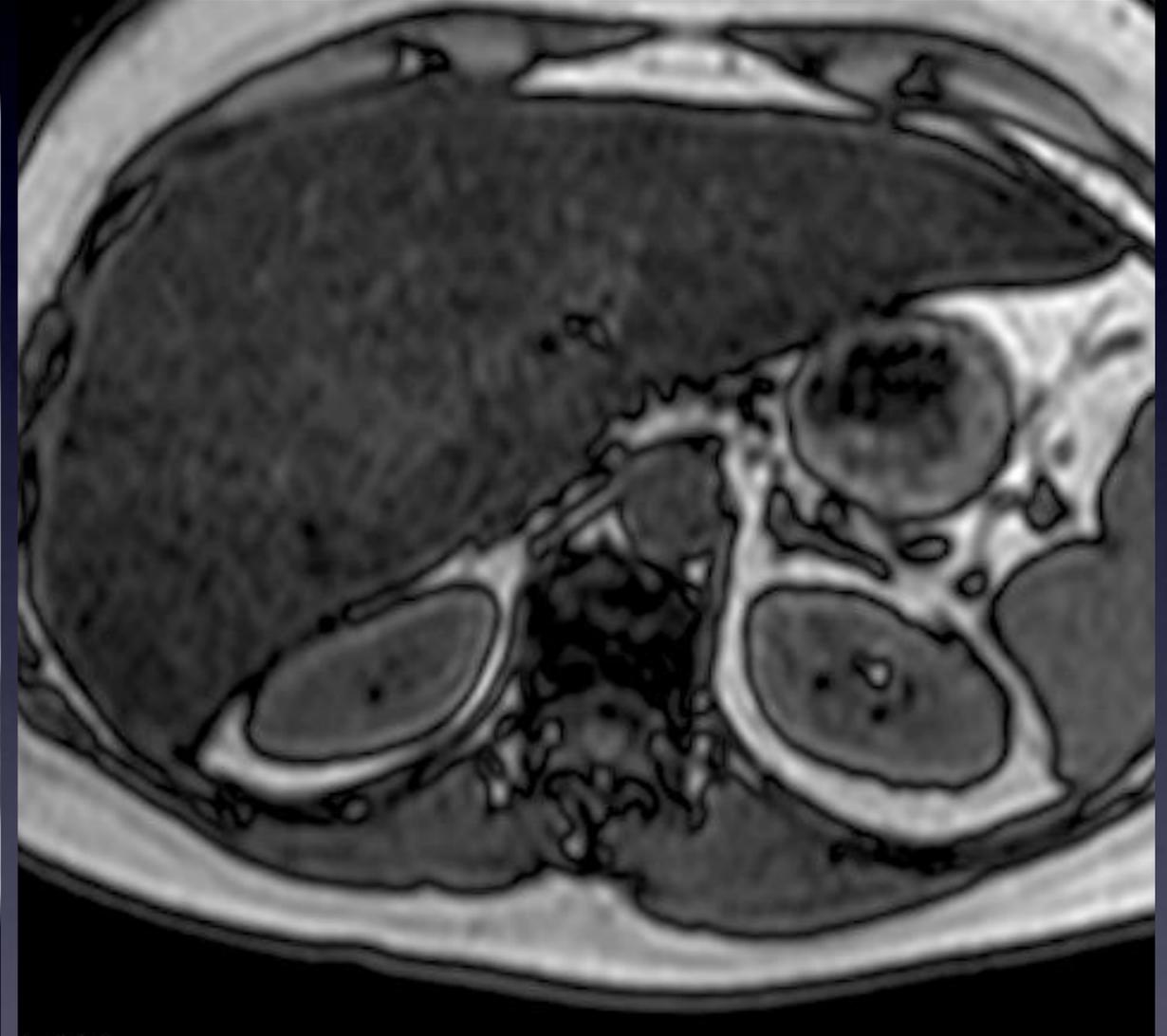
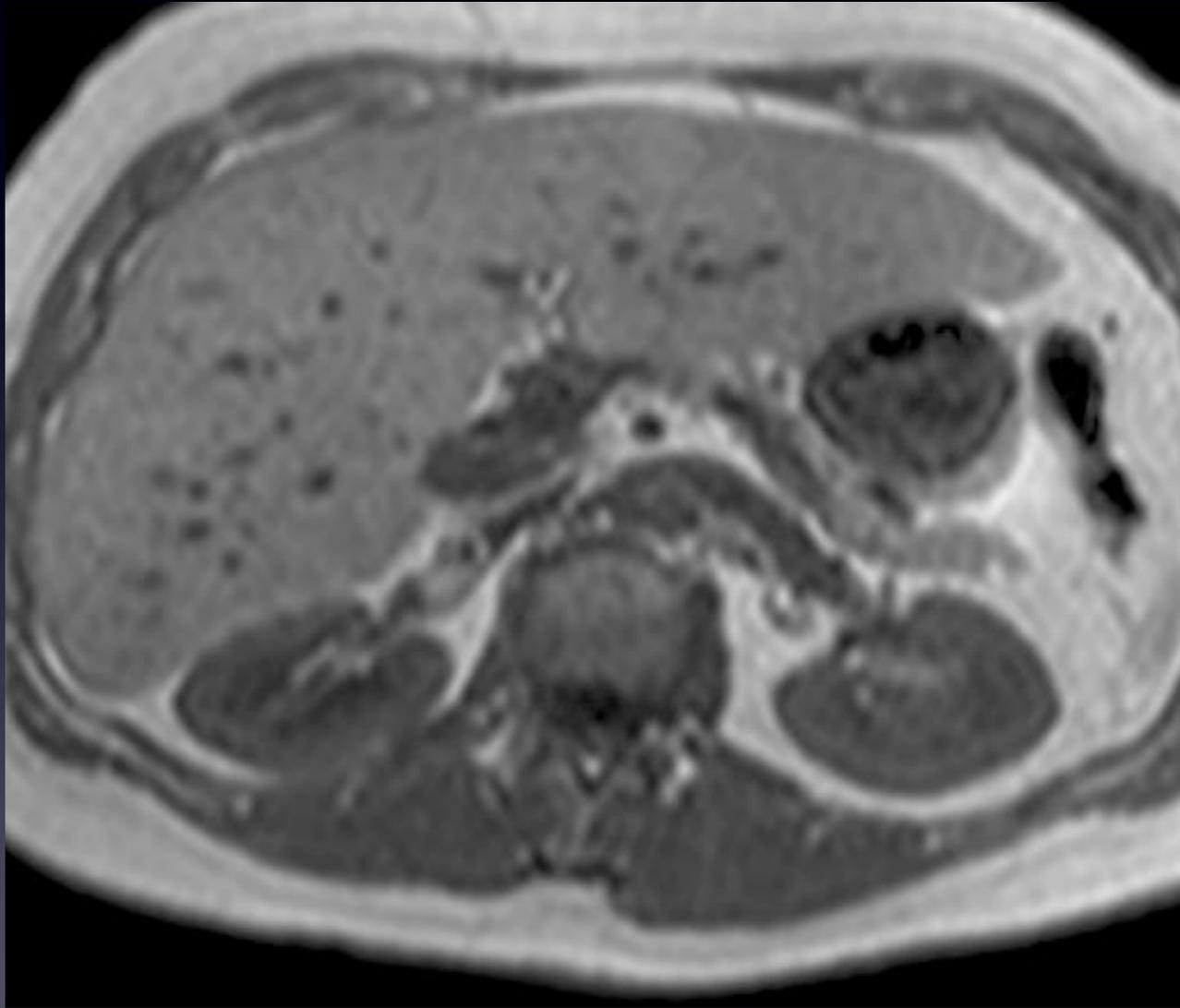
Used in neuroimaging to show evidence of neovascularity in tumours

Limited experience in paediatric body imaging

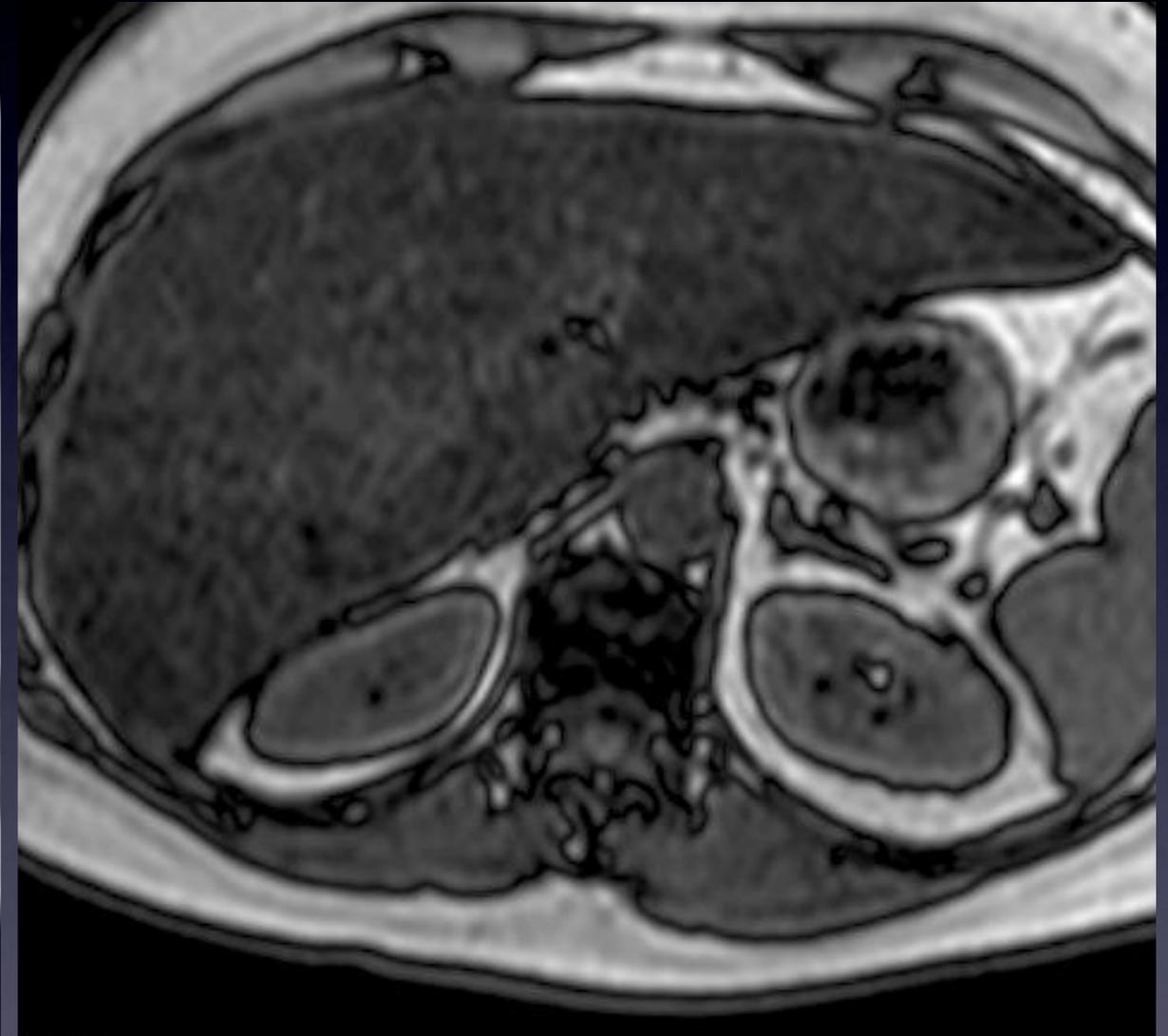
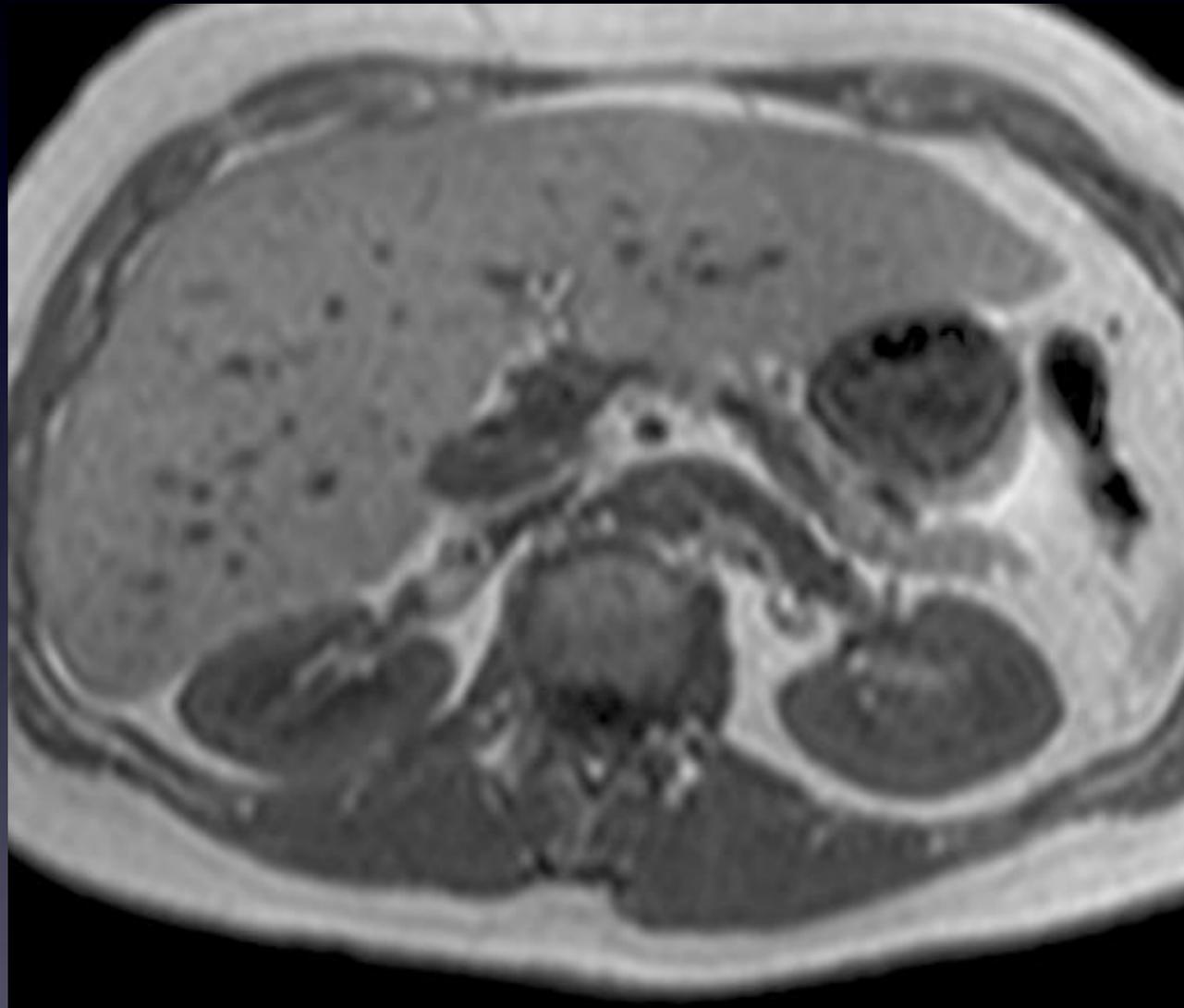
Potential for monitoring anti angiogenic therapies has not yet been proven



# T1 In and Out of phase



# T1 In and Out of phase



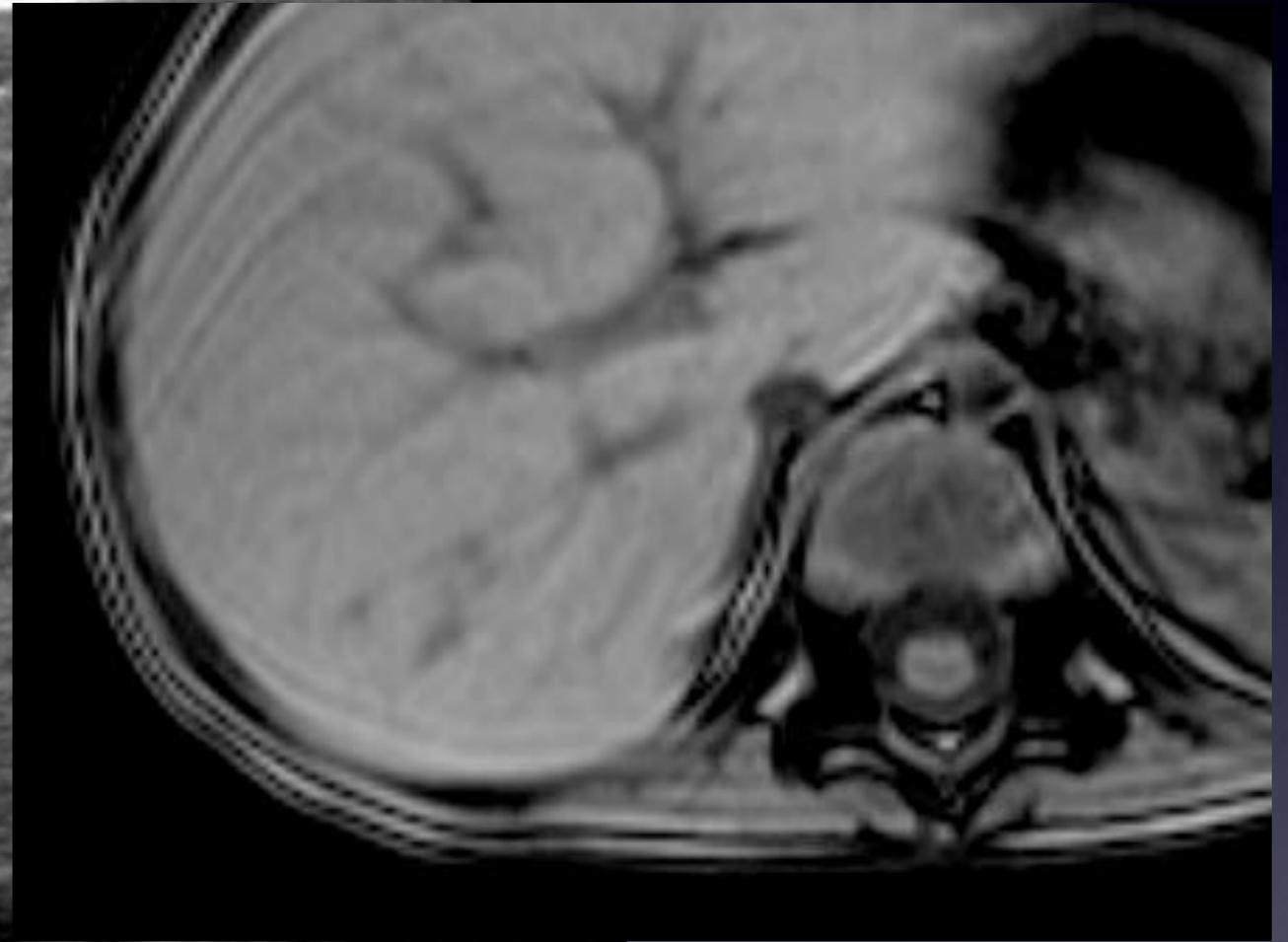
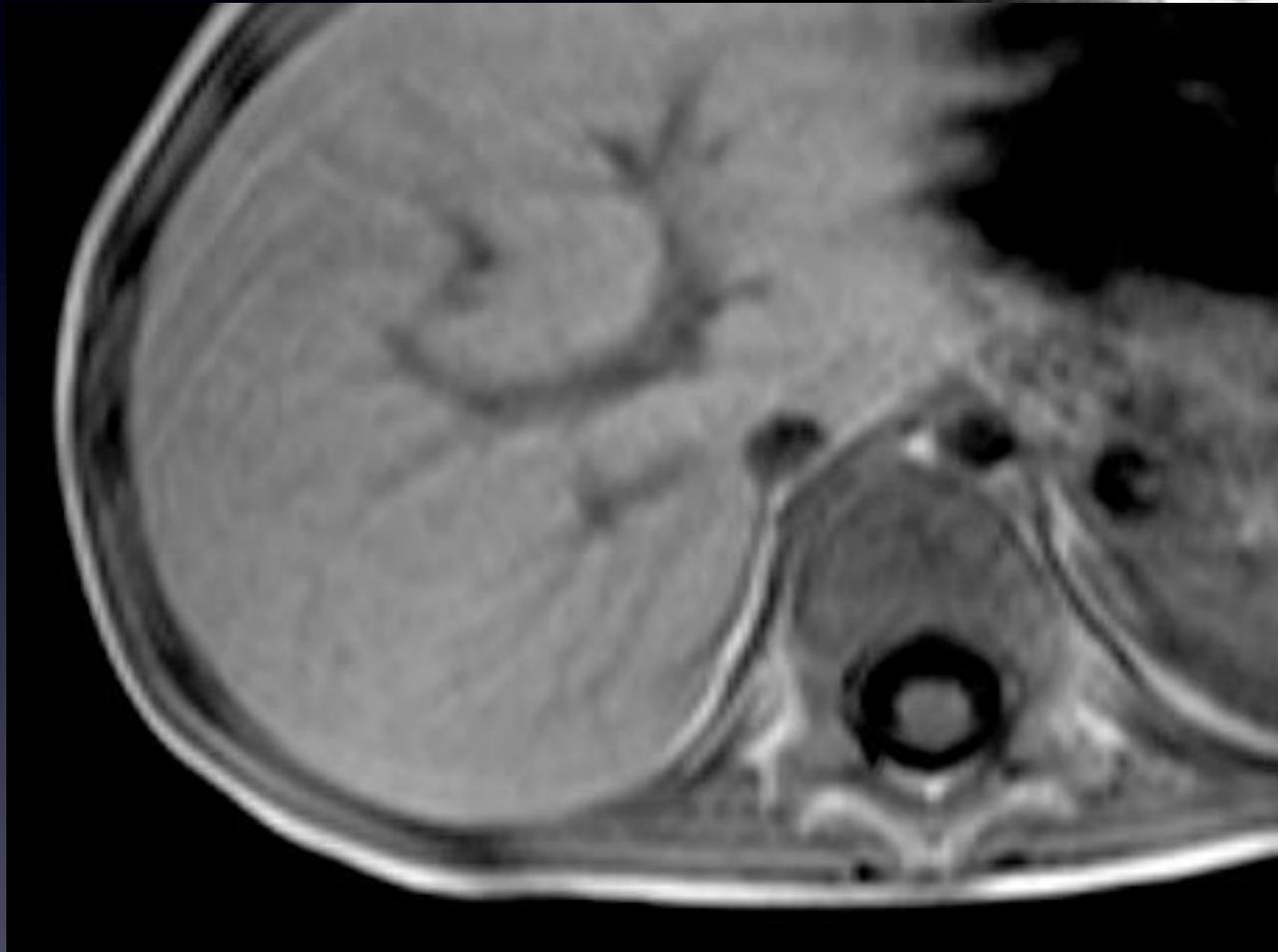
fat mixed with other tissues loses signal - fatty infiltration

# T1 In and Out of phase



# T1 In and Out of phase

Long



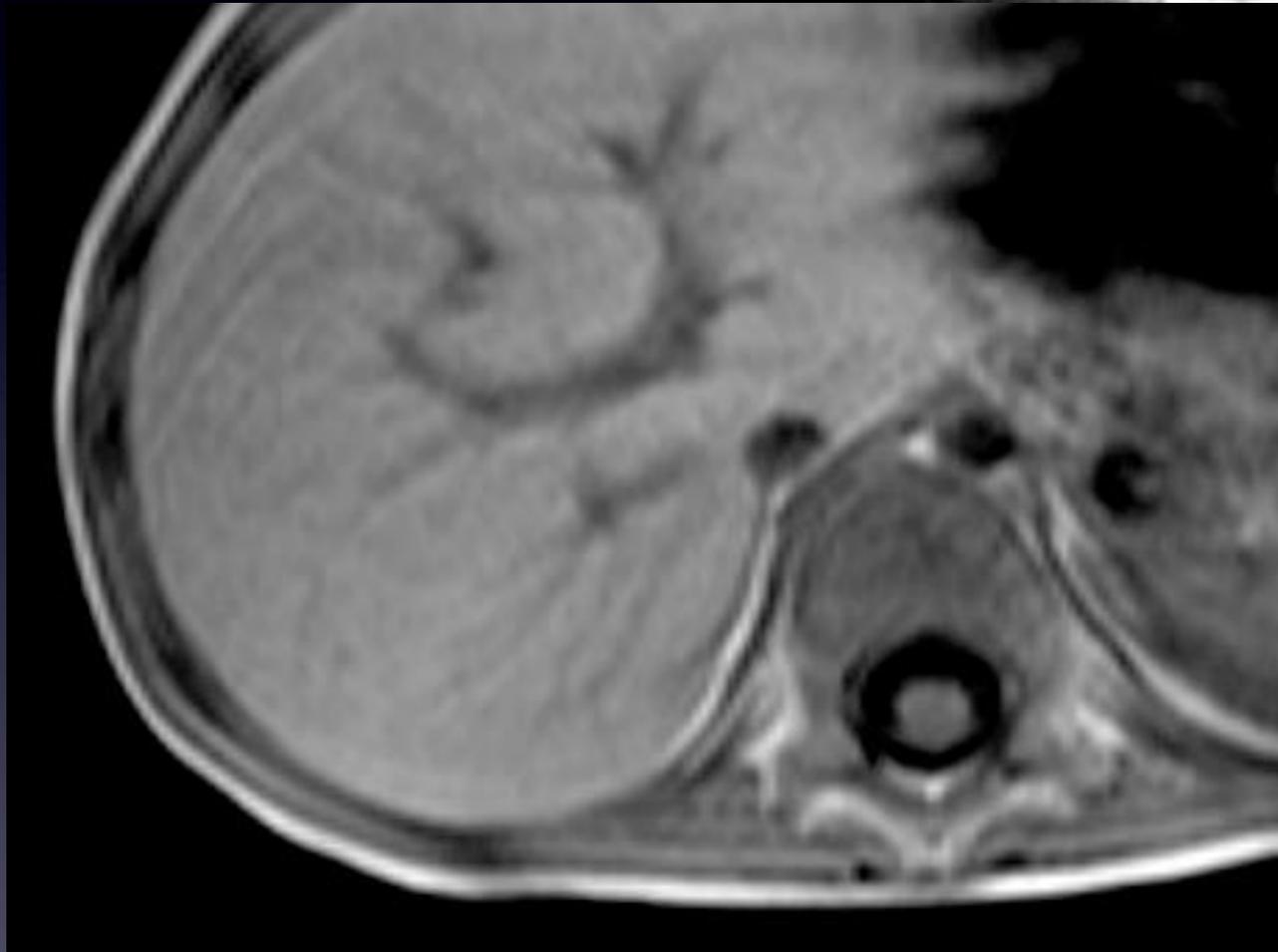
In Phase

Out of Phase

fat mixed with other tissues loses signal - AML in TS

# T1 In and Out of phase

Long



In Phase



Out of Phase

fat mixed with other tissues loses signal - AML in TS

# Fluid Sequences -MRCP, Urography

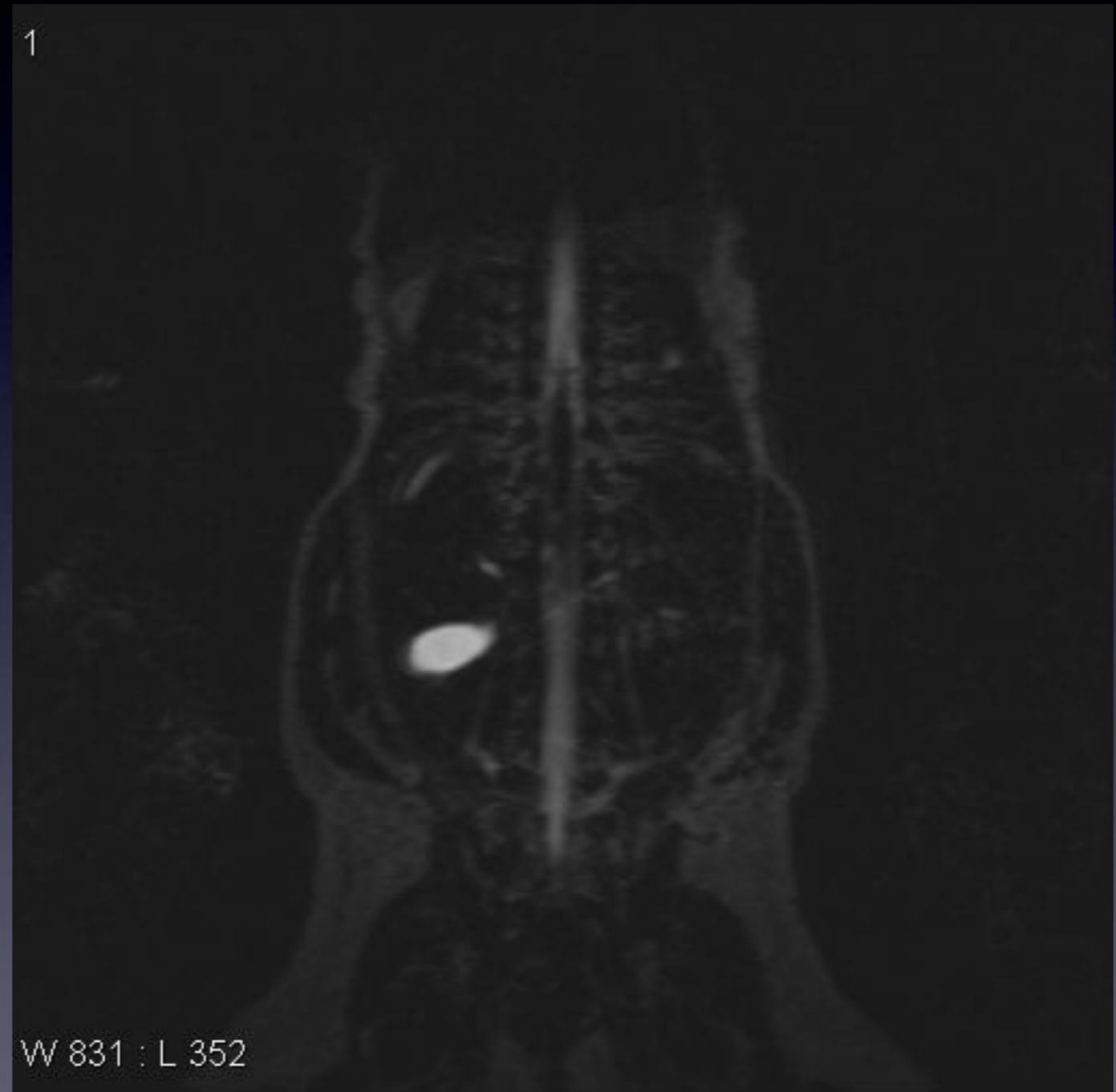
Heavily T2 weighted with  
suppression of  
background signal

Either thick slabs or 3D  
sequences reconstructed  
as Maximum Intensity  
Projections (MIP)

# Fluid Sequences -MRCP, Urography

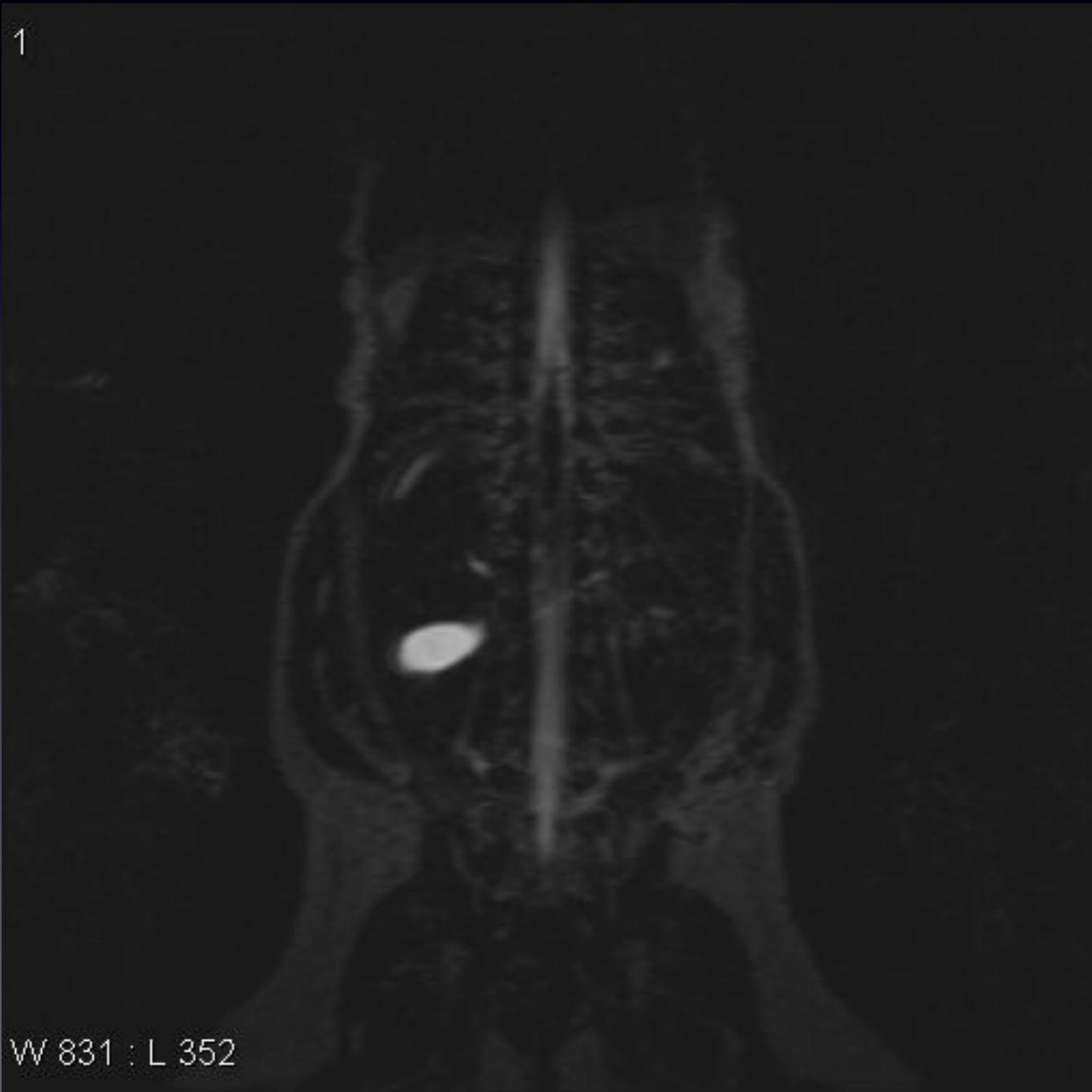
Heavily T2 weighted with suppression of background signal

Either thick slabs or 3D sequences reconstructed as Maximum Intensity Projections (MIP)



# Maximum Intensity Projection

# Maximum Intensity Projection



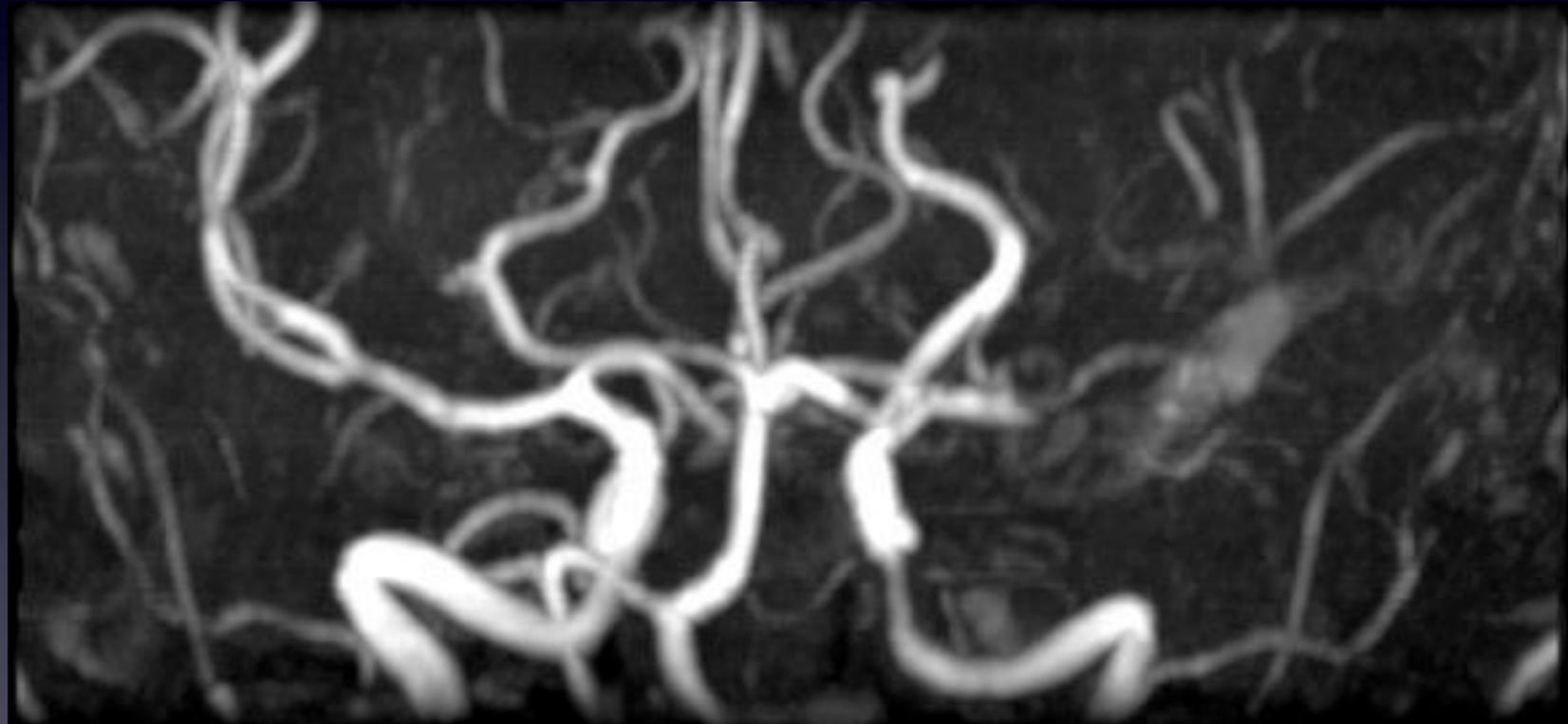
# MR Angiography

Non-contrast “Time of Flight”

(Static MRA)

Gadolinium Enhanced  
with subtraction

(Dynamic MRA)







R

# MR Angiography

Non-contrast “Time of Flight”

(Static MRA)

Gadolinium Enhanced  
with subtraction

(Dynamic MRA)



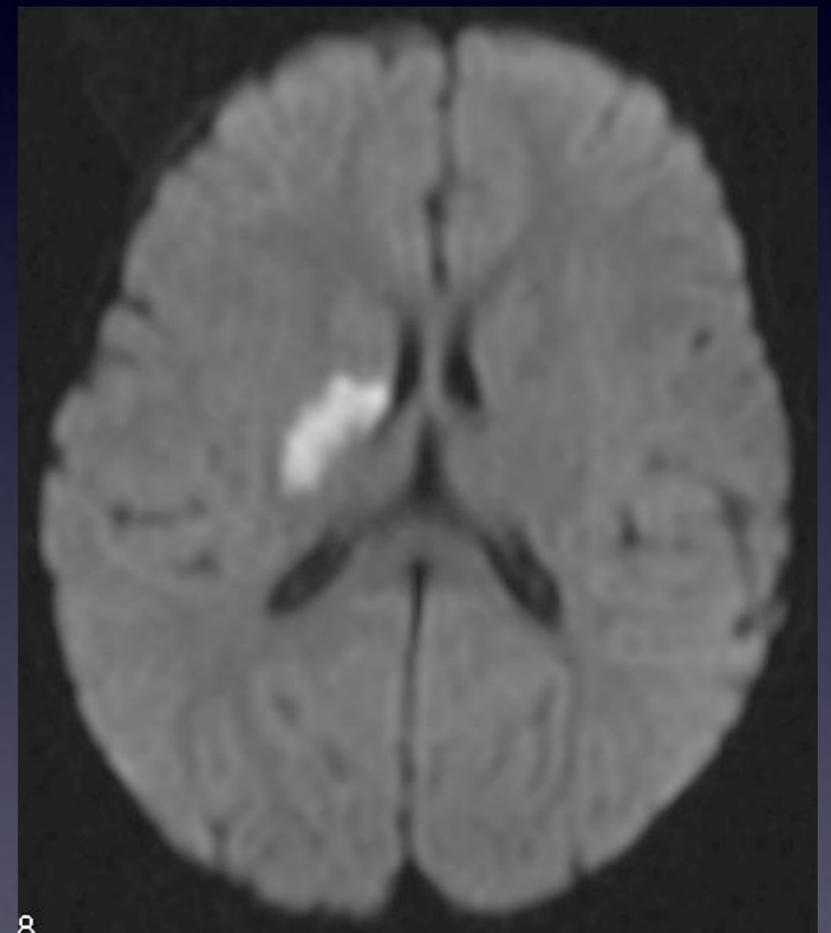


# Diffusion Weighted Imaging

Images based on a map of the amount of fluid movement within tissue

Images reflect a range of values from freely mobile unrestricted fluid (CSF, urine) to highly restricted fluid (cytotoxic oedema, highly cellular tumours, pus)

Measured as the Apparent Diffusion Coefficient (ADC)



# Diffusion Weighted Imaging



Cellular, aggressive tumours tend to have more restricted diffusion  
Increasing diffusion within tumour following therapy likely reflects  
necrosis and therefore response to therapy

Learn your local scanners sequences

Ask your local radiologist / MR techs

# Keep it simple

If you don't know the sequence, don't get phased - look for fluid (T1 vs T2) and consider what you can get from it:

Anatomy

Signal characteristics

Enhancement

# Keep it simple

**Oedema** - non enhancing diffuse tissue fluid

**Inflammation** - enhancing diffuse tissue fluid

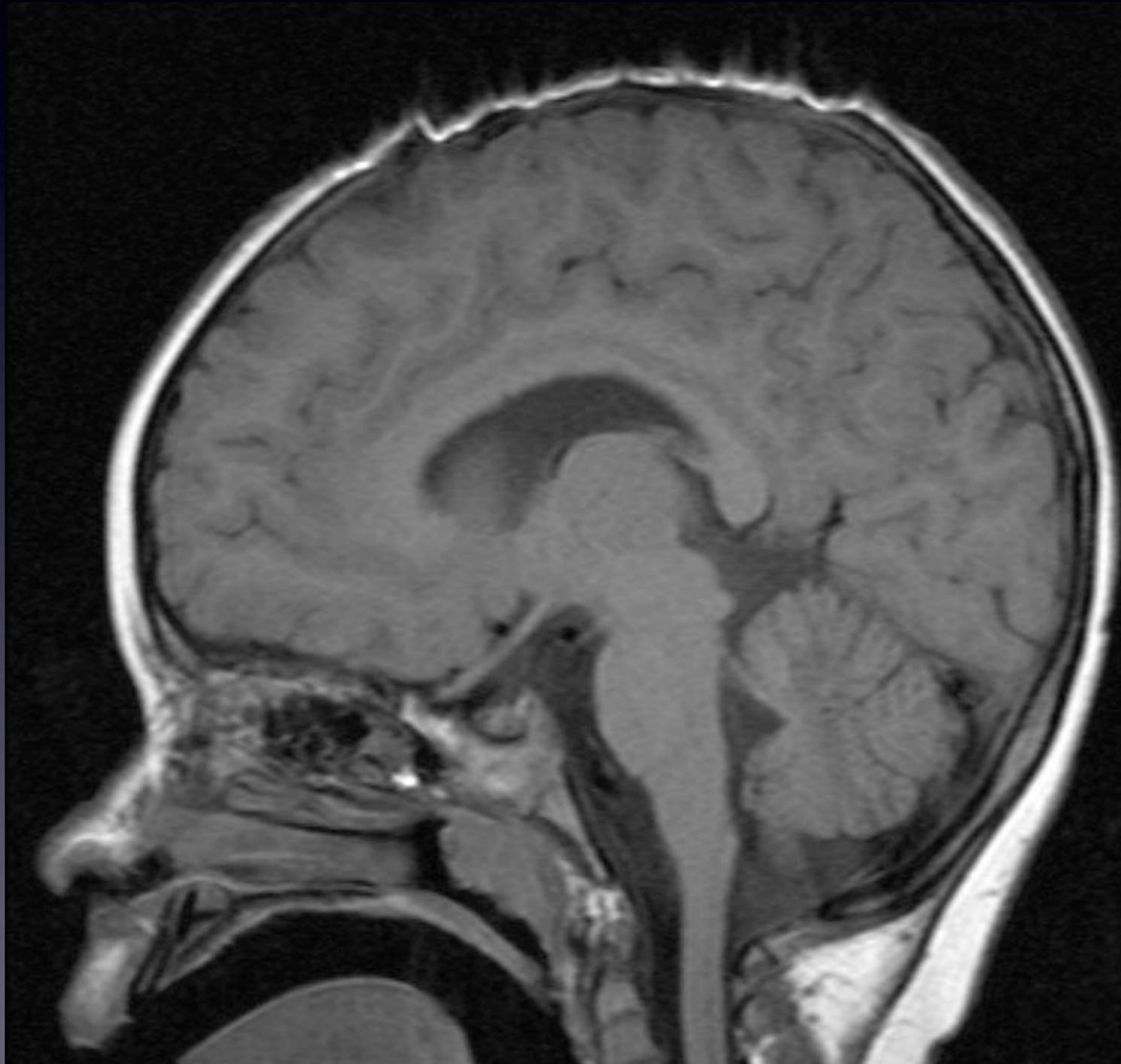
**Cyst** - non enhancing pocket of fluid

**Pus** - rim enhancing pocket of fluid

**Tumour** - variably enhancing solid tissue

**Haemorrhage** - mixed signal, layering, T1 bright

# An Auckland summer problem...



# An Auckland summer problem...

