Patient dose assessment of CT perfusion scanning at the RSCH

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Overview

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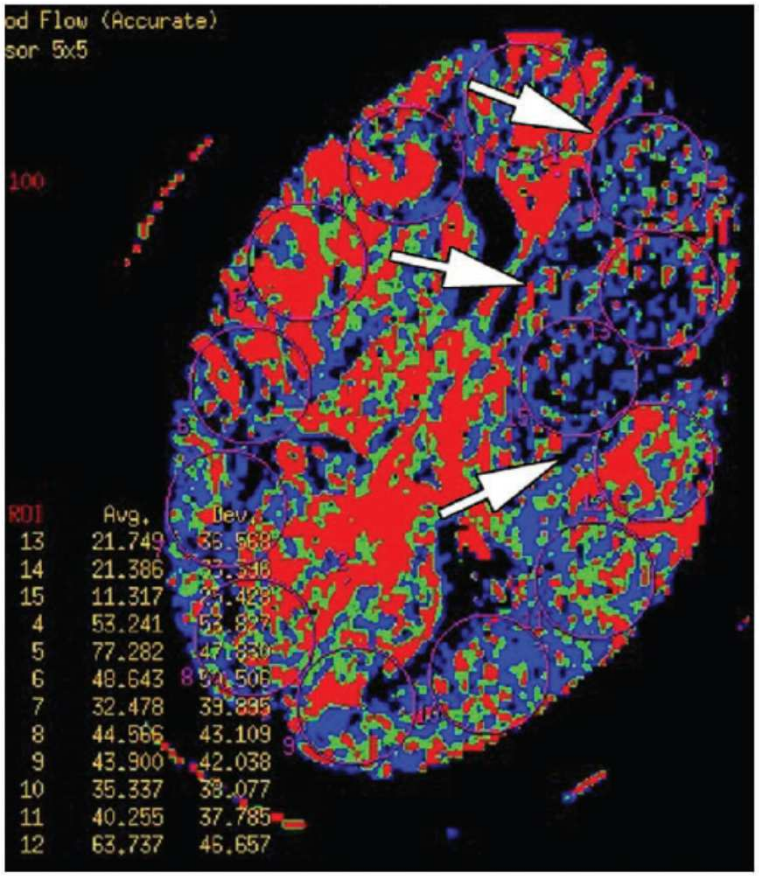
Introduction

- An estimated 150,000 people have a stroke in the UK each year
- Stroke is the third most common cause of death in the UK, after heart disease and cancer
- Stroke is the severe and sudden onset of lack of blood in the brain caused by a blood clot
- The speed of diagnosis is critical to the survival of the patient

- Non-contrast brain CT scans can be used to assess the need for thrombolytic drugs

- CT perfusion (CTP) imaging can provide further information on cerebral blood flow, cerebral blood volume, and mean transit time to help in the management of the patient recovery



USA FDA Alert: Oct. 2009

- Over exposure from CTP scans to patients in one centre in the USA
- Reported skin erythema and hair loss
- Estimated over exposure to be eight times the ‘expected’ dose level
- Doses up to 3-4 Gy

CT Perfusion scans at RSCH

- Two scanners both GE 64 slice Lightspeed (VCT and VCT XT) CT scanners.

- VCT XT which is the newer scanner employs Adaptive Statistical Iterative Reconstruction (ASIR) software which allows dose reduction to be made.

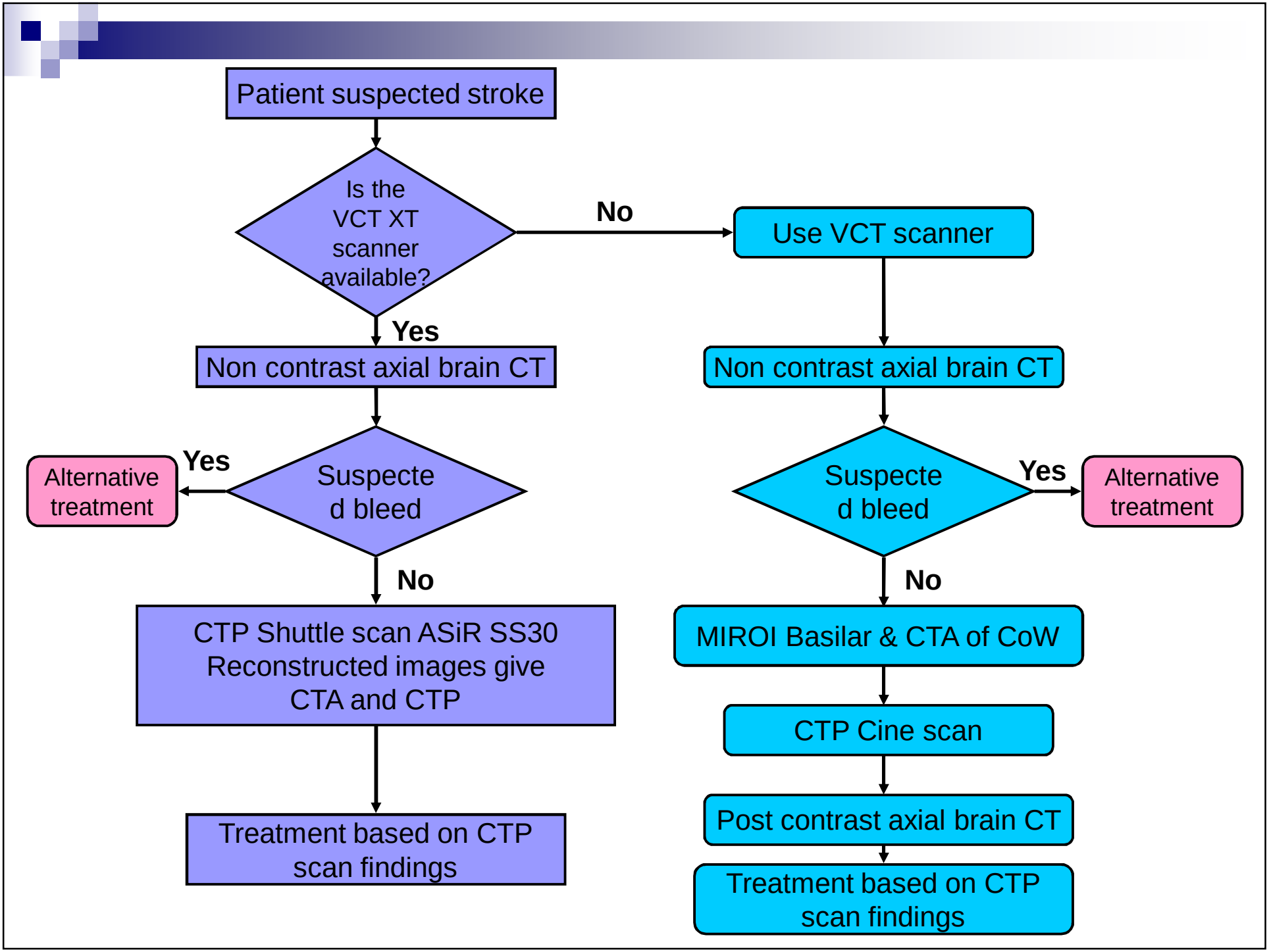
- Scan protocols for CT perfusion (CTP)

  Cine protocol available on both scanners with a scan length of 40mm.

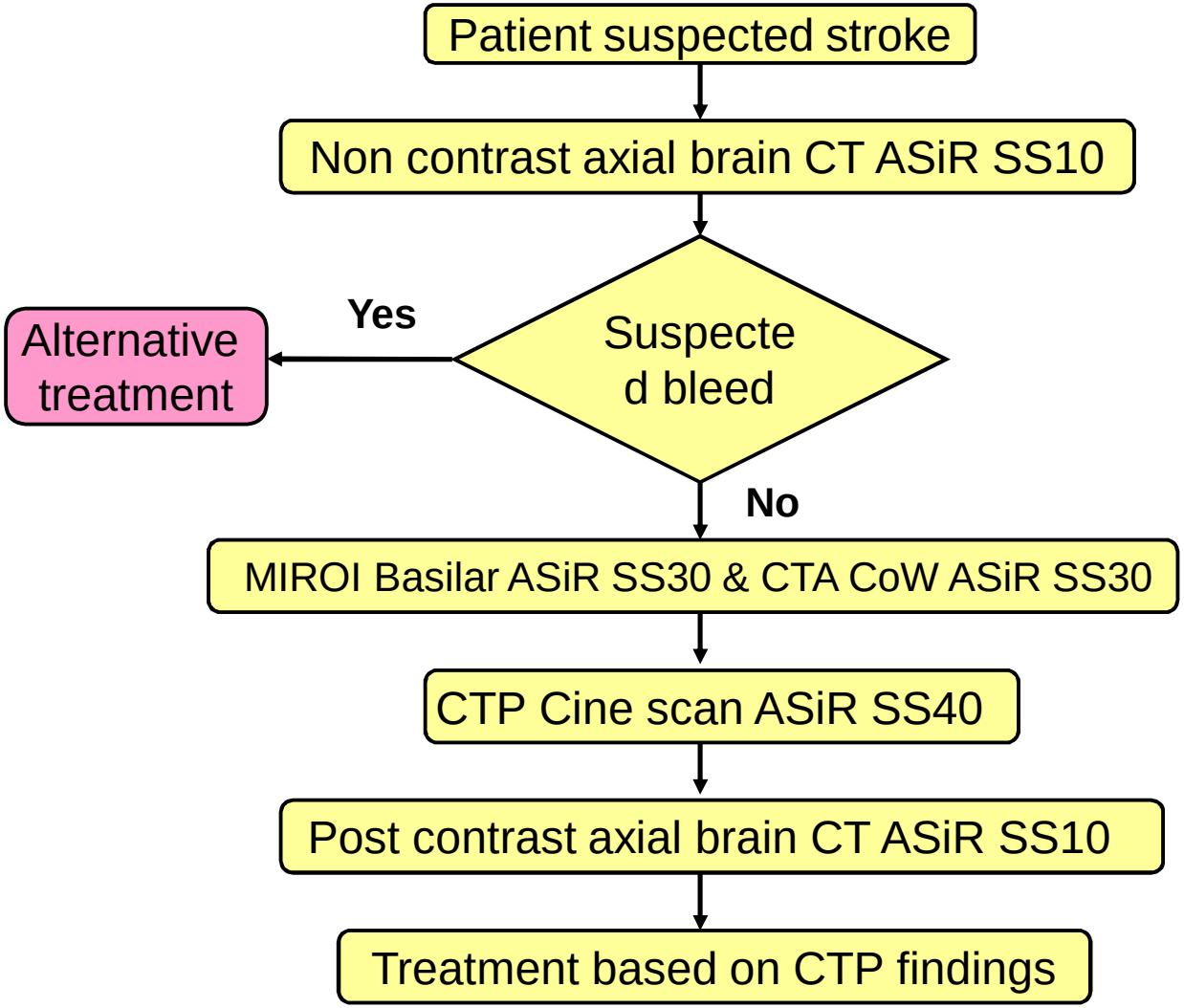
  Shuttle protocol available on VCT XT. The patient is moved in and out of the gantry during the scan with a scan length of 80mm. ASiR is applied to this scan.

Patient pathway for suspected stroke

- If VCT XT is available the patient will be scanned on this scanner using the Shuttle protocol.
- Back-up, the patient will be scanned on the VCT scanner using the Cine mode protocol.


Patient suspected stroke
Is the VCT XT scanner available?
No
Use VCT scanner
Yes
Non contrast axial brain CT
Non contrast axial brain CT
Yes
Alternative treatment
Suspecte d bleed
Suspecte d bleed
Yes
Alternative treatment
No
No
CTP Shuttle scan ASiR SS30 Reconstructed images give CTA and CTP
MIROI Basilar & CTA of CoW
CTP Cine scan
Post contrast axial brain CT
Treatment based on CTP scan findings
Treatment based on CTP scan findings

Possible option
Suspected stroke VCT XT Cine protocol



Did we have any data to compare to?

- Data has been published in the literature on cine mode
- Cohnen. M, *et al.* 2006 study assessed CTP using cine mode on a Siemens Somatom Sensation and CTA. Measured Effective Dose with TLDs and a head phantom
- Suzuki, S. *et al.* 2010 study assessed skin dose in CTP using a head phantom and four manufacturers' scanners including cine mode on a GE scanner Lightspeed VCT

Aim of the project

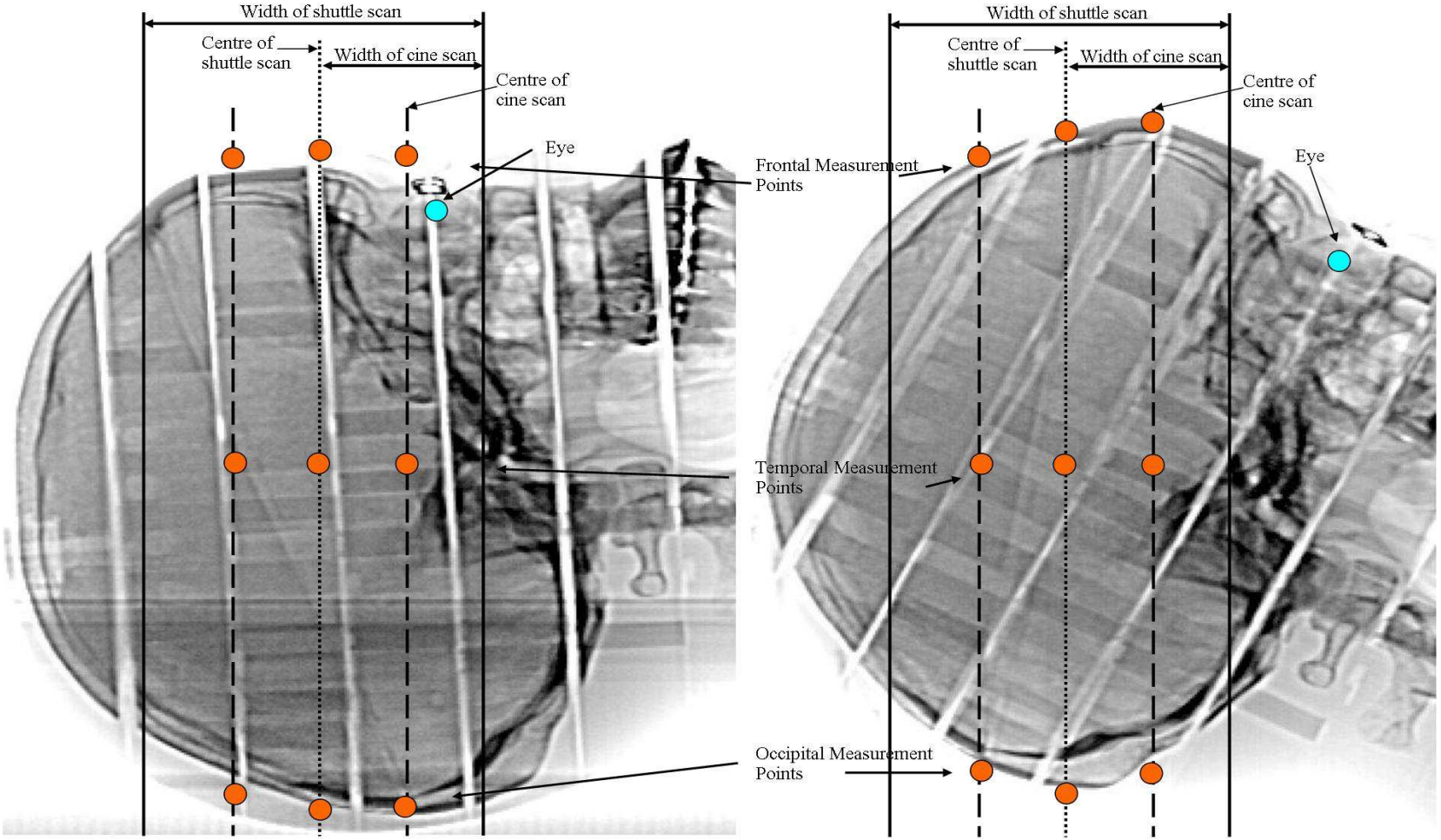
- To assess the proposed protocols at RSCH and to measure and calculate the Entrance Surface Dose (ESD), organ doses and Effective Dose using an anthropomorphic head phantom and thermoluminescent dose meters (TLDs).

- Ideally for the brain perfusion scan patients should have their head in a forward position with their chin down with some patient this is not always possible. Measurements were made to assess this.

Method

- Assessed the head position for CTP with help of radiographers
- Decided to make measurements with the phantom in two head positions the ideal scanning position and a worst case scenario
- Calibrated the TLDs
- Assessed each phase of the protocols so a total dose for each protocol could be calculated.
- Load the phantom with TLDs to measure organ dose (including scout scan) for each protocol
- Placed TLD on surface to measure ESD (including the scout scan) for each protocol

Phantom head position & position of ESD TLDs



Phantom head position and organ TLDs

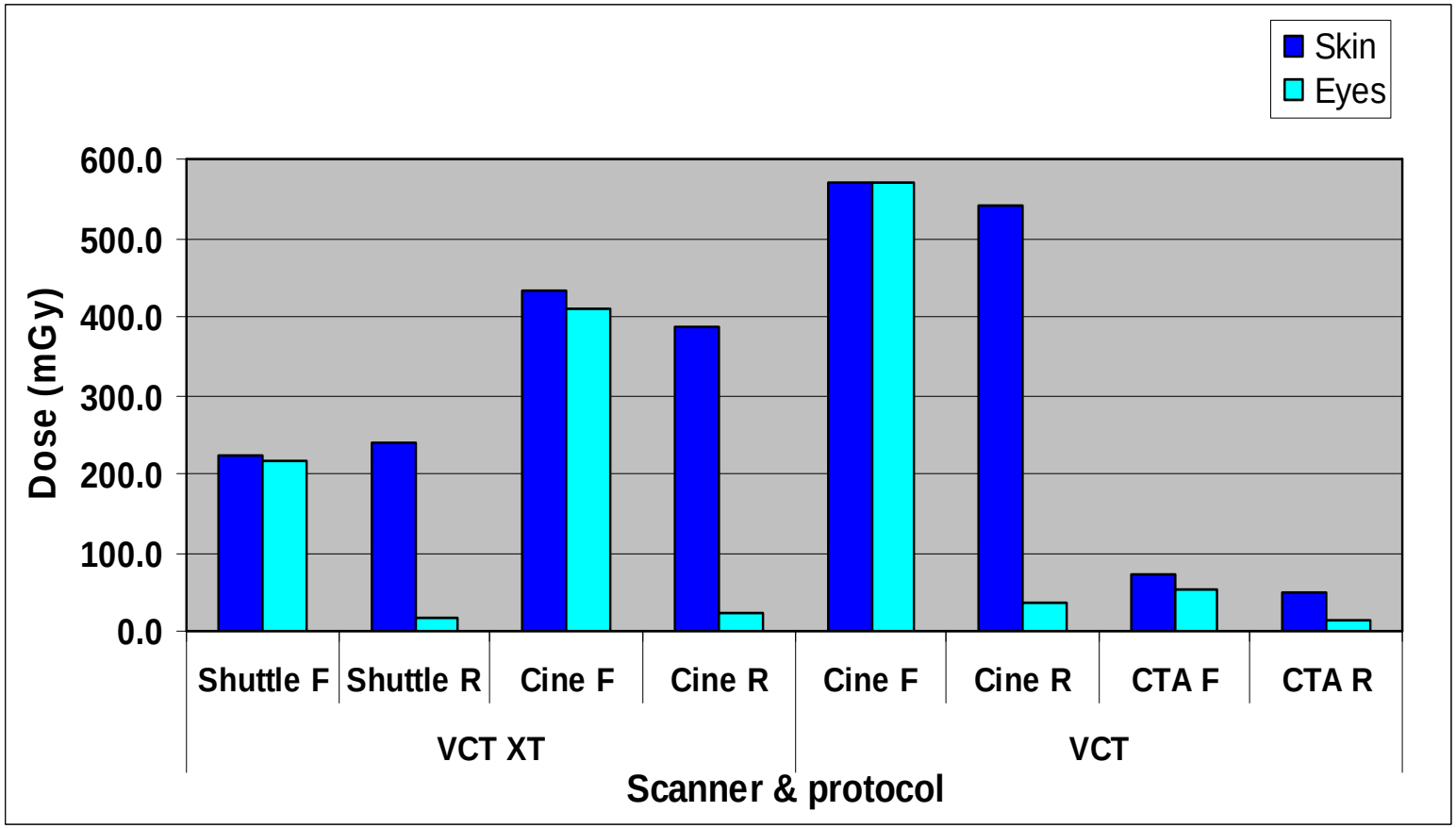
Effective dose and ESD

- Calculated effective dose using data published in the literature to account for the fact that only the head had been irradiated as a percentage of the whole body dose (Ludlow, J. and Ivanovich, M. 2008)
- Tissue weighting factors ICRP 103
- ESD measured at the same position as work published by Suzuki, S. *et al.* 2010.

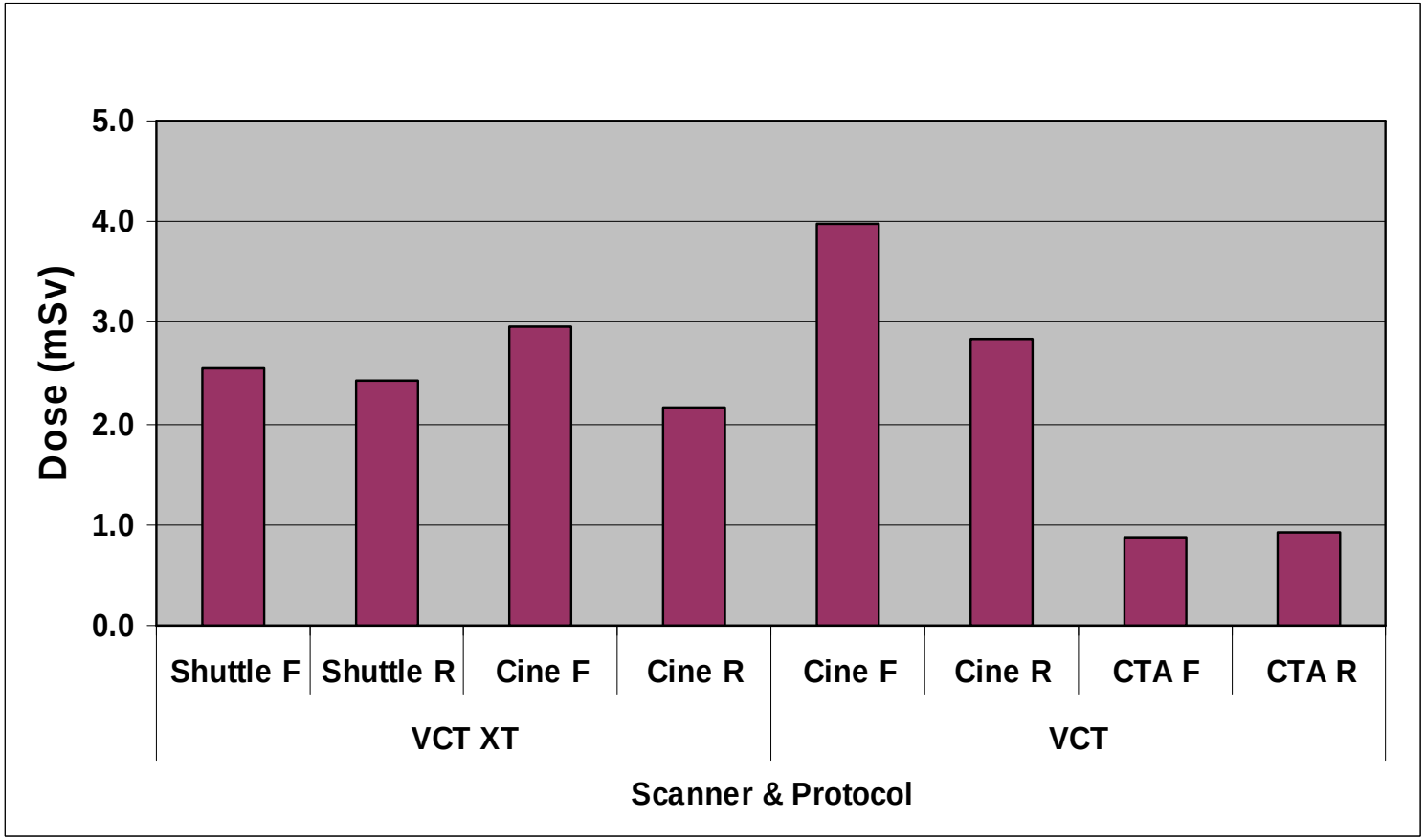
Results

- Skin dose
- Eye dose
- Effective dose

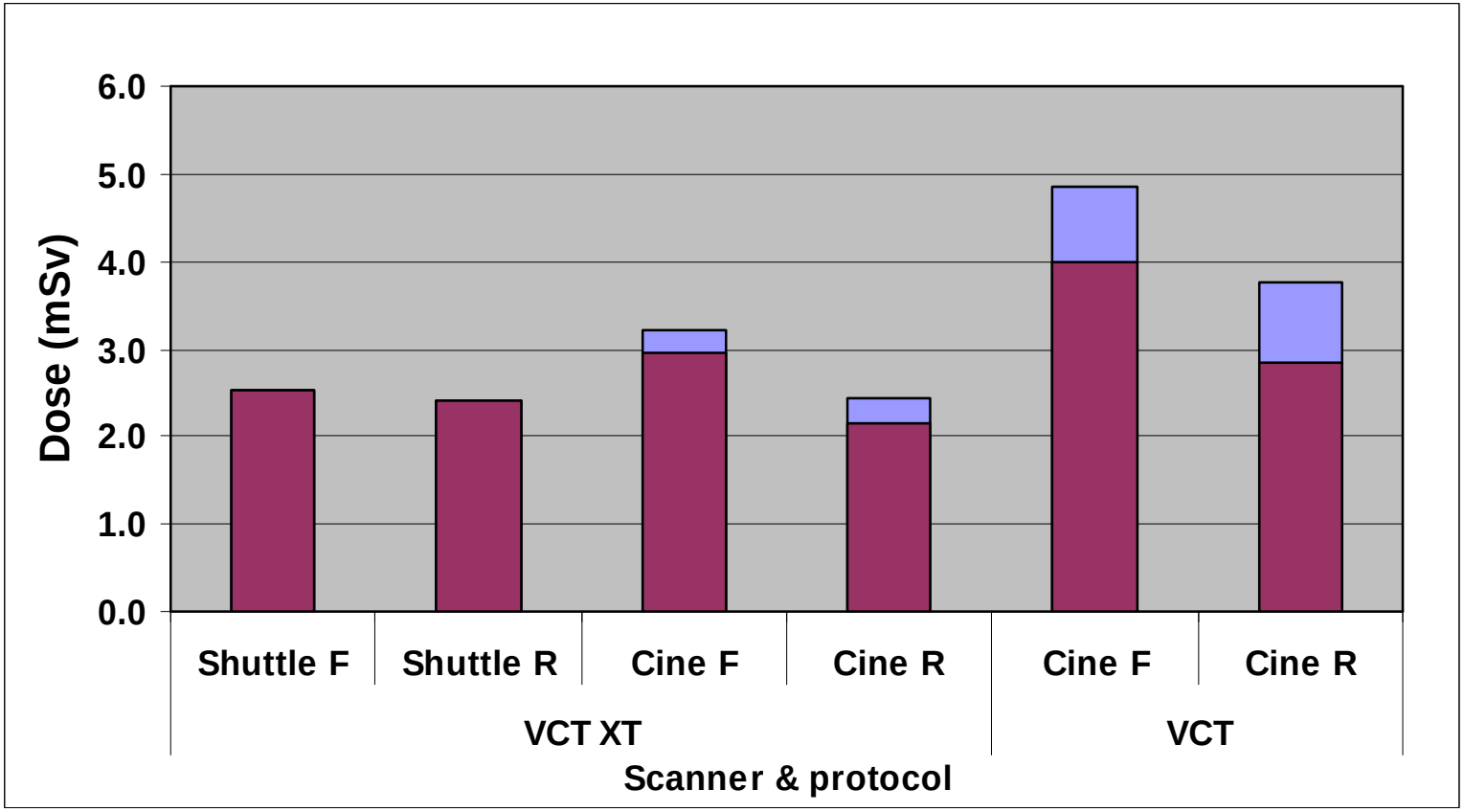
Maximum skin & eye dose for each scan type



Effective dose for each scan type



Total effective dose for each CT perfusion protocol



Discussion Skin & Eye dose

- Maximum skin doses measured from this study are below the threshold of early transient erythema and temporary hair loss (2-5 Gy)

- Maximum eye doses are below the threshold for detectable opacities or cataracts (0.5-2.0 Gy) when the head phantom was positioned in the ideal patient position (eyes outside the primary beam)

- Maximum eye doses are at level of concern when the cine protocol is used and the head phantom was flat (worst case patient scenario). Eyes were in the direct primary beam and are approaching the threshold for detectable opacities.

  VCT XT 408 mGy

  VCT 570 mGy

Effective Dose

- Effective doses on VCT XT are comparable for the shuttle and the cine protocols.
- The advantage of the shuttle protocol is the scan length is 80mm compared to only 40mm using the cine protocol providing more information for approximately the same effective dose.

CTP protocols

- Comparing the cine protocol on the VCT XT to the VCT it can be seen that there is a difference in effective dose of ~ 35% due mainly to the ASiR software and the technology of the newer scanner

- The shuttle protocol on the VCT XT gives ~ 50% lower effective dose than the equivalent protocol using cine mode on the VCT even for the flat head phantom (worst case patient scenario)

Conclusions

- Ideally patients will be scanned on the VCT XT shuttle protocol as this gives the largest coverage providing more information at the lowest dose when compared to the cine protocol
- Eye doses are below threshold for detectable opacities or cataracts for the shuttle protocol even in the worst case scenario.
- Eye doses for the cine protocol on both scanners are just below the threshold but could be of a concern if the patient is unable to adjust their head position to the ideal scanning position or undergoes a number of CTP scans

Further work

- Findings of this study are to be fed back to the Radiologists
- Image quality needs to be reviewed
- Ideally measure patient dose

References

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