CT Optimisation in the Major Trauma setting.

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Introduction

- What is Major Trauma?
  - NHS Choices defines it as “Multiple, serious injuries that could result in death or serious disability”
  - Can include serious head injuries, gun shot wounds, falls, crush injury or road traffic accidents
  - Does not have to be multiple injuries
  - Where the patient has an ISS (Injury Severity Score) score greater than 15
  - Includes bleeding in the brain, fracture of the pelvis and multiple injury, especially where there is a risk of haemodynamic instability.

Major Trauma at UHB

- The Queen Elizabeth Hospital Birmingham (QEHB) is one of the UK Adult Major Trauma Centres (with paediatrics at Birmingham Children's Hospital)
- The Royal Centre for Defence Medicine (RCDM) which supplies medical support to military operational deployments and secondary and specialist care for members of the armed forces is also based at QEHB
- Both use CT scanning (as recommended by the RCR guidelines) in the assessment of patients who have suffered a Major Trauma.

RCR Requirements for Multi-Detector CT (MDCT) for Major Trauma

- MDCT should be adjacent to or in the Emergency Room.
  - QEHB has a dedicated 128 slice CT scanner located in the Emergency Department (and as a back up 4 diagnostic CT scanners located 1 floor directly below)
- For a Seriously Injured Patient (SIP) Ultrasound and Radiography imaging should not delay a CT scan.
- CT request for trauma must comply with IR(ME)R 2000
  - QEHB has a protocol in place with a separate request form for SIP requiring whole body CT to ensure that the request is justified

ED STAFF: TAKE COMPLETED REQUEST TO ED CT SCANNER AND HAND TO RADIOGRAPHER

This form MUST be accompanied by an Oceano generated Trauma Protocol CT request

UHB Trauma CT Request Form

Hosp. No:…….. Name:…….. Male/ Female DoB:……

Date:…… Time of Request:…… ETA @UHB:…… By air / By road

Indication for Trauma CT		Tick all those that apply
Road Traffic Collision	Fatality at scene	
	Ejected from vehicle	
	High speed impact (>40 mph)	
	Prolonged extrication from wreckage (>15 mins)	
Assault	GSW / Penetrating Injury (state):	
	Injury to more than one region	
Head Injury	Reduced GCS with unknown mechanism	
Military		
Other (please state)		

Haemodynamically Stable / Haemodynamically unstable (delete as appropriate)

Area of Concern (tick)	Head:	C-spine:	Chest:	Abdo:	Pelvis:	All:

Specific question(s) to be answered:

1)……

2)……

3)……

Signed: Print surname Speciality:

RADIOGRAPHER/RADIOLOGIST TO SCAN FROM ONTO CRIS PRIOR TO AUTHORISING SCAN

RCR Requirements for MDCT for Major Trauma

- Written protocols need to be in place for preparation and transfer to scan room, this needs to include ensuring the CT room is clear to take the patient
- Contrast enhanced Whole Body CT (WBCT) is the default imaging procedure for SIP
- A primary report should be issued to the trauma team leader immediately following the CT scan
- The final report should be provided within 1 hour
- On call radiologist should have teleradiology facilities at home to allow report to be issued within 1 hour

RCR Example Polytrauma Protocols

- The RCR give three example protocols for major trauma scanning

RCR Example Polytrauma Protocols

Example 1

- Standard Head CT
- C-Spine CT from C_0 to T_1,
  - 1.25mm slices with sagittal and coronal reformats
- Chest, Abdomen and Pelvis from C_6 to Groin
  - chest in arterial phase ~25s post contrast
  - Abdo Pelvis in venous phase ~ 60s for liver
  - 2.5mm slices with sagittal and coronal reformats
  - Additional soft tissue reformats for Chest Abdo Pelvis

RCR Example Polytrauma Protocols

Example 2

- Standard Head CT
- C-Spine CT from skull base to T_4,
  - ‘thin’ slices with sagittal and coronal reformats
- Arterial phase Chest Abdomen Pelvis
  - 2mm slices
  - ~ 30s delay
- Portal phase Abdomen Pelvis
  - 2mm slices
  - ~70s delay

RCR Example Polytrauma Protocols

Example 3 (military protocol)

- Standard Head CT
  - 1.25mm slices (brain and bone)
- Circle of Willis to Symphysis Pubis
  - Portal phase scan ~60s post contrast

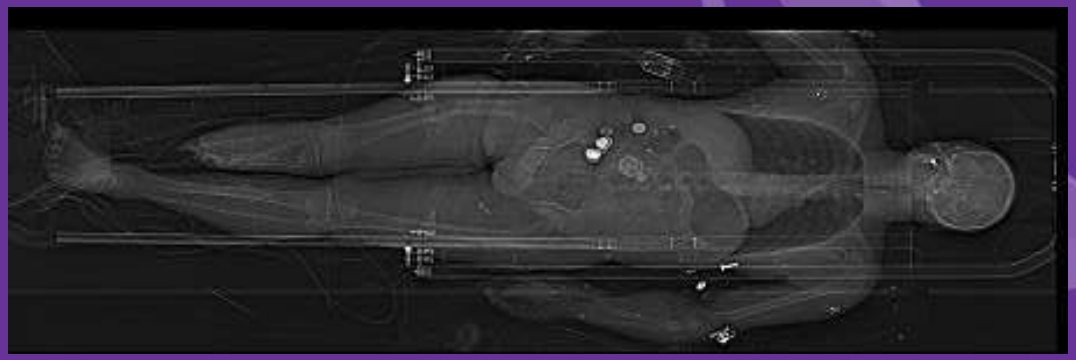
Practice at QEHB

- Dedicated CT scanner (Siemens Definition AS+) in Emergency Department so when notified of possible major trauma scanner can be cleared for immediate access.
- 24/7 rota for major trauma CT imaging ensuring there is Radiographer, SpR and Consultant Radiologist cover
- Use RCR protocol 3. This was chosen as the military radiologists with experience of this found that it provided the required information and they believed that, as there was less overlap, the effective dose was lower than the alternative protocols.

Doses for QEHB WBCT Trauma scanning

- RRPPS approached to estimate doses as there was a move to scanning patients on the ambulance service transfer device to reduce need to move the patient until after the CT scan.
- 1 years worth of data analysed
- Results were a surprise for us as they were larger than we expected
- For 505 patients scanned in the first year
  - Mean 33.4 mSv
  - Standard Deviation 12.9 mSv
  - Range 9.6 – 95.7 mSv

The Transfer Device



Summary of WBCT Doses

Sequence	Mean DLP (mGycm)	Range DLP (mGycm)	Mean Effective Dose (mSv)	Range Effective Dose (mSv)
1 Head	1267	887-2627	3.2	2.3-6.7
2 Body	1987	461-7029	30.2	7.1-92.0
Whole Scan	3286	1763-8450	33.4	9.6-95.7

- When comparing the doses with the transfer device they were 20% higher than those without
- Head scans are high when compared with NDRL
- Conclusion was that the WBCT protocol may be in need of some optimisation

Issues for Optimisation

- RCR guidelines require thin slices with low image noise.
- Nature of injury means that optimum positioning is not always appropriate or achievable.
- Removal of transfer device or monitoring equipment may not be appropriate.
- Images require immediate review and primary report i.e. before the patient leaves the CT room.
- Additionally we need to confirm the doses delivered by the other RCR example protocols to check that the Military one is lower dose.

Strategy for Optimisation

- Set up a WBCT optimisation group
  - 2 Clinical Scientists (RRPPS)
  - 1 Consultant Radiologist (RCDM and specialising in Trauma)
  - 1 Radiographer (Lead Superintendent CT Radiographer at QEHB)
  - 1 ST 4 (RCDM Radiology)
- Interest in this work for both QEHB and RCDM, particularly for use in Afghanistan – this allowed us access to military phantoms

Strategy for Optimisation

- RCDM staff arranged for use of the military's whole body phantom, Kyoto Kagaku PBU-50.
- Imaging department also had the scanners upgraded with SAFIRE iterative reconstruction (the ED 128 Slice and 2 of the imaging dept. Siemens 64 Slice AS scanners) and CarekV (this was following other work done showing the requirement to reduce CT doses).
- Aim was to investigate dose reduction strategies using the phantom and the new technologies in addition to using different protocols.

The Phantom

Scans to investigate – Stage 1

- Effect of SAFIRE on image quality and reconstruction times
  - Preliminary measurements to see the how SAFIRE effects image quality and times
  - Image quality assessed by 4 experienced radiologists who didn't know what settings were used
  - Used large variations in effective mAs
  - Provide us with feedback so we know where to focus our efforts
- Feedback
  - images were 'different but diagnostic'.
  - Time to reconstruct the full set of images increased from 6m 6s for FBP to 10m 40s for SAFIRE level 4

Scans to investigate – Stage 2

- Patient Positioning
  - Phantom was scanned as follows:
    - Both arms down
    - Right arm up
    - Left arm up
    - Both arms up
    - Both arms down on pillow
    - Both arms down on blocks
- DLP didn't vary by much (2132 – 2149)
  - For head understandable as fixed mAs
  - For body as 1 scan, with arms up increase through head and neck, for arms down increase through chest + abdomen

Scans to Investigate – Stage 3

- Comparison between the three RCR example protocols
  - Phantom scanned for the 2 alternative protocols
    - Arms down
    - Arms up
    - FBP and SAFIRE Level 3 (using Siemens standard protocols)
  - For the standard FBP protocols doses were:
    - Protocol 1: 16.2 mSv
    - Protocol 2: 26.5 mSv
    - Protocol 3: 14.6 mSv

Scans to Investigate – Stage 4

- Decision was made to keep using Military Protocol for SIP undergoing WBCT
- With SAFIRE reconstructions – but having them reconstruct in a set order so that the necessary images are available for a primary report to be issued ‘immediately’
- But how low can we go?
- Series of scans undertaken reducing the
  - Effective mAs for heads (260 – 160 in steps of 10)
  - Q_{ref} mAs for the body (150 – 50)

Scans to Investigate – Stage 4

- Radiologists to score the images to find the point where they are no longer of diagnostic quality

Outcome

- SAFIRE reconstruction has been activated for the majority of CT scans on the relevant scanners
- Not currently used for:
  - some clinical trials
  - necks for ENT and maxfax (as images were not suitable for assessing subtle tumour spread)
  - Major Trauma (waiting a final decision following this work)

Dose survey results

	Average DLP		%
	Pre SAFIRE	Post SAFIRE	Difference
CT Abdomen	562	450	-20%
CT Abdomen and pelvis	536	461	-14%
CT Abdomen and pelvis with contrast	646	560	-13%
CT Abdomen with contrast	680	565	-17%
CT Angiogram	751	600	-20%
CT Angiogram intracranial	917	685	-25%
CT Angiogram pulmonary	443	337	-24%
CT Brain neck thorax Abdo and pelvis	2644	2520	-5%
CT Chest high resolution	104	91	-13%
CT Colonoscopy virtual	742	509	-31%
CT Head	1066	857	-20%
CT Head with contrast	1593	1356	-15%
CT Internal auditory meatus Both	414	320	-23%
CT Liver triple phase	1016	728	-28%
CT Neck and thorax with contrast	738	626	-15%
CT Neck thorax abdomen pelvis with Cont	1527	1275	-17%
CT Sinuses	221	201	-9%
CT Spine cervical	602	510	-15%
CT Thorax	201	165	-18%
CT Thorax abdomen pelvis with contrast	883	704	-20%
CT Thorax and abdomen with contrast	622	506	-19%
CT Thorax with contrast	350	270	-23%

Data collected from CRIS

To improve statistical accuracy only exams with > 50 patients have been analysed

Pre SAFIRE January to May 2013

Post SAFIRE May to September 2013

Only scanners with SAFIRE included

Future Work

- Implement SAFIRE reconstructions for Major Trauma imaging.
- Trust is looking to get IRIS for the Dual Source scanner (as SAFIRE is not available for it).
- The 16 Slice scanner cannot be upgraded so alternative optimisation strategies required.
- RRPPS are looking to purchase a whole body phantom to repeat this optimisation exercise across the region.

Thank you

Any Questions?

For any questions / comments please e-mail
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