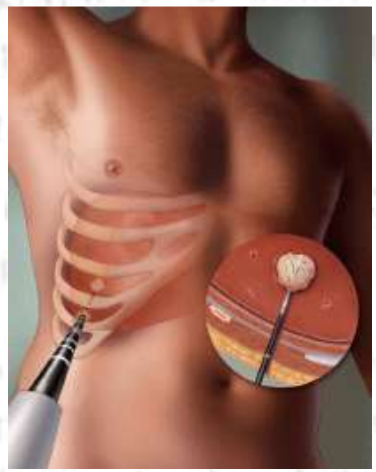
Plymouth Hospitals NHS Trust

Staff and patient dosimetry in CT-guided ablations



Rob Loader

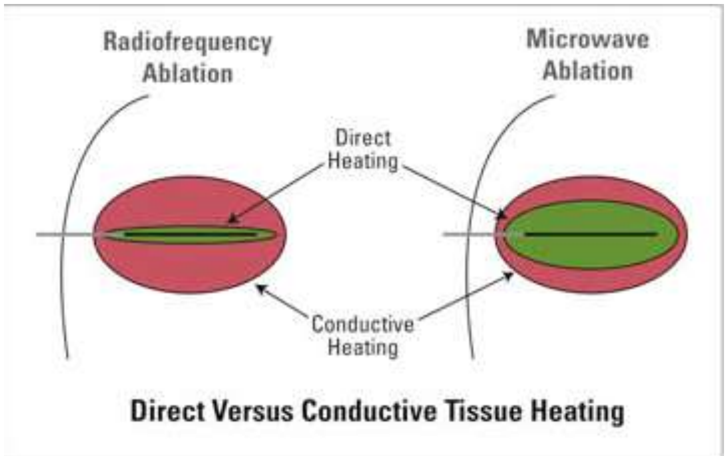
Plymouth Hospitals NHS Trust

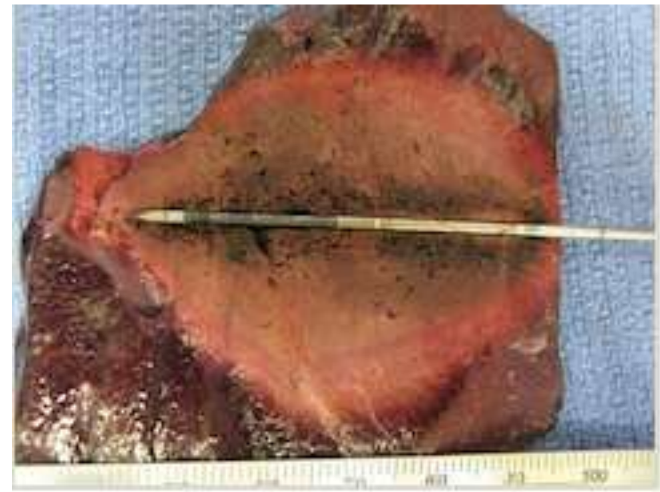
CTUG October 2016-Manchester

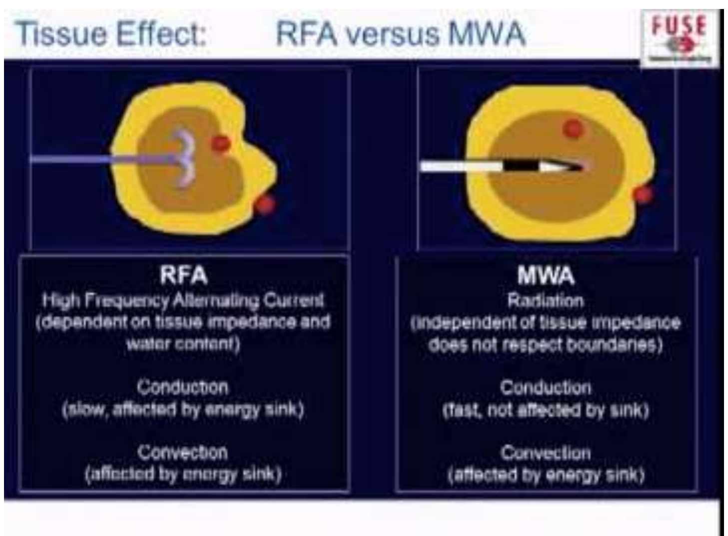
Overview

- CT Guided Microwave ablation therapy (CTMAT)- Including Justification of new practice
- Formulation of PRIOR RA in (ACOP para 44 & 45)
  - Estimation (and errors) of operator exposure to IR
  - Engineering Controls
  - Designation (advice to Employer)
  - Systems of work
  - Management of action plan
- Lessons learnt
- What about the Patient??
- Questions to the audience

CT Guided Microwave Ablation Therapy (CTMAT)







Risk assess new radiation practices!

Prior risk assessment etc.

7.—(1) Before a radiation employer commences a new activity involving work with ionising radiation in respect of which no risk assessment has been made by him, he shall make a suitable and sufficient assessment of the risk to any employee and other person for the purpose of identifying the measures he needs to take to restrict the exposure of that employee or other person to ionising radiation.

(2) Without prejudice to paragraph (1), a radiation employer shall not carry out work with ionising radiation unless he has made an assessment sufficient to demonstrate that—

(a) all hazards with the potential to cause a radiation accident have been identified; and

(b) the nature and magnitude of the risks to employees and other persons arising from those hazards have been evaluated.

(3) Where the assessment made for the purposes of this regulation shows that a radiation risk to employees or other persons exists from an identifiable radiation accident, the radiation employer shall take all reasonably practicable steps to—

(a) prevent any such accident;

(b) limit the consequences of any such accident which does occur; and

(c) provide employees with the information, instruction and training, and with the equipment necessary, to restrict their exposure to ionising radiation.

Justification of Practice

- Why do workers need to be in the room?
- Who has to be in the room?

Pneumothorax
Hemothorax/pleural effusion
Pulmonary haemorrhage
Haemoptysis
Air embolism
Fever, pain, tiredness

(b) estimated radiation dose rates to which anyone can be exposed;

Learning from others

Health and Safety Executive
HSE

NHS Trust fined after radiologist exposed to radiation

Date:

7 October 2013

United Lincolnshire Hospitals NHS Trust has been fined after an interventional radiologist was exposed to significant amounts of ionizing radiation.

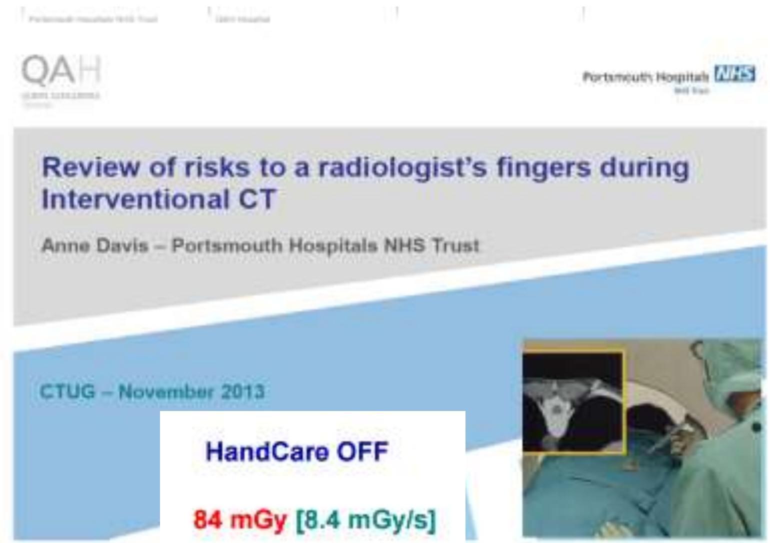
Boston Magistrates' Court today (7 October) heard that an interventional radiologist working with a CT scanner at Pilgrim Hospital, Boston, received more than double the annual dose limit for skin exposure in just over three months.

As an interventional radiologist his work involved the insertion of biopsy needles into patients, which he carried out using the CT scanner operating in continuous "fluoroscopy" mode, giving "real time" x-ray images which he observed whilst standing next to the scanner.

The scanner, which the trust had bought in 2009, was used by a number of other consultants for the same purpose but they used the conventional "step and shoot" method which required them to leave the room when the CT scanner was generating x-rays.

However, when the interventional radiologist arrived at the hospital in August 2011 he favoured the fluoroscopy mode, operating the x-rays for periods of up to 30 seconds at a time. Moreover, whilst inserting the biopsy needles he placed his hands directly in the main x-ray beam, resulting in an overexposure of radiation to his hands.

An investigation by the Health and Safety Executive (HSE) found that the Trust had never carried out a risk assessment for the CT scanner operating in the fluoroscopy mode so a safe system of work was not developed. In addition, managers were aware that this technique was being carried out but did not ensure proper procedures were followed.



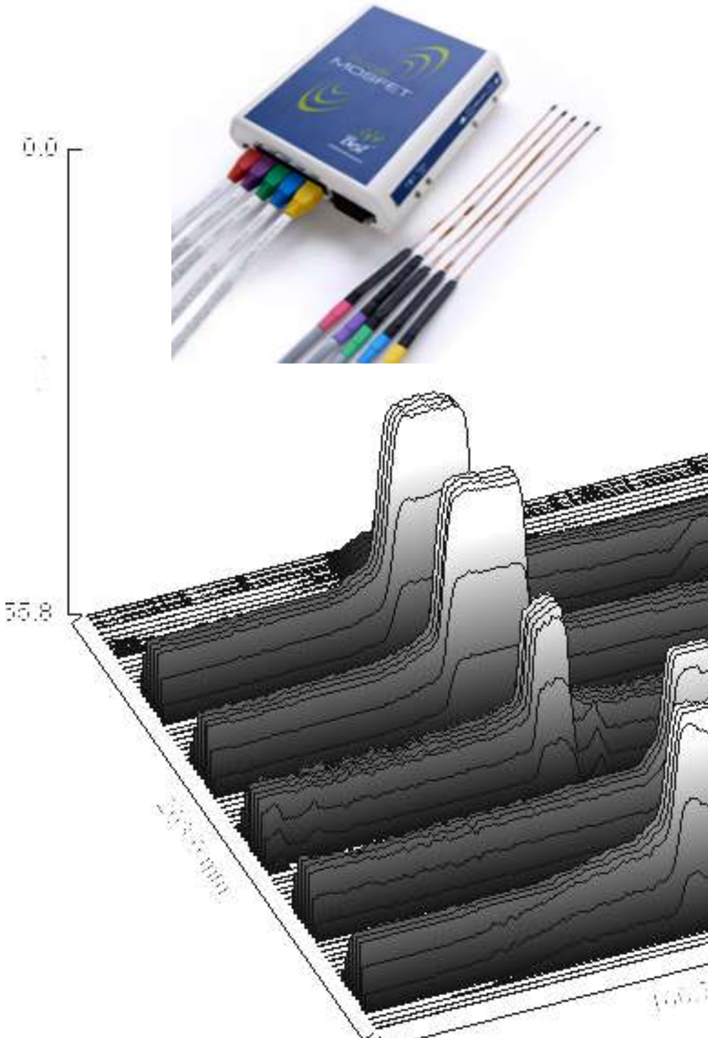
Lessons learnt

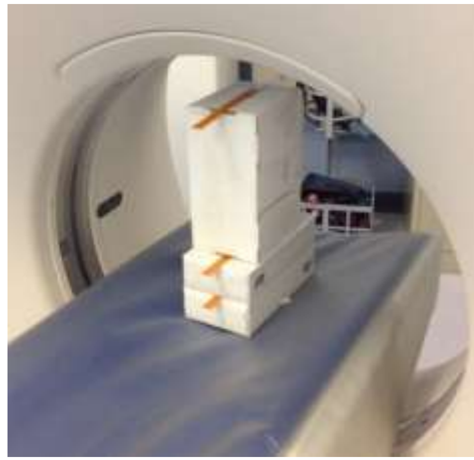
- Radiologist's training is essential.
- Extremity monitoring of limited usefulness (false reassurance?).
- Experienced CT radiographers should support these procedures
  and know what to do to minimise patient & doctor doses.
- Appropriate use of HandCare is effective at reducing operator dose.
- Patient dose data review can be useful – but no comparison data
  Must review clinical procedures and techniques.
  Understand the clinical risks to the patient.
  Look at the whole procedure not just the interventional part.
- Remind CT departments that new techniques must have a
  PRIOR risk assessment.

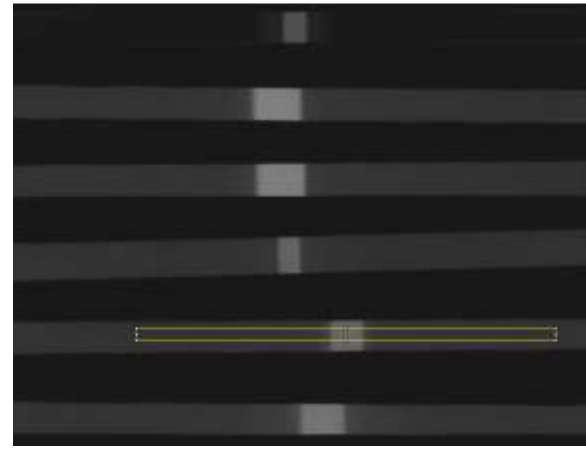
b

(b) estimated radiation dose rates to which anyone can be exposed;

XR-QA2 Gafchromic film/Mosfets – dose in gantry at other locations







Assumptions

- 25 procedures per year
- 10 iterations per case
- 50mAs/rotation
- 120KVp
- Fingers enter the beam 3% at patient surface
- What about if closer to gantry?

Lens (mSv)	E (mSv)	Extremity (mSv)
1.2	0.3	60

Estimation of doses to operator

Number of procedures per year	25
Number of iterations per intervention	10
assumed mAs per rotation	50
contingency multiple (e.g for larger scatter source)	1.5
Total number of rotations	250
Assumed max # rotations fingers in beam	7.5

All doses in uGy as persurements made with ionisation chamber. Broadly speaking, doses to fingers and eyes could be considered as equivalent dose and dose at waist height considered whole body effective dose Note measured doses for a 50mAs rotation at 120KVp and corrected to stated mAs. Contingency has not been applied to in beam measures.

Location	Fraction of total rotations	Eye 120Kvp uGy	Fingers 120KVp uGy	Body 120KVp uGy	Total eye uGy	Total finger uGy	Total body uGy
Fingers in beam (at patient surface)	**0.03**	**15**	**7162.8**	**3.3**	**168.8**	**53721.0**	**37.1**
Radiologist remains behind gantry	0.6	0.03	0.0	0.0	**6.8**	**4.5**	**6.8**
Radiologist stands over patient, holding needle	0.17	15	120.0	3.3	**956.3**	**5100.0**	**210.4**
Radiologist stands 2m diagonal from isocentre	0.2	0.57	0.5	0.5	**42.8**	**25.0**	**37.5**
Sum	1				**1174.50**	**58850.50**	**291.75**
				mSv/year	1.2	**58.9**	0.3

What if….

- Single rotation at max mA setting (120KVp) a maximum dose of ~ 70mSv possible (accident scenario)….
- Is this likely?
- Is this reasonably foreseeable?
- Typical CTMAT uses a mixture of smartstep (low mA) and out of room volumetric (high mA) procedures.
- For large patients, mA will hit maximum (440)

Difficulties and error

- **Estimating the likelihood of extremities entering the primary beam!**
- Measurement of absorbed dose at height in the CT scanner. Can we?
- Typically “approved” dosimetry methods are not suitable for this practice.
- Are successive irradiations likely to be in the same location (not really)?

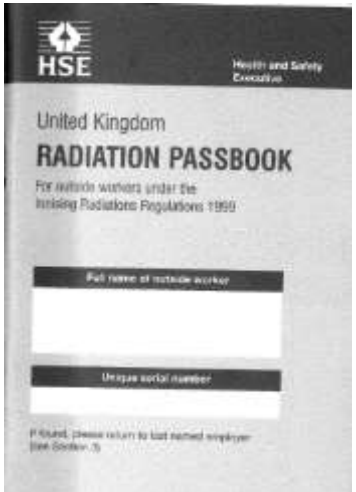
Calendar year dosimetry (without control measures)

- When we consider existing personnel dosimetry records. If our starting assumptions are reasonable then the annual dose to the extremities of the interventional radiologist with a mixed workload could be in the range:

120-190mSv/year

- If this is combined with a reasonably foreseeable accident scenario towards the year end then this range becomes:

190-260mSv/year



Advice to Employer

PAR ... ITORING OF
PER

Regulation 20

Desi

ACOP

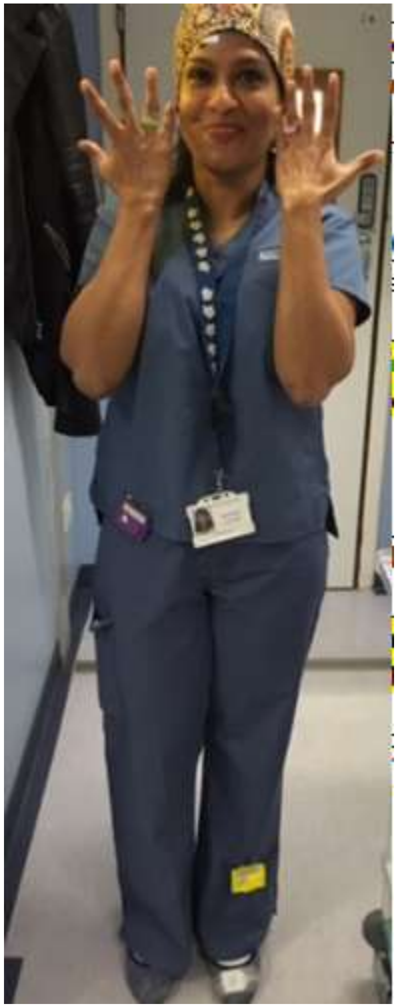
Who

367 ... **the employer should take accou ... tion (including the possi ... a result of the work the indivi**

368 ... **on any employee who work ... apable of giving rise to a dose ... loyee could receive an effect ... lent dose in** excess **of a** dose **limit within several minutes.**

20(1)-(2)

(m) the content of a suitable programme of dose assessment for employees designated as classified persons and for others who enter controlled areas (regulations 18 and 21);



- Liaised with ADS
- Personal Dosimetry Working Party (Colin Martin)
- Appointed Dr (?too much emphasis on effective dose)
- Senior Trust management
- Workers concerned
- RPS

Trust procedure implemented to ensure appropriate management of classified persons.

Training of workers on above requirements (especially when working for other Employer)

Systems of work (Summary)

- Who is permitted to stay in the room?
- System for checking required monitors are worn PRIOR to commencing work
- Who stands where (e.g. shadow of gantry)
- PPE requirements
- Use of Engineering controls (forceps)
- Systems of work to limit accidental exposure
- Systems of work where the fingers enter the primary beam

Formulation and Management of Action Plan

- Risk assessment acted as a “live” working document resulting in a detailed action plan.
- Action plan sent to the Clinical Director for Imaging and all relevant parties.
- Action plan signed off as tasks were completed.
- Clarity that first case could not be undertaken before the action plan was complete.

Conclusions (Staff)

- By systematically working through ACOP para 44 and 45 a prior RA enables the generation of an action plan that can be used as a management tool to ensure movement.
- If our assumptions turn out to be over cautious this can have unnecessary cost implications for the organisation (designation).
- If assumptions are optimistic then legal action could follow against the Trust.
- Designation as a classified person under reg 20 of IRR99 is sometimes questioned and requires the support of the Employer.

What about the Patient???

What happened next?

- Steep learning curve
- 40 in room step and shoot targets
- Patient skin dose of ~1Gy !
- Fingers remained out of primary beam!
- Practice paused due to lack of anaesthetics support!

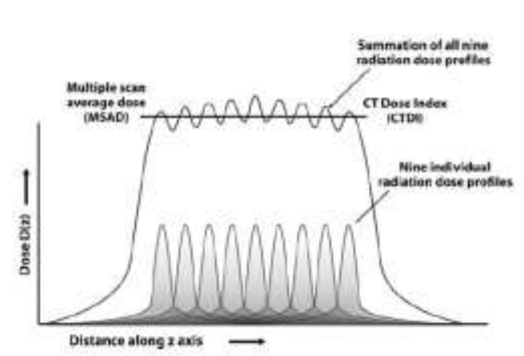
Scan No.	Type	Pitch	CTDI (mGy)			DLP
			CTDIvol	CTDIw	CTDIperiphery	(mGy.c
7.00	Smart step	1.00	1.04	1.04	1.25	1.04
8.00	Smart step	1.00	1.04	1.04	1.25	1.04
9.00	Smart step	1.00	1.04	1.04	1.25	1.04
10.00	Smart step	1.00	1.04	1.04	1.25	1.04
11.00	Smart step	1.00	1.04	1.04	1.25	1.04
12.00	Smart step	1.00	1.04	1.04	1.25	1.04
13.00	Smart step	1.00	1.04	1.04	1.25	1.04
14.00	Smart step	1.00	1.04	1.04	1.25	1.04
15.00	Smart step	1.00	1.04	1.04	1.25	1.04
16.00	Smart step	1.00	1.04	1.04	1.25	1.04
17.00	Smart step	1.00	1.04	1.04	1.25	1.04
18.00	Smart step	1.00	1.04	1.04	1.25	1.04
19.00	Smart step	1.00	1.04	1.04	1.25	1.04
20.00	Smart step	1.00	1.04	1.04	1.25	1.04
21.00	Smart step	1.00	1.04	1.04	1.25	1.04
22.00	Smart step	1.00	1.04	1.04	1.25	1.04
23.00	Smart step	1.00	1.04	1.04	1.25	1.04
24.00	Smart step	1.00	1.04	1.04	1.25	1.04
25.00	Smart step	1.00	1.04	1.04	1.25	1.04
26.00	Smart step	1.00	1.04	1.04	1.25	1.04
27.00	Smart step	1.00	1.04	1.04	1.25	1.04
28.00	Smart step	1.00	1.04	1.04	1.25	1.04
29.00	Smart step	1.00	1.04	1.04	1.25	1.04
30.00	Smart step	1.00	1.04	1.04	1.25	1.04
31.00	Smart step	1.00	1.04	1.04	1.25	1.04
32.00	Smart step	1.00	1.04	1.04	1.25	1.04
33.00	Smart step	1.00	1.04	1.04	1.25	1.04
34.00	Smart step	1.00	1.04	1.04	1.25	1.04
35.00	Smart step	1.00	1.04	1.04	1.25	1.04
36.00	Smart step	1.00	1.04	1.04	1.25	1.04
37.00	Smart step	1.00	1.04	1.04	1.25	1.04
38.00	Smart step	1.00	1.04	1.04	1.25	1.04
39.00	Smart step	1.00	1.04	1.04	1.25	1.04
40.00	Smart step	1.00	1.04	1.04	1.25	1.04
41.00	Smart step	1.00	1.04	1.04	1.25	1.04
42.00	Smart step	1.00	1.04	1.04	1.25	1.04
43.00	Helical	1.38	37.90	52.11	62.54	385.84
44.00	Helical	1.38	37.90	52.11	62.54	272.15
45.00	Helical	1.38	37.90	52.11	62.54	272.15
46.00	Helical	1.38	37.90	52.11	62.54	272.15
47.00	Helical	1.38	37.90	52.11	62.54	272.15
48.00	Helical	1.38	37.90	52.11	62.54	272.15
49.00	Helical	1.38	37.90	52.11	62.54	272.15
50.00	Helical	1.38	37.90	52.11	62.54	272.15
51.00	Helical	1.38	37.90	52.11	62.54	272.15
52.00	Helical	1.38	37.90	52.11	62.54	272.15
Total			421.64	563.77	676.52	3215.32

Example!

Experiment – GE HD750

120KVp	1s RT	250mA (Fixed)	40mm Coll	Large Body BTF

Pitch	CTDIv (Scanner)	MOSFET mV (measured at patient surface)	Cf Axial
0.516:1	37.4	161.6	198%
0.984:1	19.1	100.4	123%
1.375:1	13.5	51.7	63%
Axial (centred over MF)	20.1	81.9	100%



Patient doses from CT Guided interventions

Publication	Examination	E mSv (max)	Average CTDIv mGy (max)	Skin dose relationship with CTDIv	Max skin dose in single procedure (Gy)
Leng et al 2011	Cryoablation Biopsy Drain	119.7 (H) 11.9 (H) 23.3 (H)	183 (Ax) 515 (H) 102 (Ax) 52 (H) 95 (Ax) 79 (H)	1.2X (Helical) 0.8X (Axial)	1.95
Tsapaki et al 2014	Radio Frequency Ablation	37.5 (70)	-		1.55
"This work" (indicative)	All CT guided ablations CT biopsy CT Drainage	43 (80) 15 (71) 20(78)	(422) (180) (290)	$(CTDI_{100})_{periphery} = \sum CTDI_{vol} \times Pitch \times \frac{6}{5}$ Relationship between $(CTDI_{100})_{periphery}$ and peak skin dose found empirically with Mosfet dosimetry.	~0.8

Local doses (this work) from CRIS output over a two year period for CTbiopsy and Drainage and 8months for ablations. Local doses almost uniquely for a GE Lightspeed 16 slice CT scanner.

Conclusions (Patients)

- Accumulative values of scanner determined CTDIv can be used to broadly estimate peak skin dose in Interventional CT procedures. Patient shape and size however compared to the reference phantom will add significant error.
- Patient skin doses for **single procedures** in interventional CT can occasionally exceed 1Gy.
- During the audit a number of patients received more than 5 CT guided interventions in a 6 month period.
- Effective dose for CT guided interventional procedures can be high (100's mSv)
- Whilst many centres have systems in place to assess peak skin dose for fluoroscopically guided interventions, it is recommended that skin doses for CT guided interventions are audited and similar systems instigated if required.

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- Local Radiographers

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