Patient Contamination in Prostate LDR Brachytherapy

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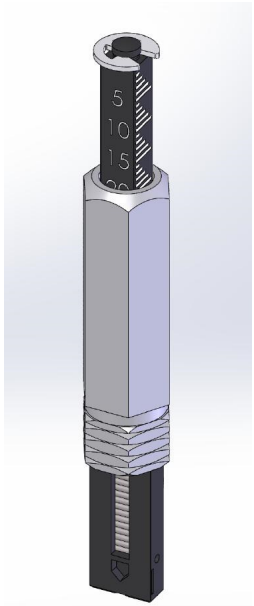
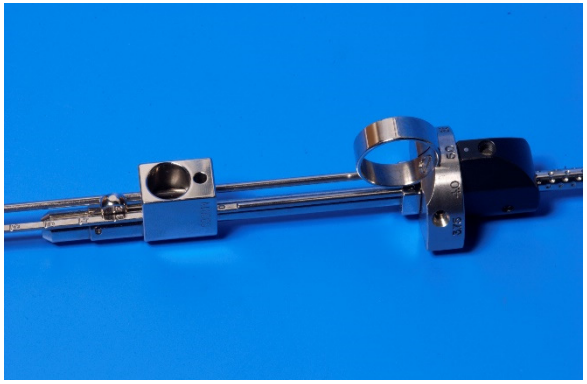
Guy's LDR Prostate Brachytherapy

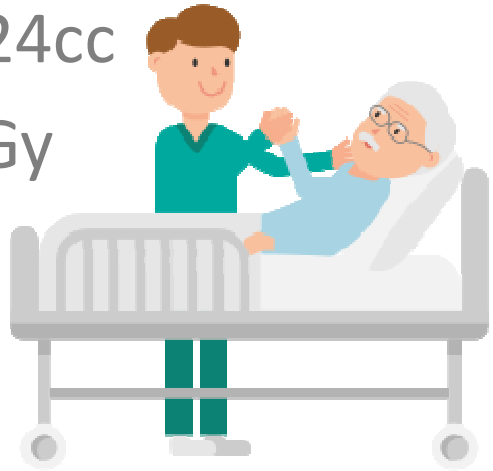
- GSTT implemented LDR PBT in Dec 2003
- How now implanted 844 NHS patients
- Currently treat around 70 NHS patients per year
- Have always used intra-operative planning
- Loose seed technique with Mick applicator
- Calculate the number of seeds to order from a estimated prostate vol obtained via TRUS or MR scan
- Use VariSeed TPS
- Post implant CT 4-6wks after implant





Patient Details

- **Diagnosis**
  - September 2017 prostate cancer
  - PSA 4.83ug/L
  - T2
  - Gleason 3+4
  - IPSS score 6, good urine flow rate
- **Age – 62yrs**
- **Treatment**
  - Monotherapy LDR prostate brachytherapy January 2018
  - 51 seeds (0.420mCi/15.5MBq)
  - Pros vol 24cc
  - D90 160Gy

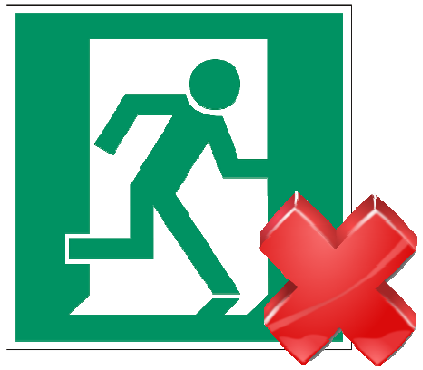


Incident Jan 2018

- Implant appeared to go as expected
- As physicists were monitoring the trolley area (Mick applicator & needles) radioactivity was detected on several items!
- Number of cps not as high as expected for a loose seed!

Incident Jan 2018

- Cps 200 to 2000
- Radioactivity detected on:
  - Used needles & seed cartridges
  - Mick applicator
  - Clinical waste bag
  - Blood on template
- No seeds could be visualised
- Phoned MPE for advice
- Contamination suspected!
- No staff to leave theatre



Radioactive Contamination

- Radiation Safety section of Medical Physics attended theatre with a radioactive spill kit
- Determined radiation contamination from unsealed iodine source
- No unsealed seeds could be located hence it was deemed to be inside the patient
- Highest concentration of radioactivity was found on the Mick applicator
- Assumed seed must have been damaged during deployment into the patient with the Mick applicator

Radioactive Contamination

- All waste items containing radioactive contamination were bagged and removed to the hospital central radioactive store for decay and disposal
- Surgical needles and empty seed cartridges were placed in a new sharps bin and quarantined in the waste store
- Mick applicator was quarantined
- The remaining partially used cartridge of active seeds was placed in a plastic specimen pot inside a lead pot and returned to the normal secure iodine seed store (labelled & sealed appropriately so couldn't be used for any further procedures)

Radioactive Contamination

- All staff involved in handling any equipment that came in contact with the radioactivity were monitored (hands, feet and scrubs/theatre shoes)
  - Consultant clinical oncologist
  - Radiotherapy physicists
  - Scrub nurse
- Radioactive contamination was only located on the gloves of the oncologist (from contaminated patient blood)
- Once cleared of contamination the theatre was quickly returned clean for the next patient

Further Advice

- Nuclear Medicine Physics colleagues were advised of the incident as this was assumed radioactive iodine internal contamination from a damaged seed
- The patient's urine was collected and monitored using a type 44A monitor obtaining a reading of maximum 300cps
- This indicated that there was systemic uptake of radioactive iodine and that there was excretion of the radioactivity via the patient urinary system

Further Advice

- Literature was sourced which indicated damaged seeds could potentially leak radioactive ^{125}I contents with respective half-release periods of between 9 and 180 days following implant (Chen *et al*, 2006)
- At this time, it was not known how many seeds were potentially damaged
- The presence of radioactivity in urine (and subsequently in blood sample counting) indicated systemic internal contamination of the patient

Patient Advice

- Decision was made to keep the patient overnight so his urine and general well being could be monitored

Radiation Dose & Risk Estimates

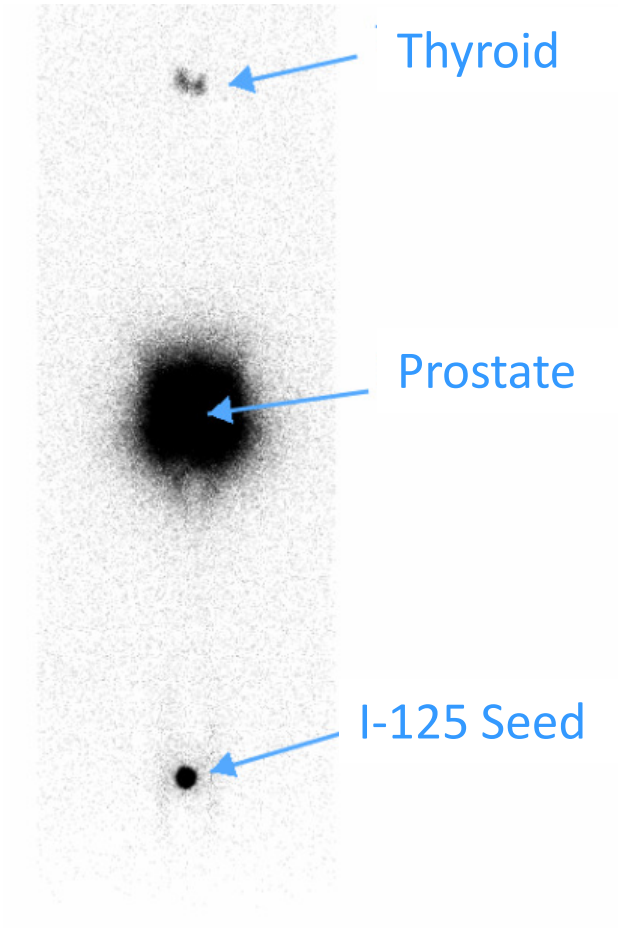
- Physical half-life of ^{125}I is 59.4 days
- Biological half-life approximately 40 days
- The occupational annual limit of intake (ALI) for Iodine-125 is 1.3MBq, which would give an effective whole body dose of 20mSv (Delacroix,2002)
- Seed activity 15.5MBq
- Therefore, if the full contents of a seed leaked into the patient's body, the effective dose from the initial assessment could approach 240mSv, mostly resulting from an equivalent thyroid dose of up to 6Gy (ICRP, 2007)

Further Action

- Blood sample was taken from the patient
- Analysed by Nuclear Medicine Physicists on a gamma camera (without collimators) together with a control seed of known activity
- The cps from the samples varied between 90-300 cps with a peak around 35-40keV, confirming contamination was Iodine-125 and not another radioactive contaminant
- The sample indicated a circulating activity in the patient's blood stream of approximately 0.027MBq (assuming 4 litres blood volume)

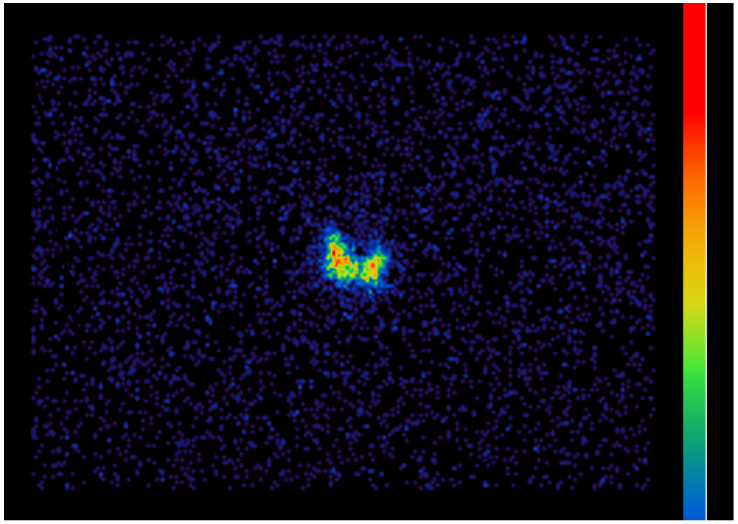
Further Action

- The patient was referred for a whole body scan in the Nuclear Medicine Department to check thyroid activity
- The scan revealed a thyroid uptake of approximately 0.17MBq (a committed equivalent dose of 43mGy) to the thyroid gland



Further Action

- From the measurements taken, it was thought likely that only one seed has been damaged as the activity levels are consistent with a damaged single seed
- ARSAC Guidance (ARSAC, 2016) recommends thyroid blocking if the activity to the thyroid gland could exceed 50mGy, or 0.2MBq of I-125



Further Action

- A paper issued by the FDA in 2001 suggested the age of the individual should also be taken into account as part of the decision making process
- Patients >40yrs of age may benefit less from this intervention
- It recommended the dose to the thyroid in such patients would need to exceed 500mGy before thyroid blocking is recommended

Patient Treatment

- In this instance, thyroid blocking was deemed appropriate due to the possible extended nature of the exposure and the possible activity levels involved
- Stable iodine (170mg od Potassium Iodide) was prescribed two days after the implant procedure for a duration of two weeks

Patient Advice

- Patient was then discharged with additional precautions to follow at home
  - Use of own toilet
  - Pee sitting down
  - Close the toilet seat before you flush
  - Don’t share crockery or cutlery

Incident Investigation

- Seeds were undamaged prior to implant as no contamination was found on any packaging
- Seed manufacturer was contacted for more information on QC results from the batch of seeds for this patient
- Formal report sent, no indication of any problems at manufacture (Theragenics, 2018)

Incident Investigation

- Theatre staff are responsible for the Mick applicators
- No records they had ever been serviced
- No recording of how many times each applicator used

RECOMMENDED SERVICE SCHEDULE FOR
MICK APPLICATORS AND MICK REUSABLE MAGAZINES

The Mick 200 –TP Applicator, Mick 200-TPV Applicator and Mick Reusable Magazines are designed for reuse and are to be cleaned and sterilized prior to each use.

These products contain no user serviceable components.

Any and all repairs must be performed by
MRNI's qualified service personnel at MRNI's facility.

The life expectancy of these products is based on **PERIODIC INSPECTION** and **REPAIR** performed by MRNI.

These products can last indefinitely when they are inspected and repaired as needed and at the recommended frequency.

MRNI recommends the following:

Product	Service Frequency
Mick 200-TP Applicator	Every 50 Implants
Mick 200-TPV Applicator	Every 50 Implants
Mick Reusable Magazines	Every 50 Implants

NOTE: WHEN A MALFUNCTION OCCURS, IMMEDIATELY CONTACT MRNI TO OBTAIN A RETURN AUTHORIZATION NUMBER AND INSTRUCTIONS TO SEND PRODUCT IN FOR REPAIR!

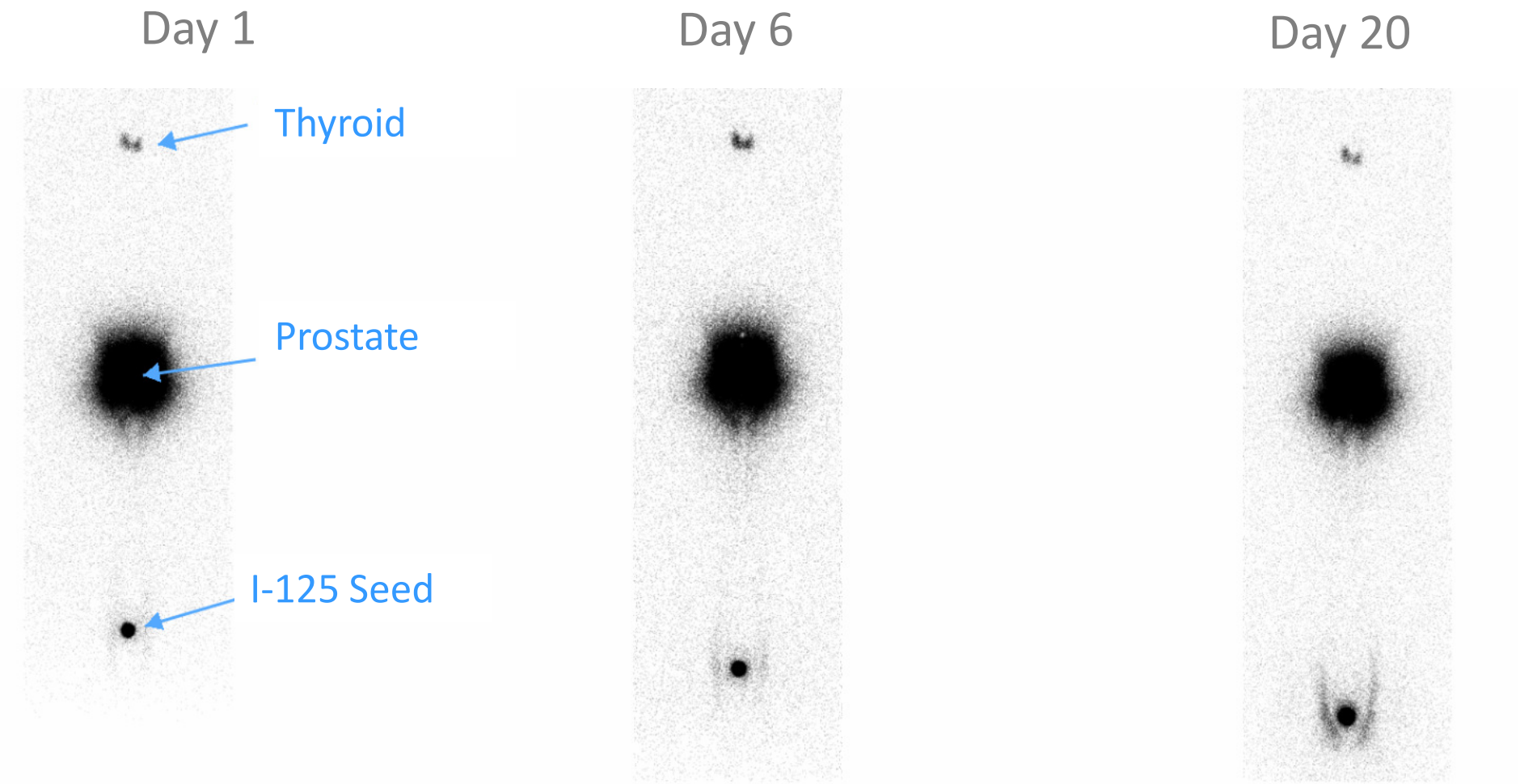
Check for remaining seeds by inspecting the plunger first, then look for a last seed under an appropriate viewing angle, if unsure use a radiation detector.

Before disposing empty cartridges always check with a contamination monitor, that they are free from any contamination.

Patient Treatment

- The patient received repeat blood tests and thyroid uptake scans 6 days & 20 days post implant
- Further dose information was obtained from those tests with regards to whether the activity in the blood stream was increasing, decreasing or was being maintained at a reduced level

Whole Body Imaging



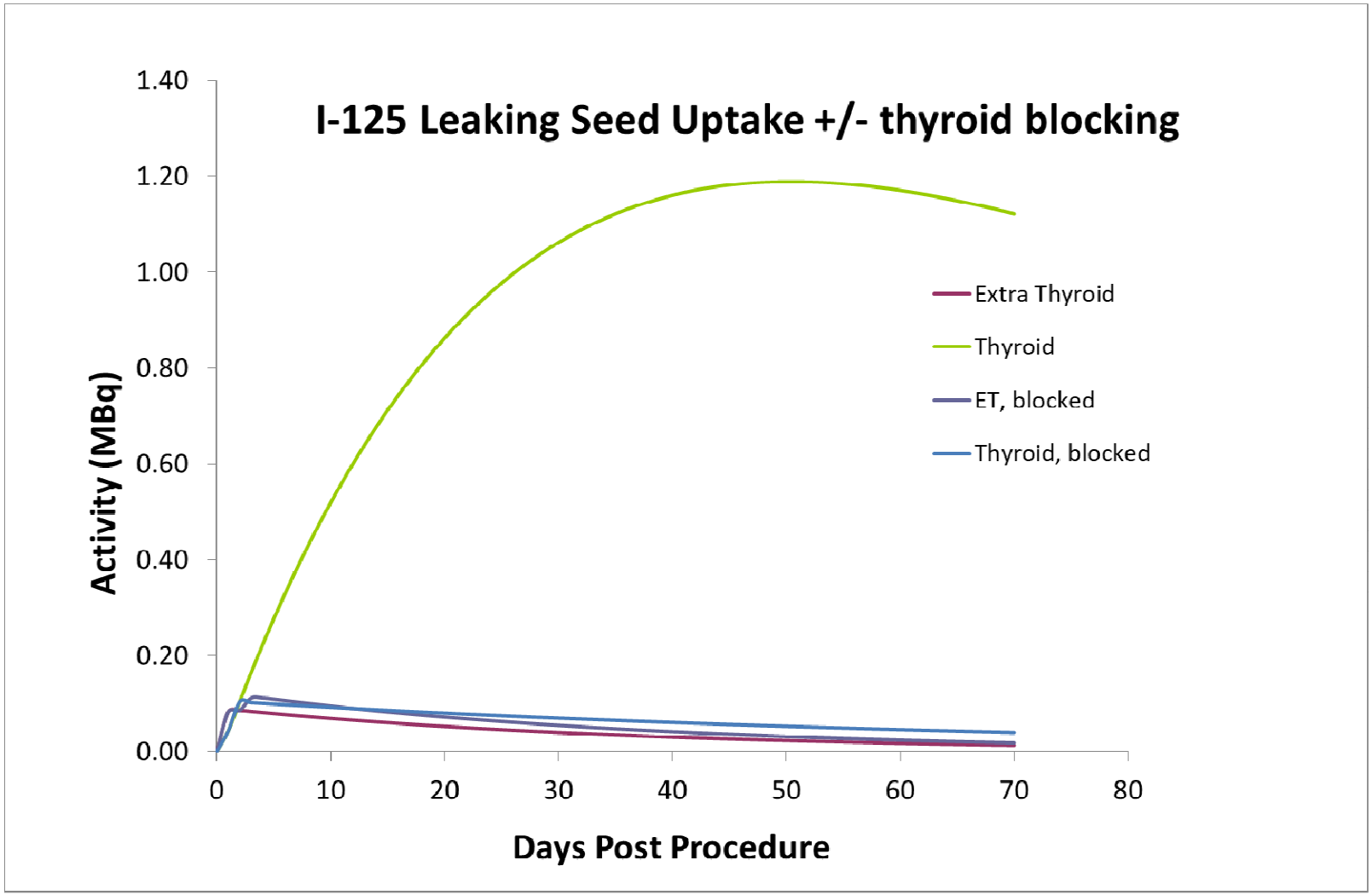
Biokinetic Models for I-125 Uptake

- The compartment first order kinetic transfer models for the extra-thyroid compartment and the thyroid compartments were solved for 2 scenarios:
- $\frac{dA_{ET}}{dt} = f_L A_s(t) - (k_{51}+k_{21}- k_{12} -k_{32} - k_{42})\, A_{ET}$

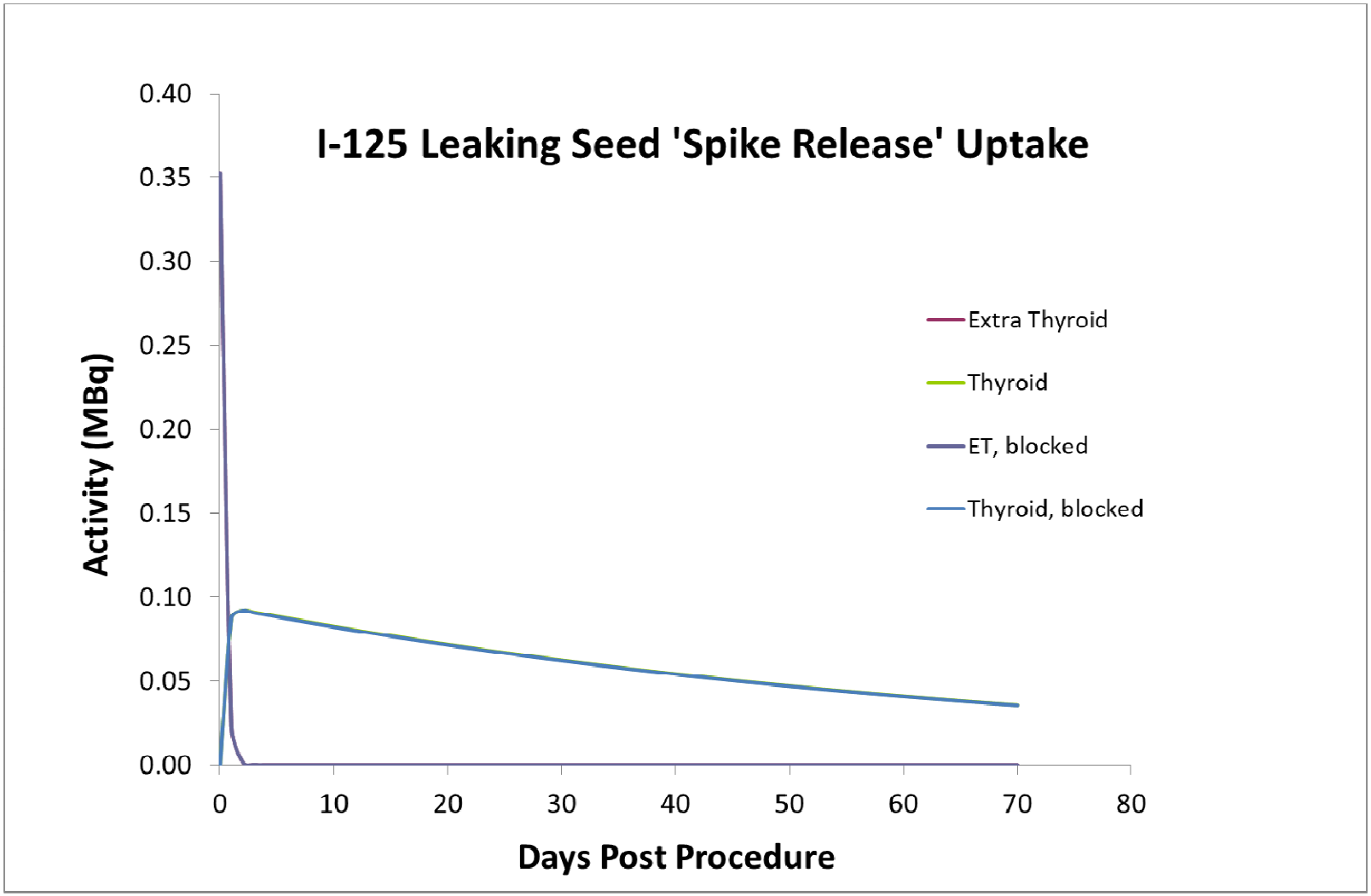
$$\frac{dA_{th}}{dt} = k_{21} A_{ET} - (k_{12}+k_{32}+ k_{42})\, A_{th}$$

- Using different initial conditions the solutions for the 'spike' release and 'exponential' release were solved.
- A seed could release a given fraction of its activity (single spike release model) or release at a rate proportional to the amount left in the seed

Biokinetic Models for I-125 Uptake



Biokinetic Models for I-125 Uptake



Biokinetic Models for I-125 Uptake

- In order to work out an effective dose delivered from the two models the cumulated activity time product was calculated and compared to the normal model
- It should be noted that the conversion factor to effective dose of 15mSv/MBq used (Delacroix,2002) related to ingestion, and that the activity figure to be used is not the actual gland uptake (25%) but the equivalent amount ingested
- The estimated seed spike release was 2.6% of the 15.54MBq seed activity, or 0.35MBq

Patient Treatment

- Scans at day 6 & day 20 indicated that there is a reduction in thyroid activity which is more consistent with an initial spike release than an exponential release
- The blood plasma results appeared to be falling off more rapidly than the exponential blocked model would indicate
- However uncertainty in figures due to low count rates
- Evidence to support the assertion that the release is clearing in accordance with a single spike release

Effective Dose

- Accumulated activity-time products and effective dose

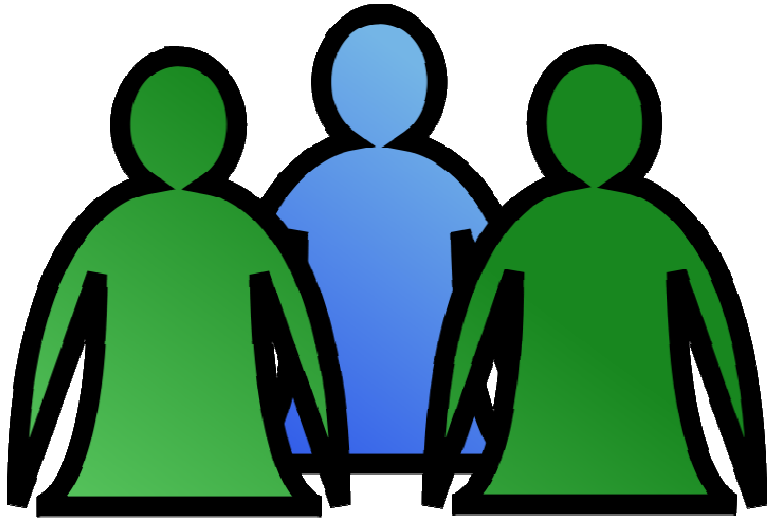
Release	Blocking	Activity-time Product (MBq.d)	Equivalent Single Ingestion (MBq)	Effective Whole Body Dose (mSv)	Approximate Thyroid Gland Dose (Gy)
Exponential	No	135.5	7.72	116.0	2.9
Exponential	Yes	6.12	0.35	5.2	0.130
Spike	No	6.19	0.35	5.3	0.133
Spike	Yes	6.16	0.35	5.3	0.132

Risk of Thyroid Cancer

- Using an effective dose of 5.2mSv (with thyroid blocking) to estimate fatal cancer risk the exposure resulting from the seed release would be equivalent to approximately two years on background radiation or a risk of 1 in 4000
- For a patient of age 60 years with an existing malignant condition the risk factor may be reduced further
- The risk of a new primary malignancy is considered very small from this unintended exposure

Contingency Planning

- The incident is so rare that its possibility had not been considered in any local contingency planning
- All local procedures and contingency plans have now been reviewed and the possibility of damaged seeds included with an action plan and emergency contact numbers advised



Equipment Involved

- The surgical equipment involved in the incident was placed in quarantine for several months
- The Mick applicator was never returned to clinical use and a replacement was purchased
- All other Mick applicators were serviced by the manufacturer
- Records initiated of which Mick applicators used for each implant, so equal use and auto flag for manufacturer service requirement

Equipment Involved

- The remaining contaminated seeds could not be returned to the manufacturer for disposal
- Std waste disposal 26wks, inform EA go beyond this
- They were stored until low enough (380 days) to be disposed of in general waste (exemption order)
- Exempt ≤200kBq per 0.1 cubic meters of general waste
- Each contaminated seed was placed in an individual black bag (≤0.1m^3) and disposed of as general waste via GSTT waste management team

External Reporting

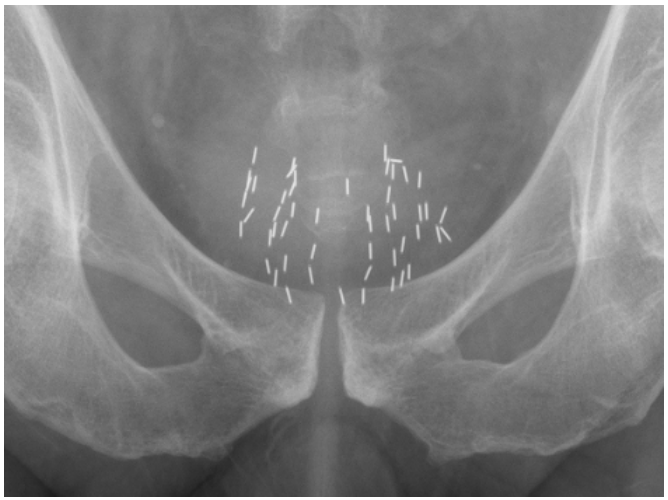
- The Chair of the RSAC and Trust RPA recommended this incident to be reportable to the MHRA and the CQC in accordance with Department of Health guidance (DoH, 2017)
- The incident could be deemed reportable under any of the following headings:
  - [1] Wrong radioactive medicinal product administered
  - [2] Delivered dose (organs at risk >1.1 intended dose)
  - [3] Geographical errors
  - [4] Any other situation where a patient has been exposed to ionising radiation, which in the judgement of the employer, is much greater than was intended for the patient

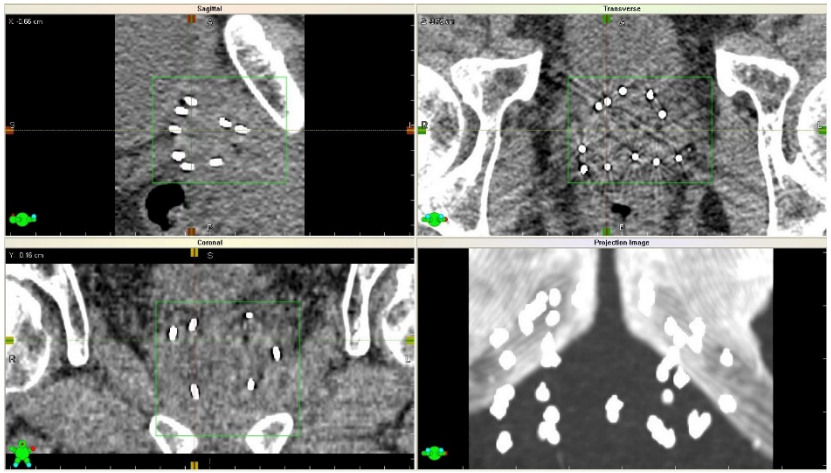
External Reporting

- The CQC & HSE subsequently visited the department to discuss the incident in detail, (to see a Mick applicator), to review our procedures and training records and to confirm the lessons learnt had been applied

Patient Follow-up

- Post implant CT and x-rays of the pelvis showed all 51 seeds
- No sign of seed breakage
- He had some urinary tract symptoms which have now improved, as expected with std treatment
- His PSA will continue to be monitored as per std follow-up





Changes in Practice

- Annual contingency plans rehearsal training
- Monitor Mick applicator at every cartridge change
- Physicists wear gloves during seed handling
- Oncologists hands and feet are monitored prior to exiting the theatre
- The serial number of the Mick applicator used for the implant is recorded in the patient record
- Regular rotation of the Mick applicators used and routine servicing initiated

Acknowledgements

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  - Julie Robinson (Deputy RPA)
  - Ian Honey (Deputy RPA)
- **Consultant Clinical Oncologist**
  - Dr Stephen Morris

Guy's Cancer

PROSTATE BRACHYTHERAPY UK & Ireland Conference 2019

NHS Guy's and St Thomas' NHS Foundation Trust

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Questions?