Effective dose for CT head scans with a modulated tube current

John Loveland
Royal Infirmary of Edinburgh
NHS Lothian

Introduction

- The use of modulated tube current in CT
- Dose audit pre and post mA modulation
- Effective dose calculations with a modulated tube current
- Study conclusions
- Study limitations and further work

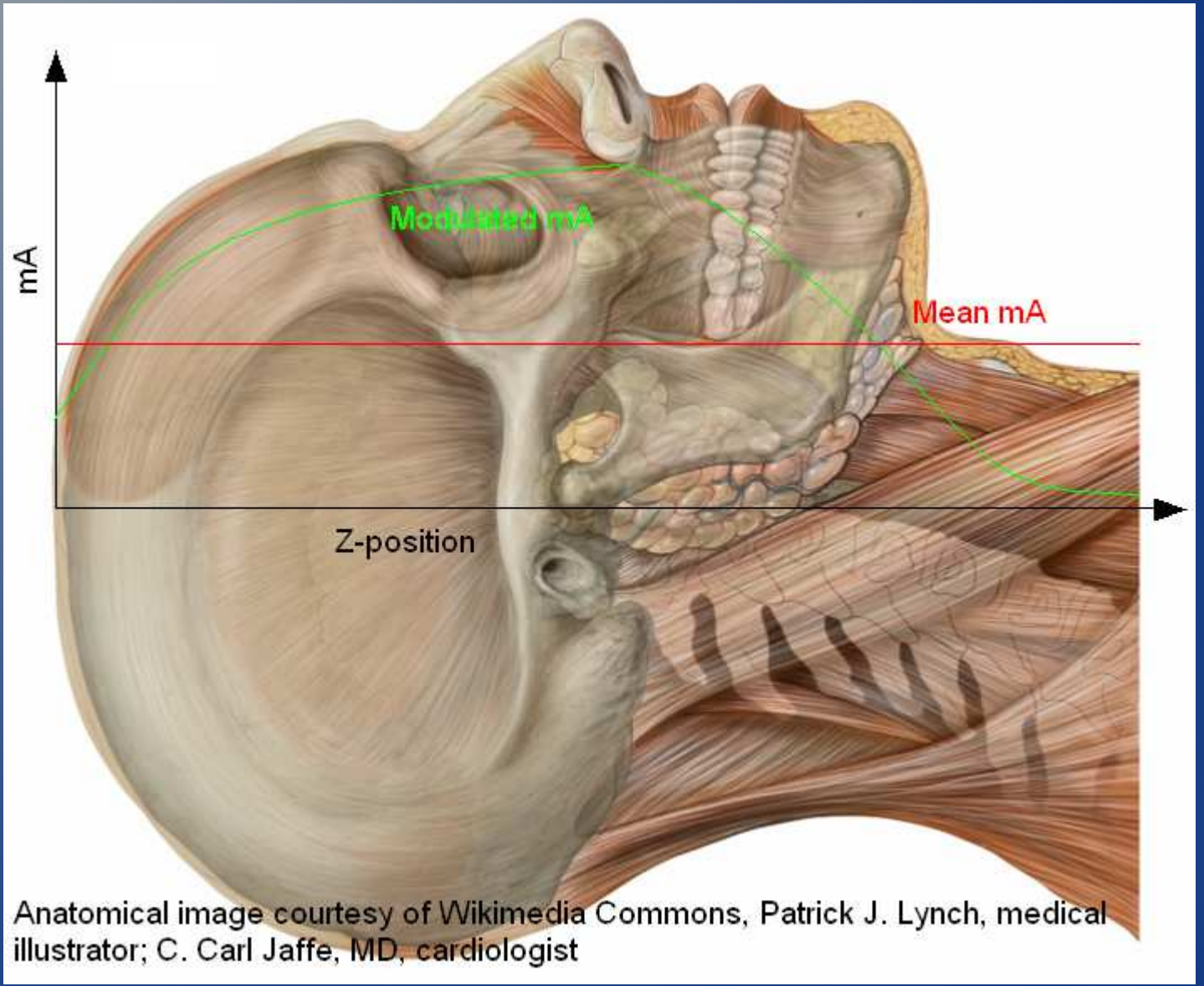
Tube current modulation in CT

- All major manufacturers of CT scanners now offer automatic tube current modulation (ATCM)
- All adopt slightly different approaches
- The aim is to reduce unnecessary radiation for any given slice

Tube current modulation in CT

- A literature search on CT tube current modulation returns numerous scientific publications mostly from quite recent work
- Those that quote 'dose' reductions do not explicitly specify what measure of dose is being used
- Closer scrutiny suggests that it is absorbed dose
- Absorbed and effective dose may not be proportional when tube current is modulated

Tube current modulation in CT



Anatomical image courtesy of Wikimedia Commons, Patrick J. Lynch, medical illustrator; C. Carl Jaffe, MD, cardiologist

Dose audit results with and without tube current modulation

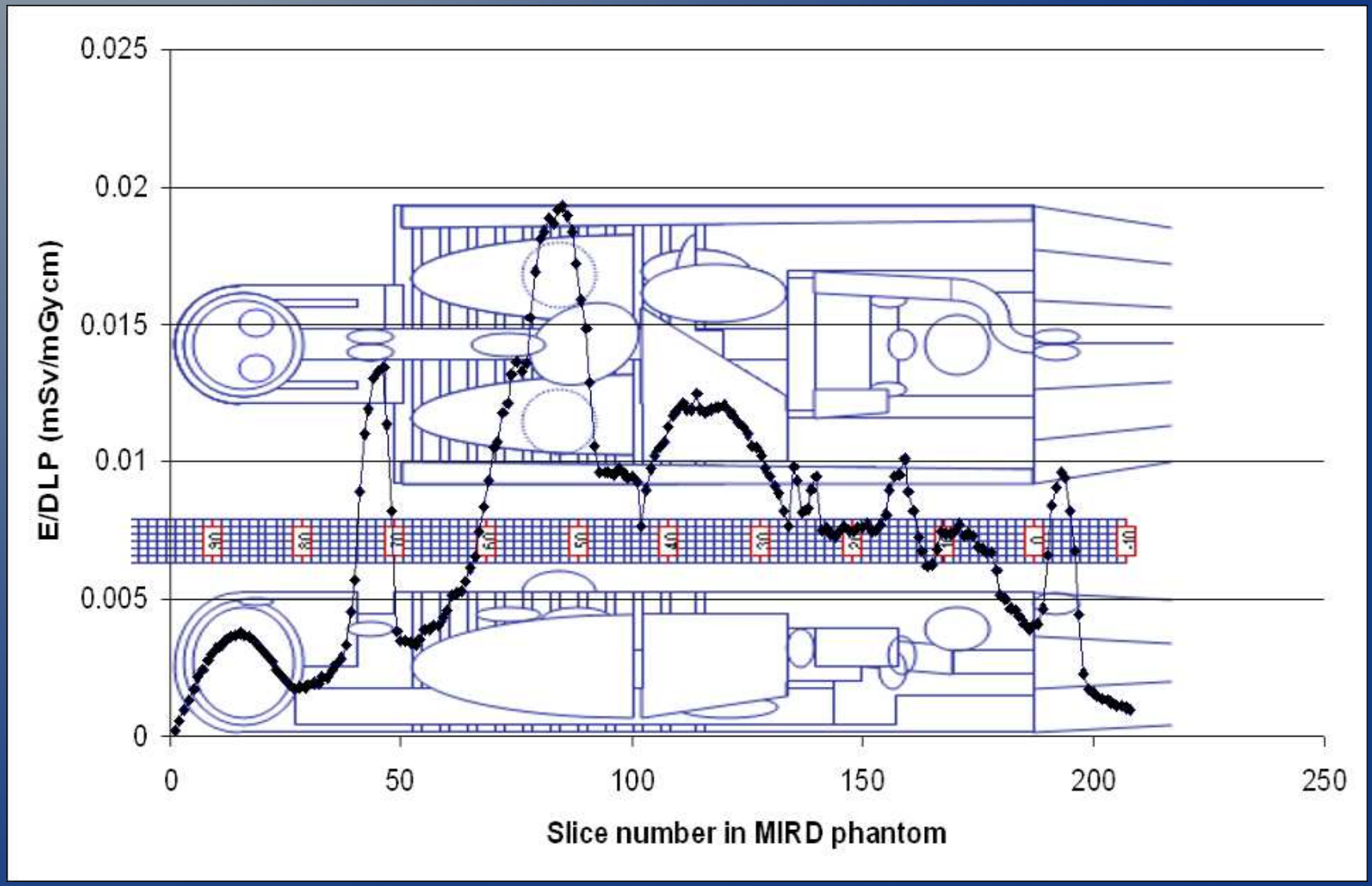
- Caldicott approval has been granted to download patient images for our routine dose audits
- Custom java code is used to extract the mA curves and these are used to determine the mean mA for the scan
- The effective dose is estimated using the IMPACT CT dose calculation spreadsheet with the mean mA

Dose audit results with and without tube current modulation

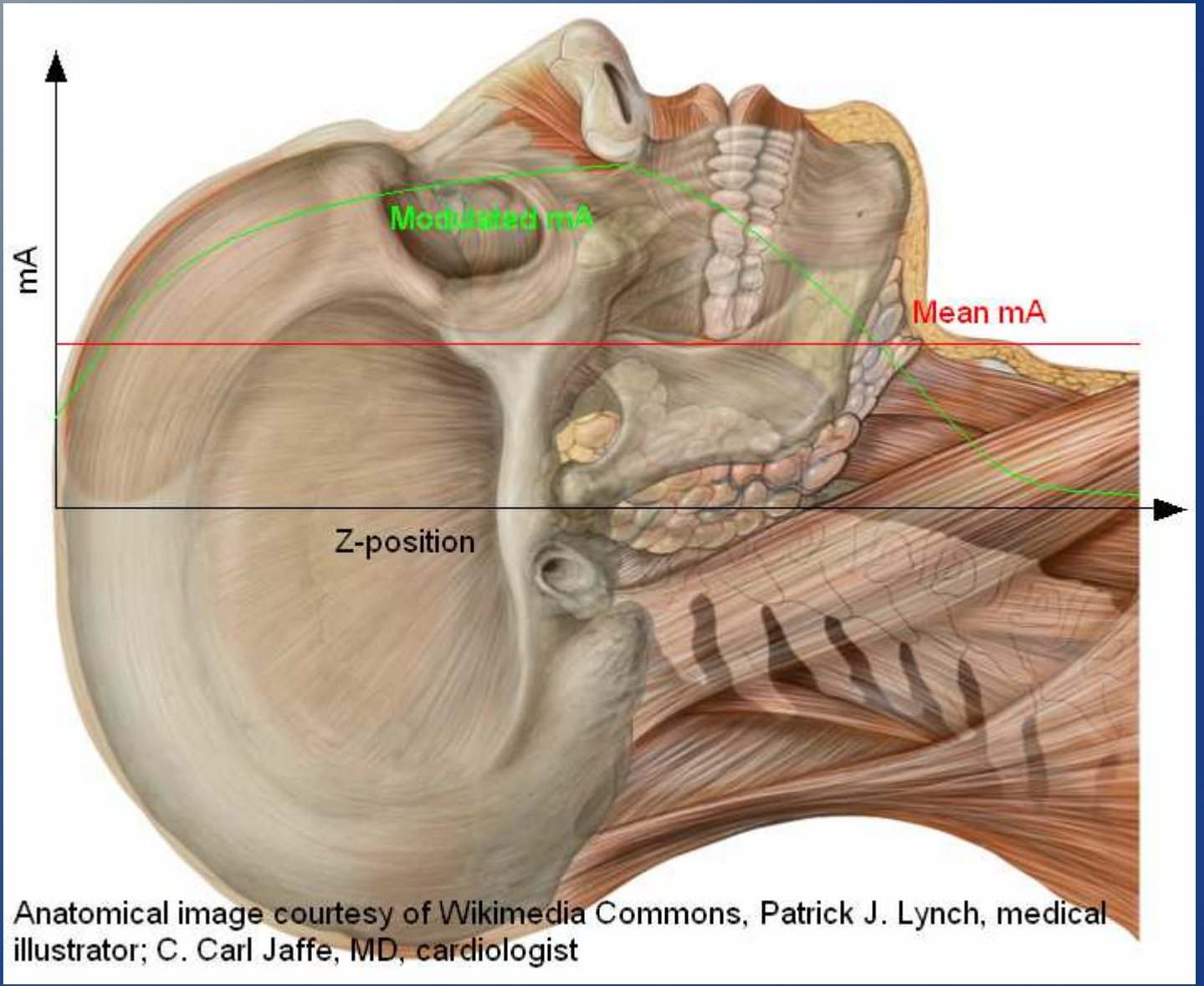
- Results agreed with literature values of approximately 10% dose reduction with modulation on as opposed to a constant current technique
- The reduction was reflected in the DLPs for the scans

The end?

Variation of risk of radiation damage with z position in the MIRD mathematical phantom



Tube current modulation in CT



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Effective dose calculations with a modulated tube current

- Is there another way to calculate the effective dose for a modulated scan?

Effective dose calculations with a modulated tube current

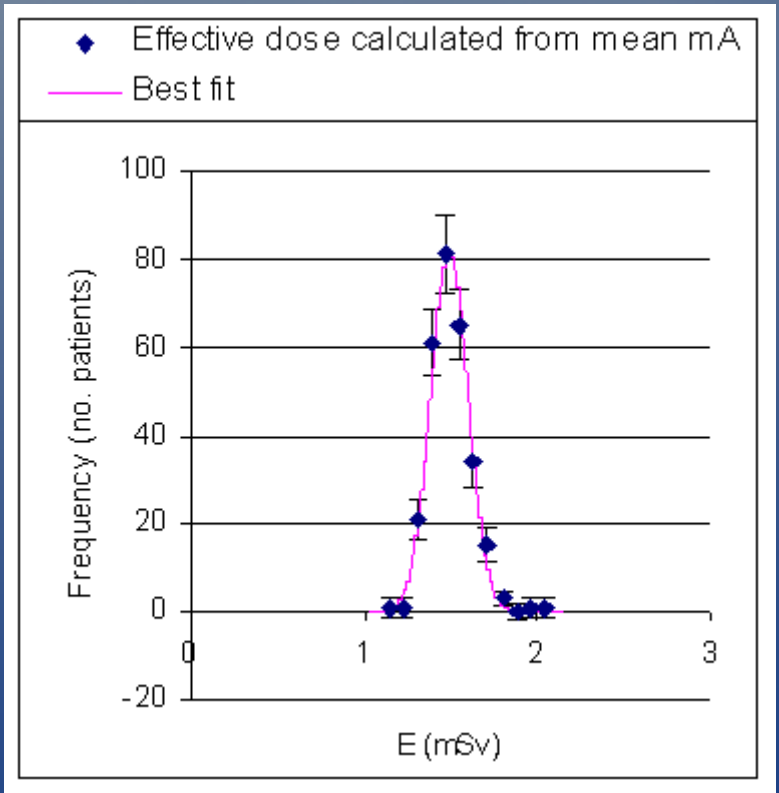
- Ensure a constant scan range using anatomical markers (top of skull to base of posterior fossa)
- Re-bin the data to match the smallest collimation available in the IMPACT spreadsheet (5mm)
- Calculate the effective dose in IMPACT on a slice by slice basis and sum the results

Effective dose calculations with a modulated tube current

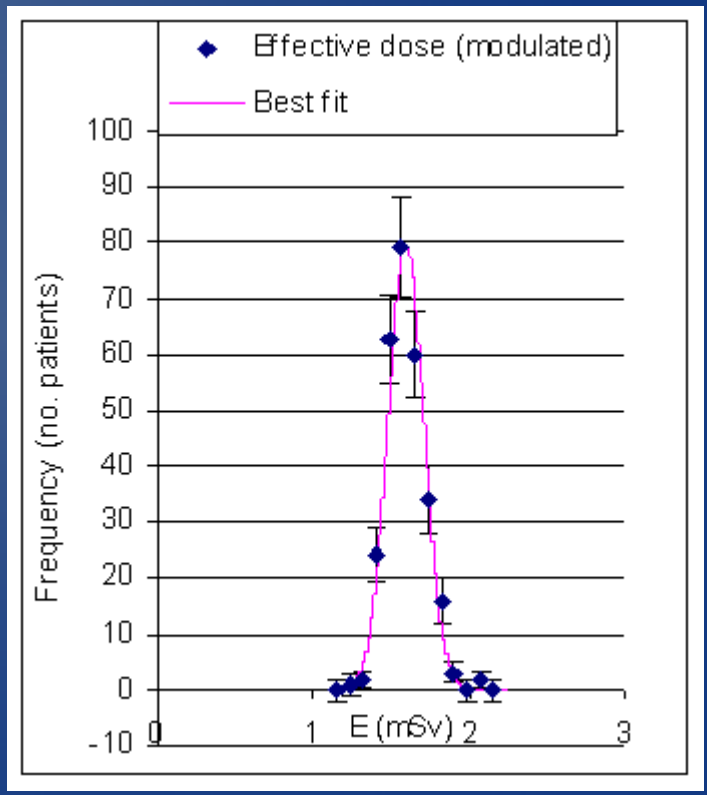
- Study involved 300 patients scanned within the last three months
- 49 were discarded due to unusual positioning or insufficient scan range
- 251 patients were in the final analysis

Effective dose calculations with a modulated tube current

- Plots of effective dose using mean mA and effective dose using modulated method



Fit gives mean E of 1.5 with reduced chi square statistic of 0.99



Fit gives mean E of 1.6 with reduced Chi square statistic of 1.1

Effective dose calculations with a modulated tube current

- Difference in absolute value is quite small... could it simply be overscan?
- Repeated all measurements of effective dose using the mean mA with the slice by slice methodology.
- The maximum percentage difference was 6.7×10^{-14}

Effective dose calculations with a modulated tube current

- Using the mean mA suggested a dose reduction of 4.4% with modulation as opposed to without
- Using the DLPs suggested a dose reduction of 4.2%
- Using a modulated analysis on a slice by slice basis suggested a small dose increase of 1.9%

Study conclusions

- The mA modulation had not been suitably optimised
- If the image quality was acceptable at 180mA then, for an average patient, there should be no need to exceed this for any slice
- The mean maximum mA was 210 +/- 4 mA with 3 sigma confidence
- Suggests could reduce the mean max mA to 184
- Then the average patient will receive at least a max mA of 180 with 3 sigma confidence

Study conclusions

- A significant effective dose reduction is possible
- DLP is not a good indicator of effective dose for modulated scans
- CTDIvol may be a more appropriate optimisation parameter

Further incidental conclusion

- Overscanning may be falsely increasing DLP values

Study limitations and further work

- Limitations
  - Only one make and model considered
  - Modulation possible during rotation as well as along z-axis
  - Minimum slice available in IMPACT
  - Very time consuming process
  - Uncertainties
- Further work
  - Include uncertainty calculations
  - Develop tests of mA modulation from a QC perspective
  - Investigate other scan regions (potentially much harder to match mA curve to anatomical regions in MIRD phantom)

Questions and feedback?