Optimisation in Cardiac CT

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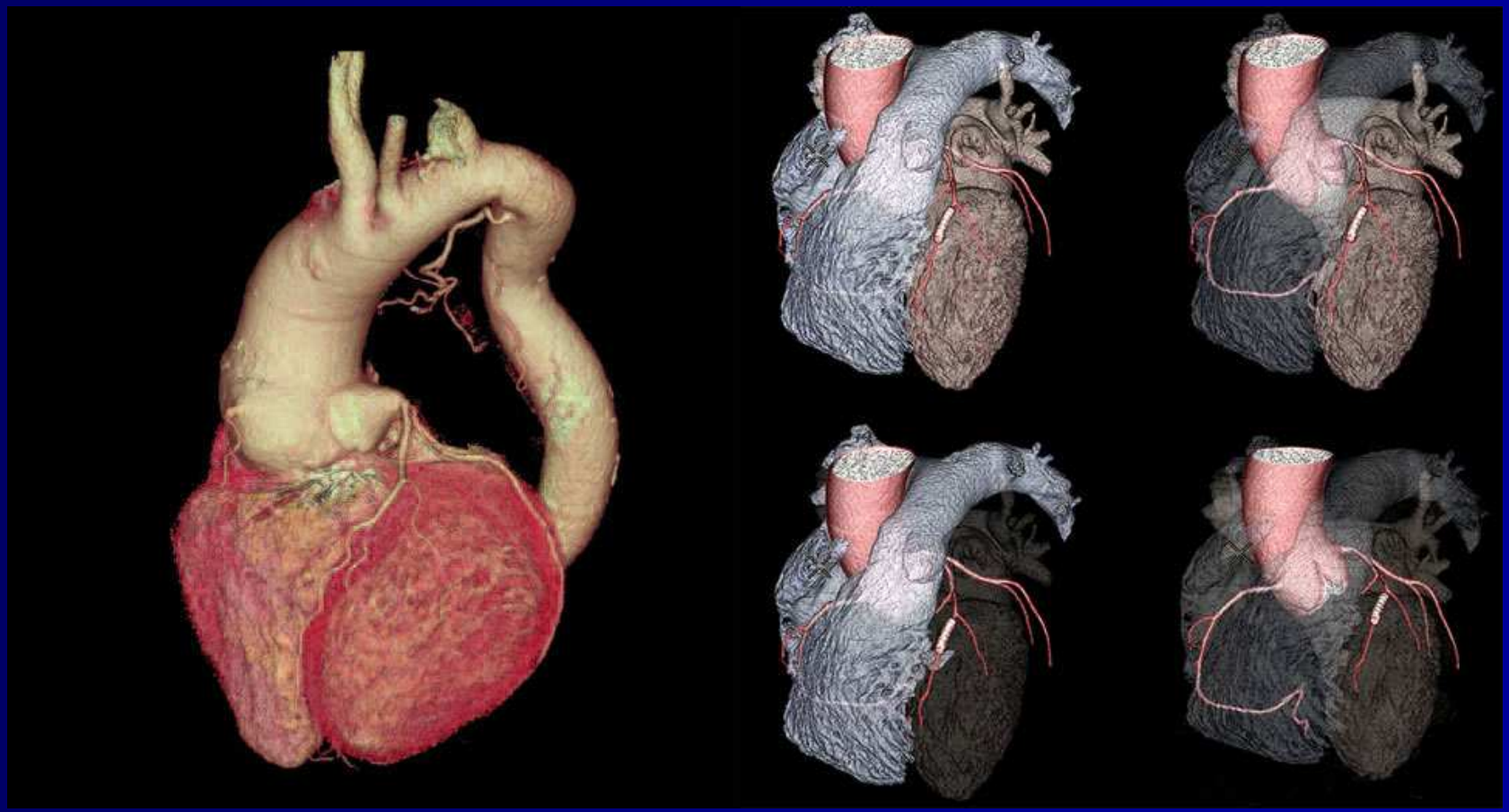
What it's all about!



Optimisation? No Problem. Er....

Cardiac CT requires case by case clinical judgement.

Applications may not have had time to go into much depth.

Quoted doses may only be for part of the scan, and small changes can make a big difference in dose.

Scan Stages:

- Scout (AP and Lat)
- Non-contrast scan (optional)
- Timing bolus
- Cardiac Helical Acquisition

If only the latter is quoted, this would explain why some papers suggest doses comparable with Cardiac Angiography

Variables

- The Patient!

The patient is the biggest variable and their clinical state significantly affects the dose they will receive.

MUST have stable heart rate. Ideally on Beta blockers and have plenty of time lying on couch to stabilise heart rate.

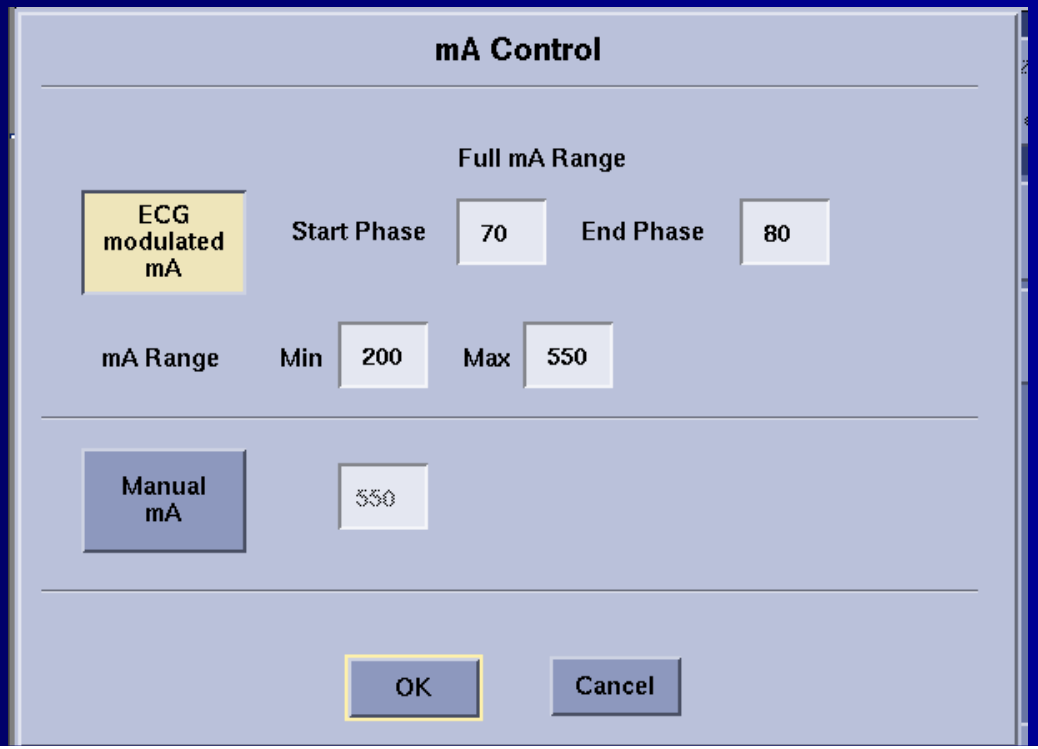
Variables

- Protocols for specific patient size
- Min and max mA settings
- Bow Tie Filter
- Cardiac Filter
- FOV
- Pitch – A function of heart rate and regularity

Driven by clinical requirements.

Min and max mA settings

Patient Size	Minimum mA Value	Maximum mA Value
Small	100 mA	450 mA
Average	250 mA	550 mA
Large	400 mA	750 mA



FOV, Cardiac and Bowtie Filters

Cardiac Noise Reduction Filters:

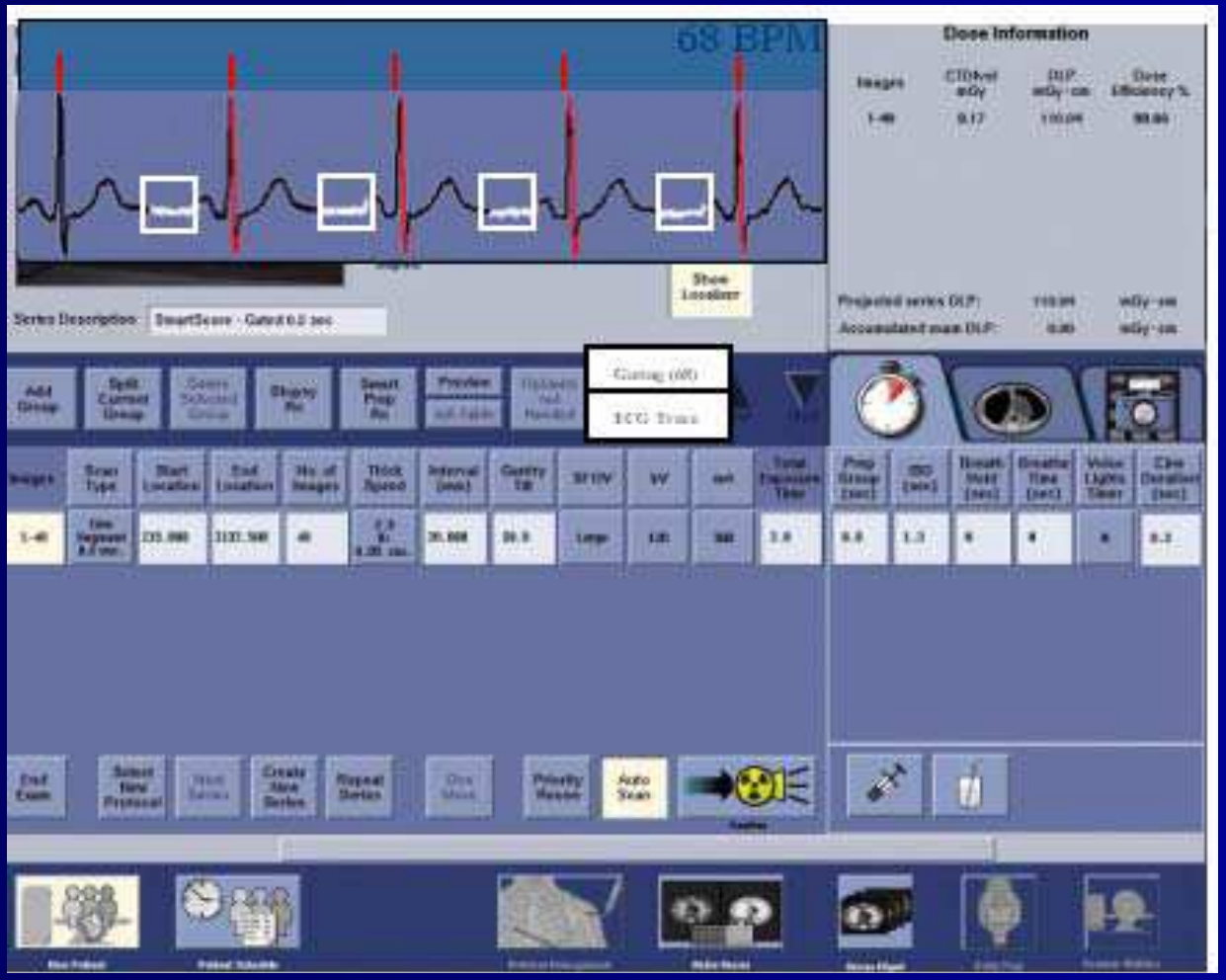
Select appropriate Cardiac noise reducing and edge preserving filter, C1, C2, or C3. These filters when used allow the user to reduce the dose up to 30% on top of the ECG modulation dose reduction while preserving the same image quality.

Scan Mode	Bowtie Filter	Display Field of View
Cardiac Small	Small	9.6 cm to 32 cm
Cardiac Medium	Small	9.6 cm to 36 cm
Cardiac Large	Large	9.6 cm to 50 cm

Pitch

HR Range	Gantry Speed	Recon/Scan Mode	Pitch
30-40 BPM	0.35	Snapshot Segment (SSEG)	0.16
41-49 BPM	0.35	Snapshot Segment (SSEG)	0.18
49-57 BPM	0.35	Snapshot Segment (SSEG)	0.20
58-65 BPM	0.35	Snapshot Segment (SSEG)	0.22
66-74 BPM	0.35	Snapshot Segment (SSEG)	0.24
75-85 BPM	0.35	Snapshot Burst (SSB)	0.2
86-95 BPM	0.35	Snapshot Burst (SSB)	0.22
96-113 BPM	0.35	Snapshot Burst (SSB)	0.24
114+ BPM	0.35	Snapshot Burst Plus (SSB+)	0.20

Phases


68 BPM
Dose Information
Images
Show Localizer
Series Description:
Add Group
Split Current Group
Modify Rx
Smart Prep Rx
Preview
Cycling (0/0)
ECG Trace
End Exam
Select New Protocol
Create New Series
Repeat Series
Priority Review
Auto Scan

SnapShot Segment Mode

Retrospectively gated reconstruction using data from 2/3 of a gantry rotation to create an image from one cardiac cycle

Heart rate 30-74 BPM
1 sector
TR: 175 msec

SnapShot Burst Mode

A retrospectively gated reconstruction, using data from up to 2 cardiac cycles within the same cardiac phase, to create an image at a given table/anatomic location

Heart rate 75-113 BPM
2 sectors
TR: ~87 msec

SnapShot Burst reconstruction relies on coherency of data between adjacent cardiac cycles. As a result it is more susceptible to artifacts due to beat to beat variations.

SnapShot Burst Plus Mode

A retrospectively gated reconstruction, using data from up to 4 cardiac cycles within the same cardiac phase, to create an image at a given table/anatomic location

Heart rate 114+ BPM
2, 3 or 4 sectors
TR: 44 msec
Stable heart rates

Effect of Pitch on DLP

Mode	Bpm	Pitch	CTDI	DLP
Burst Plus	>114	**0.16**	65.06	601.8
Burst	76-113	**0.2**	57.16	528.74
Segment	30-75	**0.22**	50	462.51

Application Specialist

In the first instance the protocols where changed

1. kV adjusted
2. mA adjusted to patient size
3. mA modulation to clinical need
4. Bow tie filters to small Cardiac / medium Cardiac
5. decrease in smartscore mA and Kv
6. Use of Smartscore images for large DFOV lung settings
7. Restriction of scan coverage

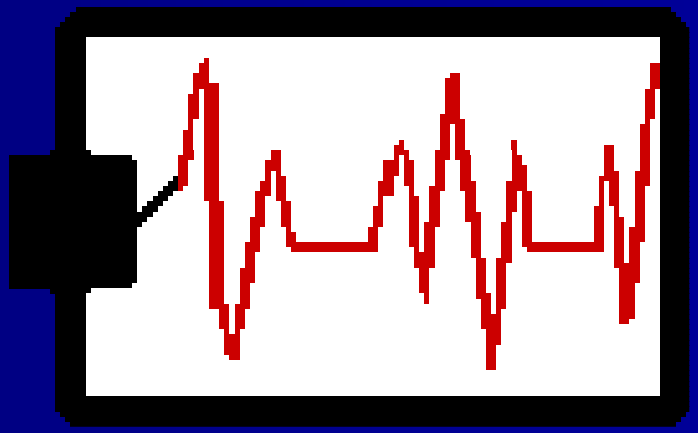
Initial Changes

	KV	min mA	Max mA	Bow tie Filter	Cardiac Filter	phases
Cardiac protocol	120	250	750	large bow tie	none / C1	35 - 95
Snapshot burst and Burst Plus same techniques						
Snap shot segment						
Cardiac small < BMI 25	100	110	520	small	c3	70 - 80
Cardiac small	120	110	520	small	c3	70 - 80
Cardiac Medium	120	110	550	medium	c3	70 - 80
Cardiac Large	120	130	650	small	c3	70 - 80

Testing it

- Not straightforward.
- Needs equipment not normally kept by medical physics

You need one of these



To get one of these

Low Contrast Sensitivity

Catphan 600

Supra-Slice

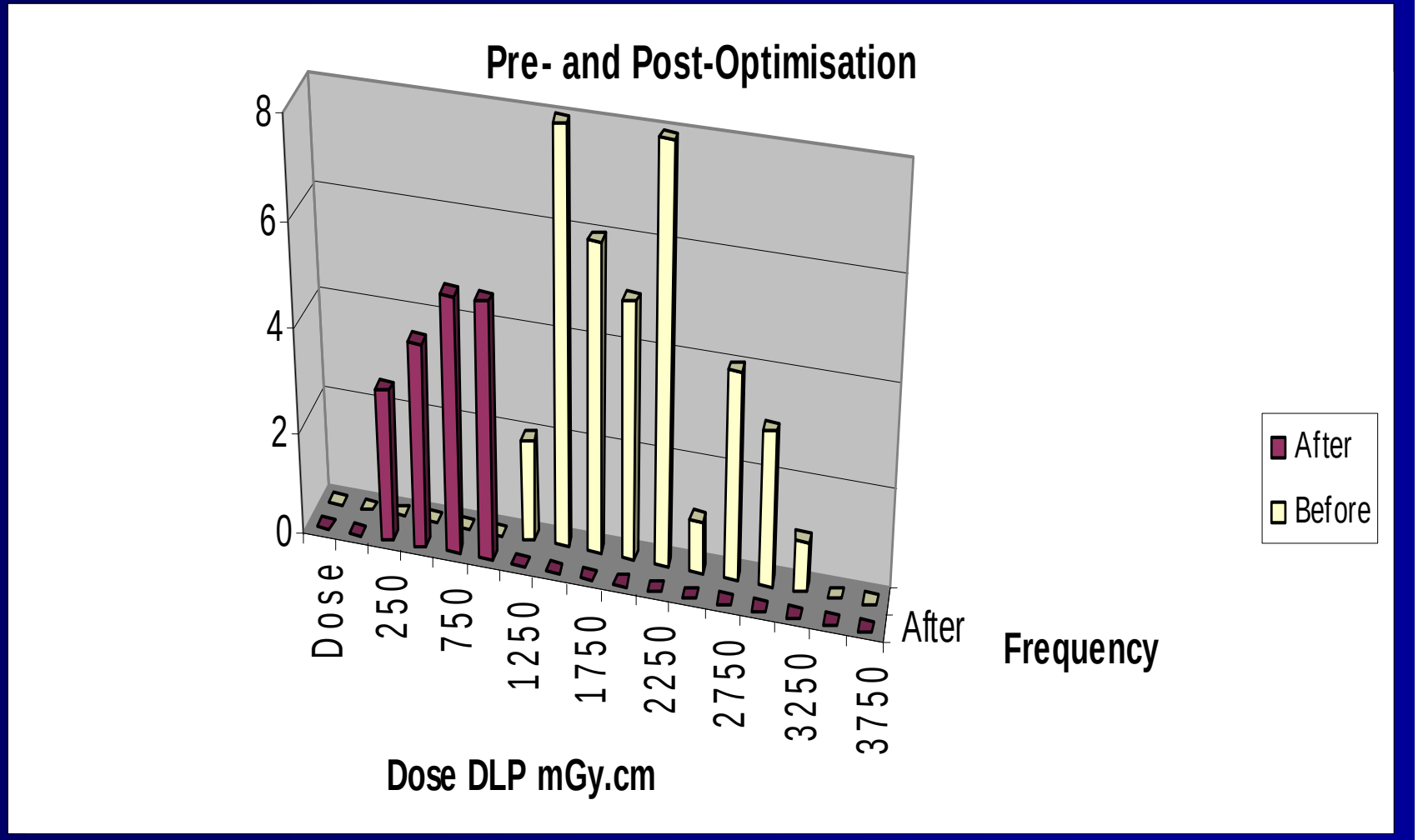
	Segment	Burst	Burst plus
No. of Objects 1.0 %	5.5	5	6.5
Diameter (mm) @ 1.0 %	5.5	6	4.5
No. of Objects 0.5 %	1.5	1.5	3.5
Diameter (mm) @ 0.5 %	12	12	7.5
No. of Objects 0.3 %	0	1	1
Diameter (mm) @ 0.3 %	>15	15	15

Low Contrast Sensitivity

Catphan 600

	Sub-slice (1.0 %)		
No.of objects (7 mm length)	2	2	2.5
Diameter (mm)	7	7	6
No.of objects (5 mm length)	3	3	3
Diameter (mm)	5	5	5
No.of objects (3 mm length)	2.5	1.5	2
Diameter (mm)	6	8	7

Optimised?


Pre- and Post-Optimisation
8
6
4
2
0
Dose
250
750
1250
1750
2250
2750
3250
3750
After
Frequency
Dose DLP mGy.cm
After
Before

Conclusions

- There is significant scope for dose reduction, but:
  - Many of the critical variables are outside the scope of the MPE's role
  - Appropriate patient preparation is essential
  - There is remains scope for further optimisation work assessing:
    - IQ at reduced mAs
    - IQ at increased pitches

Acknowledgements

- Becky Alkins for supplying the dose data after optimisation.
- Phil Heath for access to the scanner.

Reference

Lightspeed VCT Cardiac Scanning Guidelines for Coronary Artery Imaging