2023-06

# Drugless and radiographer led: the start of a new era for CT coronary angiography

Morgan-Hughes, G

https://pearl.plymouth.ac.uk/handle/10026.1/21454

# openheart

# Drugless and radiographer led: the start of a new era for CT coronary angiography

Gareth Morgan-Hughes [iD],[1] Rebecca McNally,[1] Christopher Gibbs Gibbs,[2] Stelios Iacovides,[1] Prabesh Kirat-Rai,[1] Nang Thiriphoo,[1] Alison Powell,[1] Colin Stuckey,[1] Ross Thorpe,[1] Louisa Mayo,[1] Carl Roobottom[1]

[1]Cardiology and Radiology, University Hospitals Plymouth NHS Trust, Plymouth, UK
[2]Cardiology, North Devon District Hospital, Barnstable, UK

**Correspondence to**
Dr Gareth Morgan-Hughes; garethmh@me.com

## ABSTRACT

**Objective** Since inception CT coronary angiography (CTCA) has required facilitating beta blockers (BB). However, CT technology has improved rapidly as has radiographer and reporter expertise. Using these factors, we instituted a radiographer led cardiac CT service (RLCCTS), without routine BB, which we studied for quality control (QC).

**Methods** RLCCTS started October 2021 using a wide detector array CT system, with 20 min slots. QC study was registered with the clinical audit team, University Hospitals Plymouth, CA_2020-21-118. Uniform reporting was agreed including indication, BB administration, demographics, dose length product (DLP) and the coronary artery disease—reporting and data system (CAD-RADS) score. Uncertain CAD-RADS meant a non-diagnostic scan (NDS). Six months of data were collected; stable chest pain (SCP) patients, who have national CTCA QC comparators, were analysed using descriptive statistics.

**Results** Of 1475 patients, 447 were not SCP patients—known CAD (157); valves (286); removed (4, data incomplete) leaving 1028 SCP patients CTCA for analysis. Demographics—mean age 63 years, body mass index 29, 50.4% women. BB therapy—four patients (two recalls). Overall, 36/1024 or 3.5% were NDS; median DLP 173mGy×cm; mean heart rate (HR) 70 bpm, 99/1024 or 9.7% HR >90 bpm (45% not sinus rhythm).

**Conclusions** Quality for RLCCTS was judged by NDS rate and DLP. National QC comparators suggest 4% NDS rate; median DLP for SCPP CTCA 209 mGy×cm. RLCCTS compares favourably. With modern cardiac CT, experienced radiographers and reporters, 'drugless' RLCCTS can deliver 20 min slot CTCA with satisfactory QC indicators.

## WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ CT coronary angiography (CTCA) is a much-required test in the United Kingdom (UK) for stable chest pain patients and timely access is an issue. Traditionally CTCA has been supervised by a medical practitioner, commonly involving the administration of beta-blockers to slow the heart rate and taking up a 30 min time slot.

⇒ Although radiographer led cardiac CT service (RLCCTS) have recently become more widespread in the UK, there is minimal published data confirming the quality of these services; to our knowledge, there has been no previous attempt to introduce 'drugless' RLCCTS in the UK.

## WHAT THIS STUDY ADDS

⇒ The quality control (QC) data for drugless RLCCTS are persuasively favourable for a cohort of more than 1000 patients. Both QC parameters selected, namely, radiation dose equivalent (dose length product) and the non-diagnostic scan rate, were equivalent to nationally reported averages for similar indications undergoing traditional CTCA acquisition processes.

## HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Drugless RLCCTS is delivered more quickly, with 20 min time slots, without requiring medical practitioner time or input. Therefore, CTCA may be undertaken more efficiently, and medical practitioners reallocated time to reporting, thus potentially reducing cost and increasing efficacy, with preservation of quality.

## INTRODUCTION

The 2016 iteration of the National Institute for Health and Care Excellence (NICE) guidance for the assessment and diagnosis of recent-onset chest pain of suspected cardiac origin (Clinical Guideline 95 (CG95)) recommends diagnostic testing when stable angina cannot be excluded by clinical assessment alone.[1] The first-line diagnostic test suggested is CT coronary angiography (CTCA). Consequent on this, the demand for CTCA has grown exponentially.[2] The British Society of Cardiovascular Imaging has previously highlighted the inadequacy of CTCA service provision across the UK in stark terms.[3]

Traditionally CTCA acquisition has required the facilitating administration of beta blocker (BB) therapy to gain adequate heart rate (HR) control. This has commonly been given on the CT table as an intravenous injection or orally outside the scanner with

monitoring; patient appointment times have been 30 min or more. Advances in CT technology have enabled single rotation, whole heart imaging to be combined with improved tube and detector technology. Automated selection of an appropriate ECG-gated acquisition point to the patient's HR, along with postprocessing algorithms capable of reducing image movement blur, have resulted in improved CTCA image quality without HR control.[4] Additionally, our centre (University Hospitals Plymouth (UHP)) has favoured CTCA imaging without administration of glyceryl trinitrate (GTN), for fear of overestimating fixed coronary artery stenosis since the service inception, in 2005. More recently, the increased use of GTN, to facilitate subsequent CT-derived fractional flow reserve assessment, has been questioned by the emergence of real-world data, diminishing the perceived need for this technology.[5]

Also, reporter, and particularly radiographer, expertise has grown over time; the former having more reporting resilience and later greater autonomy. Instigation of a radiographer led cardiac CT service (RLCCTS) without routine BB or GTN ('drugless' RLCCTS) appears timely, therefore. Following a successful pilot scheme borne out of COVID-19 pandemic-related clinical need (unpublished, 2020), we instituted drugless RLCCTS, which we then studied for quality control (QC). The service was set up to deliver 20 min CTCA through a dedicated cardiac CT scanner, during weekday working hours. Prior to this, CTCA was delivered with consultant supervision, using intravenous BB therapy as required, and 30 min time slots.

This report of the initiative has been completed with reference to the revised standards for quality improvement reporting excellence template and previously presented in abstract form.[6 7]

## METHODS
### Study design
This was a single centre, retrospective analysis of a (service quality improvement driven) drugless RLCCTS for NICE CG 95 stable chest pain (SCP) patients. The parameters of QC assessed and compared with national standards for drugless RLCCTS were total dose length product (DLP), as a direct marker of radiation dose, and the non-diagnostic scan rate (NDS).

RLCCTS started in October 2021 using a wide detector array CT system (256 detectors (0.625 mm), 0.28 s gantry rotation) with 20 min slots. The QC study was registered with the clinical audit team, UHP (CA_2020-21-118). Written informed consent and ethical approval were not obtained as patient care was not affected. Only fully anonymised data were used in analysis.

Specialist CT radiographers, with at least 5 years dedicated cardiac CT experience, who had carried out a period of supervised sessions and developed increasing levels of autonomy in a semisupervised setting, undertook drugless RLCCTS. These radiographers followed a preagreed and established CTCA acquisition parameter matrix. A standard pro forma for patient demographic collection was used and immediate basic image review was used to ensure diagnostic reciprocity. A uniform reporting template was agreed between the CTCA reporting medical practitioners (six of whom were consultant radiologists and two of whom were consultant cardiologists).

### Data collection
Local electronic patient records, hospital coding data and picture archiving and communication systems (PACS) were used to collect data; 6 months of data collection was completed by April 2022. The data collection covered demographic information (age, sex and body mass index (BMI)), CTCA scan indication, BB administration, heart rate (HR) in bpm, DLP and CTCA results. For all diagnostic CTCA, the coronary artery disease—reporting and data systems (CAD-RADS) score was provided (CAD-RADS 0=0% coronary stenosis; CAD-RADS 1=1%–24%; CAD-RADS 2=25%–49%; CAD-RADS 3=50%–69%; CAD-RADS 4=70%–99%; CAD-RADS 5=100% or coronary occlusion), with the most severe stenosis defining the patient's score.[8 9] The reporting cardiologist or radiologist decided whether the CTCA was diagnostic or not, primarily based on the ability to provide a definitive CAD-RADS score. Inability to provide a specific CAD-RADS resulted in a NDS.

### Statistical analysis
Data pertaining only to SCP patients, referred as per NICE CG95 (2016), undergoing drugless RLCCTS were analysed, using descriptive statistics. Patient age and BMI are given in the text as mean±SD HR as mean (range) and sex as a percentage. Ordinal categorical variables (CAD-RADS scores, DLP and diagnostic scan rate) are presented as numbers, or percentages, and graphically displayed in bar charts. All statistical descriptive analyses were completed using SPSS V.23. The median DLP was compared with the results from the 2017 UK national survey of CTCA radiation by Castellano *et al*, which was taken as a national QC comparator.[10] The effective radiation doses have been calculated from the median value using a conversion factor of 0.026 mSv/mGycm.[11] The NDS rate was compared with the one which was published in the recent national survey of NICE CG95 (2016) SCP patients undergoing CTCA, also taken as a national QC comparator.[12]

## RESULTS
### Patient population
Over a 6 month period till April 2022, a total of 1475 patients underwent RLCCT. Of these 447 were not deemed to be SCP patients; 157 underwent CTCA to assess known CAD, 286 had a valve-based indication for cardiac CT and 4 patients had incomplete data capture. This left 1028 SCP patients undergoing RLCCTS for analysis. Patients had a mean age of 63±13 years, BMI 29±6 kg/
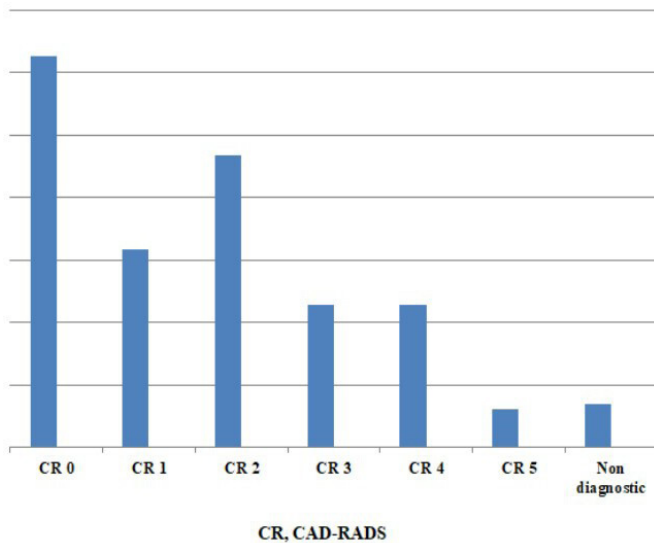
**Figure 1** Drugless radiographer led CTCA for chest pain assessment following NICE CG 95 (2016), CAD-RADS distribution 1024 cases (%). CR, CAD-RADS, Coronary Artery Disease—Reporting and Data System; CTCA, CT coronary angiography; NICE-CG95, National Institute for Health and Care Excellence—Clinical Guidance 95.



**Figure 2** Drugless radiographer led CTCA for chest pain assessment following NICE CG 95 (2016), diagnostic scan rate by HR (%). CTCA, CT coronary angiography; HR, heart rate in beats per minute; NICE-CG95, National Institute for Health and Care Excellence—Clinical Guidance 95.

m², with an even sex distribution of 50% women, 50% men. Four patients were given either sublingual GTN or BB (as recalls or as part of a trial protocol), or both and were, therefore, excluded such that the remaining 1024 underwent drugless RLCCTS. For these, the mean CTCA acquisition HR was 70+/−(40–148) bpm, of which 9.7% (99/1024) HR >90 bpm (45% not sinus rhythm on assessment of the CTCA recorded rhythm strip).
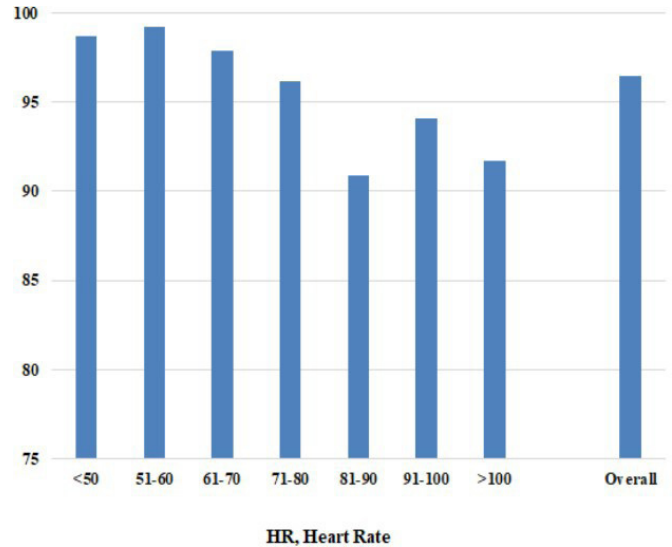
### Findings and quality assessment measures
The CAD disease distribution is illustrated in figure 1 using the CAD-RADS scores.

The overall NDS rate of drugless RLCCTS was 3.5% (36/1024); the national comparator NDS rate is 4%. The variability in diagnostic scan rates by HR is shown in figure 2.

The overall median DLP for drugless RLCCTS was 173 mGy×cm, corresponding to an estimated total effective radiation dose of 4.5 mSv; the national comparator is 209 mGy×cm, corresponding to a total effective dose of 5.4 mSv. The variability in the median DLP by HR is shown in figure 3.

### DISCUSSION
The breath-hold in Achenbach's initial description of multidetector CTCA over two decades ago was 37 s long; the modality was not ready for clinical use.[13] Jump forward to 2022 and cardiac CT technology has improved almost beyond recognition. Acquisition, reconstruction and postprocessing algorithms have been developed to the extent that, in the correct context, a drugless, RLCCTS has become clinically applicable. We have taken advantage of the combination of local radiographer and

reporter expertise, along with a modern wide detector array cardiac CT system, to institute this service improvement. This has facilitated 20 min time slots for cardiac CT and released consultant time for reporting. We have then studied the service for QC purposes.

In general terms, the QC data obtained are persuasively favourable (diagnostic scan rate of 96.5% across over 1000 patients) and confirms the safety (median estimated total effective radiation dose 4.5 mSv) and clinical utility of the new service despite the marked increase in the rate of patient turnover. This is despite nearly 10%
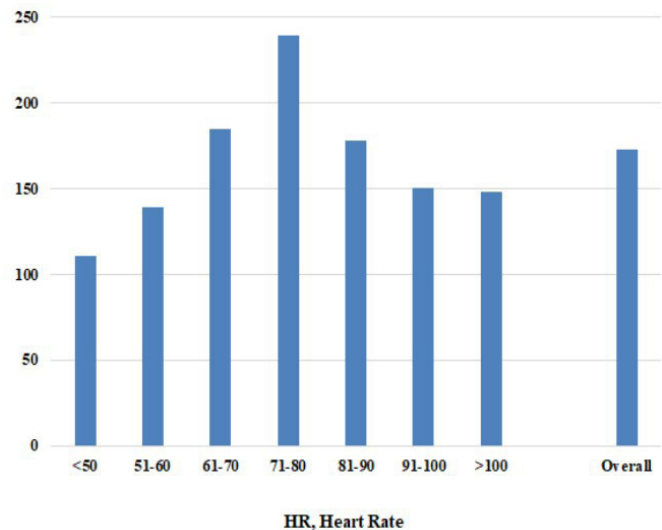


**Figure 3** Drugless radiographer led CTCA for chest pain assessment following NICE CG 95 (2016), distribution of median DLP by patient's HR. CTCA, CT coronary angiography; DLP, dose length product; HR, heart rate in beats per minute; NICE-CG95, National Institute for health and Care Excellence—Clinical Guidance 95.

of the patients having a HR >90 bpm and 4.5% having both a HR >90 bpm and an irregular rhythm. The demographic data and CAD distribution are broadly comparable to previous similar data sets. It will be noted that the median DLP at 'intermediate' HRs is higher than at either end of the HR spectrum. In general, the coronary artery motion-free acquisition 'window' is 'mid-diastolic' when the HR <65 bpm and 'end-systolic' when the HR is >80 bpm. RLCCTS has been delivered with a double, mid-diastolic and end systolic, acquisition for intermediate HR patients. It could be argued that administering BBs would alleviate the resulting modest, intermediate HR range, DLP spike. However, the counter argument is that some patients would move from a single end-systolic acquisition to a double acquisition and so an inadvertently elevated DLP. An alternative approach going forward is to increase radiographer training and autonomy further such that the automated double acquisition is manually over-ridden to offer a single acquisition with a repeat acquisition at the alternate acquisition window if the immediate image review proves unsatisfactory.

There is also a modest drop off in the diagnostic scan rate at the higher end of the HR spectrum and, therefore, again an argument could be made for a return to the traditional approach for high HR patients. The context is that a return to longer CTCA scan slots leads to increased delays in delivering the CTCA-guided care that SCP patients require and across the whole population the NDS rate for the RLCCTS is acceptably low. There is an alternative solution in view of the naturally heterogenous level of reporter tolerance to HR-related coronary artery movement blur. Dual reporting of potential NDSs is the solution we have proposed when assessing this QC data locally.

### Strengths and limitations

There are of course limitations to a QC study of a service improvement initiative, which involves collection of data in an observational manner. There may be unadjusted confounding factors and referral bias. Every effort has been taken to ensure tht data collection was accurate and complete, however, as with all analyses involving healthcare records, even PACS, these may be incomplete, inaccurate or unclear. Also, this is an unusually high volume, single centre that has been involved in CTCA for two decades already; this is service improvement and QC data and not prospective randomised control research trial evidence.

Conversely, one major strength of the data presented is its 'real-world' nature; the number of patients is persuasive. Our hope is that this initiative will encourage those that run CTCA services across the UK to consider the RLCCTS approach where appropriate, if need be, by lobbying for modern wide detector array cardiac CT systems and empowering and rewarding radiographer colleagues for embracing new challenges. In many ways, with the modern NHS 'in crisis', this practical demonstration of the safety of a resource saving service improvement could not be timelier.

### CONCLUSIONS

Quality for drugless, RLCCTS was judged by the NDS rate and DLP, extrapolated to total estimated effective radiation dose. National audit data suggest a 4% NDS rate and a median DLP for SCP patient CTCA of 209 mGycm. The RLCCTS described compares favourably to this with an NDS rate of 3.5% and a median DLP of 179 mGycm or an estimated total effective radiation dose of 4.5 mSv. With modern wide detector array cardiac CT systems, experienced radiographers and reporters, drugless RLCCTS can deliver 20 min slot CTCA for SCP patients with satisfactory QC indicators. This is highly efficient and allows reallocation of medical practitioner time to CTCA reporting.

**ORCID iD**
Gareth Morgan-Hughes http://orcid.org/0000-0001-8568-6440

### REFERENCES

1 National Institute for Health and Care Excellence (NICE). *Guidance for the assessment and diagnosis of recent-onset chest pain of suspected cardiac origin (Clinical Guideline 95 (CG95))*. 2010.
2 Asher A, Ghelani R, Thornton G, *et al*. UK perspective on the changing landscape of non-invasive cardiac testing. *Open Heart* 2019;6:e001186.
3 Dreisbach JG, Nicol ED, Roobottom CA, *et al*. Challenges in delivering computed tomography coronary angiography as the first-line test for stable chest pain. *Heart* 2018;104:921–7.
4 de Graaf FR, Schuijf JD, van Velzen JE, *et al*. Diagnostic accuracy of 320-row Multidetector computed tomography coronary angiography in the non-invasive evaluation of significant coronary artery disease. *Eur Heart J* 2010;31:1908–15.
5 Hamilton MCK, Charters PFP, Lyen S, *et al*. Computed tomography-derived fractional flow Reserve (FFR$_{CT}$) has no additional clinical impact over the anatomical coronary artery disease - reporting and data system (CAD-RADS) in real-world elective healthcare of coronary artery disease. *Clin Radiol* 2022;77:883–90.
6 SQUIRE. *Revised standards for quality improvement reporting excellence SQUIRE2.0*. 2015.
7 Morgan-Hughes G, McNally R, Iacovides S, *et al*. P11 radiographer led CTCA – the beginning of the end for routine facilitating beta blocker therapy. *Heart* 2022;108:A6–7.
8 Xie JX, Cury RC, Leipsic J, *et al*. The coronary artery disease-reporting and data system (CAD-RADS): prognostic and clinical

implications associated with standardized coronary computed tomography angiography reporting. *JACC Cardiovasc Imaging* 2018;11:78–89.

9 Cury RC, Abbara S, Achenbach S, *et al*. CAD-RADS™: coronary artery disease - reporting and data system: an expert consensus document of the Society of Cardiovascular Computed Tomography (SCCT), the American College of Radiology (ACR) and the North American Society for Cardiovascular Imaging (NASCI). endorsed by the American College of Cardiology. *J Am Coll Radiol* 2016;13:1458–66.

10 Castellano IA, Nicol ED, Bull RK, *et al*. A prospective national survey of coronary CT angiography radiation doses in the United Kingdom. *J Cardiovasc Comput Tomogr* 2017;11:268–73.

11 Trattner S, Halliburton S, Thompson CM, *et al*. Cardiac-specific conversion factors to estimate radiation effective dose from dose-length product in computed tomography. *JACC Cardiovasc Imaging* 2018;11:64–74.

12 Morgan-Hughes G, Williams MC, Loudon M, *et al*. Downstream testing after CT coronary angiography: time for a rethink *Open Heart* 2021;8:e001597.

13 Achenbach S, Ulzheimer S, Baum U, *et al*. Spiral CT non-invasive coronary angiography by retrospectively ECG-gated multislice. *Circulation* 2000;102:2823–8.