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FULL PAPER

CT coronary angiography first prior to rapid access chest pain clinic review: a retrospective feasibility study

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Objectives: Since rapid access chest pain clinics (RACPC) were established to streamline stable chest pain assessment, CT coronary angiography (CTCA) has become the recommended investigation for patients without known coronary artery disease (CAD), with well-defined indications. This single-centre retrospective study assessed the feasibility of General Practice (GP)-led CTCA prior to RACPC.

Methods: RACPC pathway patients without pre-existing CAD electronic records were reviewed (September–October 2019). Feasibility assessments included appropriateness for RACPC, referral clinical data *vs* RACPC assessment for CTCA indication and safety, and a comparison of actual *vs* hypothetical pathways, timelines and hospital encounters.

Results: 106/172 patients screened met inclusion criteria (mean age 61 ± 14, 51% female). 102 (96%) referrals were 'appropriate'. No safety concerns were identified to preclude a GP-led CTCA strategy. The hypothetical pathway increased CTCA requests *vs* RACPC (84 *vs* 71), whilst improving adherence to guidelines and off-loading other services. 22% (23/106) had no CAD, representing cases where one hospital encounter may be sufficient. The hypothetical pathway would have reduced referral-to-diagnosis by at least a median of 27 days (interquartile range 14–33).

Conclusion: A hypothetical GP-led CTCA pathway would have been feasible and safe in a real-world RACPC patient cohort without pre-existing CAD. This novel strategy would have increased referrals for CTCA, whilst streamlining patient pathways and improved NICE guidance adherence.

Advances in knowledge: GP-led CTCA is a feasible and safe pathway for patients without pre-existing CAD referred to RACPC, reducing hospital encounters required and may accelerate time to diagnosis. This approach may have implications and opportunities for other healthcare pathways.

INTRODUCTION

Chest pain remains a common presentation in primary care, historically making-up ~1% of all General Practice (GP) appointments,[1] and heart and circulatory diseases are responsible for 27% of all deaths in the UK, predominantly secondary to coronary artery disease (CAD).[2] In 2000, responding to the burden of CAD and escalating outpatient waiting times, the National Service Framework for Coronary Heart Disease[3] outlined a vision for future national cardiac healthcare services, committing to "*help professionals to give better, fairer and faster care everywhere, to everyone who needs it.*"

This introduced rapid access chest pain clinics (RACPC) targeting swift investigation, symptom relief and improved outcomes for patients with features of potential CAD. The RACPC model drew from experiences at innovative UK centres[4,5] and included a history, examination, ECG and exercise test (where indicated), all undertaken as a 'one-stop shop'.

Fast-forward 20 years and the RACPC is now the cornerstone for the assessment of patients with potential stable CAD across the UK. However, we again face escalating challenges in outpatient care as the NHS struggles to adapt following the COVID-19 pandemic. Further, the recommended approach to the assessment and investigation of this patient group has evolved significantly, as outlined in National Institute of Health and Clinical Excellence (NICE) Clinical Guideline 95 (CG95).[6]

NICE now recommends CT coronary angiography (CTCA) as the first-line investigation for new-onset symptomatic patients without a pre-existing diagnosis of CAD. CTCA provides a sensitive anatomical assessment for the presence of CAD, not relying on the presence of ischaemia as a surrogate marker of CAD, and streamlines the RACPC pathway.[7,8] CTCA can reliably exclude CAD, enabling rapid discharge, and its use over other tests improves patient outcomes.[9–11]

NICE-CG95[6] clearly defines the indications for CTCA based on the typicality of chest pain and/or presence of ECG changes, with CTCA recommended for all patients without pre-existing CAD who have typical or atypical chest pain, or non-anginal chest pain with an abnormal ECG.

The recent Getting It Right First Time (GIRFT) review for Cardiology states "*patients on the stable chest pain pathway should be seen in a clinic within two weeks of referral*".[12] In an era of optimising existing pathways, there is an opportunity to evolve the RACPC pathway 20 years on from its inception. With such well-defined criteria for chest pain assessment and its subsequent investigation, we postulated that an initial GP consultation with upfront CTCA (where CG95 felt to be met) and subsequent result-led decision regarding secondary care review may enable streamlining of services, improve resource efficiency and accelerate the patient journey. Thus, this study aimed to test the hypothesis that a novel pathway (Figure 1) with CTCA-first, where indicated, is feasible and safe for potential RACPC referrals.

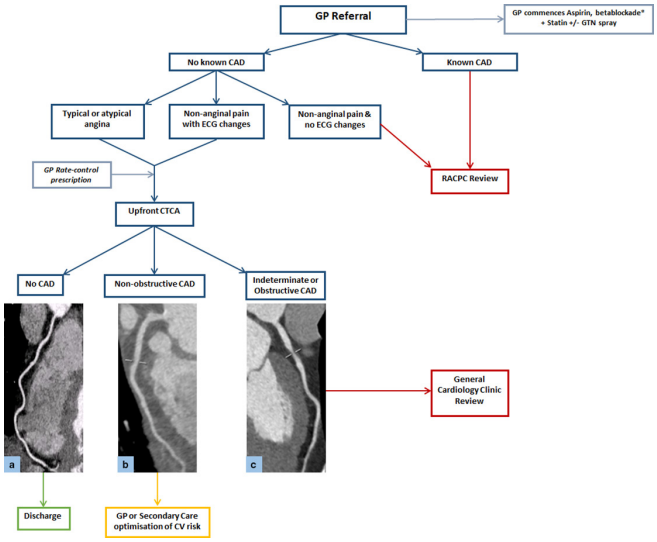
METHODS

Study design

We conducted a single-centre retrospective feasibility study of implementing a hypothetical CTCA-first model (Figure 1) for GP referrals to our RACPC service. The study was approved by our institution's Trust Audit Committee as a service evaluation project of retrospective analysis of routine clinical data and therefore exempt from formal ethics review and patient consent. Our institution, XXXXX, is an acute medium-sized trust with 759 beds, a catchment population of approximately 500,000, and reviews an average of 100–120 RACPC patients per month.

172 electronic patient records were selected at random from September to October 2019 RACPC lists and reviewed by investigators with no prior knowledge of patient's clinical background or clinical outcomes. Patients were excluded if they had pre-existing CAD, were non-GP referrals, did not attend (DNA), were diverted to another cardiology clinic or had insufficient electronic records (Figure 2). For included patients, data

Figure 1. Proposed new hypothetical RACPC pathway alongside example CT coronary angiogram findings demonstrating: a, no CAD; b, non-obstructive CAD; and c, obstructive CAD. CAD, coronary artery disease; CTCA, CT coronary angiography; CV, cardiovascular; GP, General Practice; RACPC, rapid access chest pain clinics.



recorded included demographics, comorbidities, in addition to a detailed assessment of GP referral, RACPC review and primary investigation as outlined below to assess the feasibility of the proposed strategy.

Referral "appropriateness" for RACPC

For the hypothetical CTCA-first strategy, referrals must be appropriate for the RACPC pathway. This was assessed via dedicated re-review of the GP referral, with a binary outcome recorded. 'Grey cases' (*e.g.* atypical presentation but some documentation of pain that could be perceived as cardiac) were assumed to be appropriate, recognising that GPs review a multitude of chest pain patients yet refer only a small proportion.

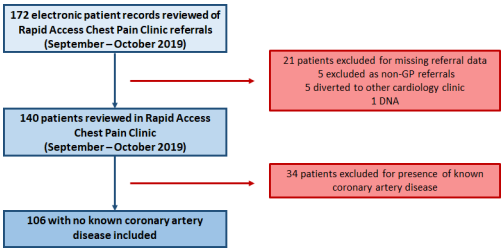
GP referral and RACPC clinical data

GP referrals and RACPC letters were reviewed and compared to evaluate concordance of the clinical data required to assess whether an individual patient meets NICE-CG95 CTCA criteria. This included: (1) known pre-existing CAD; (2) chest pain typicality; and (3) presence of a murmur or known valvular heart disease (to assess for contraindications to rate-controlling medications and GTN for image optimisation) as these patients must be identifiable prior to CTCA.

Current *vs* hypothetical RACPC pathway

The primary investigation for CAD requested or management plan via the actual RACPC was recorded and compared with the proposed hypothetical approach to assess impact on workstreams. This did not include secondary, additional investigations for non-coronary specific work-up selected at time of RACPC (*e.g.* echocardiogram), where these were organised as co-investigations.

Figure 2. Study flowchart. DNA, did not attend; GP, General Practice.



Dates of GP referral, RACPC review and definitive subsequent investigation (where one was undertaken) or discharge were recorded. Time from GP referral-to-diagnosis or exclusion of CAD and time-to-diagnosis of obstructive CAD via current RACPC was compared with the modelled pathway (using mean waiting times prior to the COVID-19 pandemic). Obstructive CAD was defined anatomically (≥70% stenosis in a major epicardial vessel or ≥50% in the left main stem) and/or functionally via assessment of ischaemia. The number of hospital encounters each pathway required was recorded.

Statistics

Statistical analysis was performed using SPSS v. 21 (Armonk, NY: IBM Corp). Categorical data are presented as frequency (percentage), and continuous data as mean (± standard deviation) or median (interquartile range [IQR]) for non-parametric data, which were compared with Kruskal–Wallis test. Between group differences were tested with an independent samples *t* test. Interobserver agreement for clinical assessment of chest pain type was assessed with Cohen's κ statistic and categorised as weak (κ 0.40–0.59), moderate (κ 0.60–0.79), strong (κ 0.80–0.90) or near perfect (κ > 0.90). Change in primary management selected between RACPC and hypothetical management was assessed with χ^2 test. Significance was defined as two-tailed $p < 0.05$.

RESULTS

62% (106/172) of patients screened met study inclusion criteria. Exclusion reasons included known CAD [34], missing referral data,[13] non-GP referrals,[5] diverted to non-RACPC clinic,[5] DNA.[1] Mean age was 61 ± 14 years with 51% female, as presented in Table 1, alongside a comparison of RACPC management selected into "CTCA" *vs* "other".

Referral 'appropriateness'

Dedicated cardiology registrar re-review of referrals reported 96% (102/106) were appropriate for RACPC. Cases cited as inappropriate included: palpitations, shortness of breath with pre-syncope, shortness of breath and peripheral oedema, and asymptomatic with an abnormal ECG. All were readily identifiable from the GP referral.

Referral *vs* RACPC clinical data

All 106 patients referred as 'no known pre-existing CAD' were confirmed as such at RACPC. 6% (6/106) of patients had a murmur recorded on their GP referral, of which all were confirmed at the RACPC appointment. 16% (17/106) were reported to have a murmur at RACPC not recorded in the referral. Of these 17 patients, none had significant valve disease (defined as ≥moderate) at subsequent echocardiography and therefore would not have influenced choice of CTCA assessment for potential CAD. A comparison of chest pain character defined

Table 1. Demographics and CAD risk factors, including subdivided via RACPC management selected (CTCA *vs* other)

Demographic	All	CTCA request	Other	*p*
	(*n* = 106)	(*n* = 71)	(*n* = 35)	
Age	61 ± 14	59 ± 12	65 ± 17	*0.03*
Female gender	54 (51%)	34 (48%)	20 (57%)	0.38
Hypertension	53 (50%)	33 (47%)	20 (57%)	0.47
Diabetes mellitus	19 (18%)	11 (15%)	8 (23%)	0.36
Dyslipidaemia	43 (41%)	30 (42%)	13 (37%)	0.66
Smoking				0.28
Current	18 (17%)	12 (17%)	6 (17%)	
Ex-smoker	37 (35%)	28 (40%)	9 (26%)	
Non-smoker	50 (47%)	30 (42%)	20 (57%)	
Unknown	1 (1%)	1 (1%)	0 (0%)	
Angina status				*0.02*
Typical	37 (35%)	28 (39%)	8 (23%)	
Atypical	35 (33%)	23 (32%)	12 (34%)	
Non-anginal pain	30 (28%)	20 (28%)	11 (32%)	
None	4 (4%)	0 (0%)	4 (11%)	

CAD, coronary artery disease; CTCA, CT coronary angiography; RACPC, rapid access chest pain clinics.

Table 2. Comparison of chest pain type as defined by GP referral *vs* RACPC assessment

	RACPC assessment				
GP referral	*n* = 106	Typical	Atypical	Non-anginal	No pain
	Typical	19	13	4	0
	Atypical	6	20	9	0
	Non-anginal	1	15	15	0
	No pain	0	0	0	4

GP, General Practice; RACPC, rapid access chest pain clinics.

by GP referral letter *vs* RACPC review is presented in Table 2, with interrater agreement graded as strong (κ 0.82, $p < 0.005$).

Actual *vs* hypothetical management

Table 3 outlines the management pathway selected in the study cohort *vs* the proposed hypothetical pathway based on primary assessment of potential CAD selected.

The hypothetical modelled pathway would have significantly changed the choice of primary management selected versus the actual management selected in the RACPC (χ^2 113.4, $p < 0.001$), with an increase in CTCAs requested to 84 from 71. This was in-part related to a proportion of patients currently investigated outside NICE guidance with functional tests or invasive coronary angiography (ICA). Of these, 43% (3/7) of patients referred for an initial functional tests required a subsequent CTCA, as did 18% (2/11) of patients referred for echocardiogram only and 50% (1/2) patients referred for direct current (DC) cardioversion. 80% (4/5) of patients referred directly for ICA had obstructive CAD identified, with 40% (2/5) revascularised.

Impact on RACPC pathway timeline

Median referral-to-RACPC appointment time was 27 days (IQR 14–33). Referral-to-diagnosis time was not significantly different ($p = 0.26$) when comparing all patients assessed (83 days [IQR 69–106]) *vs* those diagnosed with obstructive CAD (93 days [IQR 73–100]). This is in the context of the post-ponement of elective work for the COVID-19 pandemic, however at this point, 60% (3/5) ICAs requested were yet to be undertaken *vs* 4% (3/71) CTCAs, 2 of which had been attempted but delayed due to inadequate heart-rate control. Median RACPC-to-CTCA time increased to 106 days (from 54 days) for cases referred for CTCA where an alternative initial management step (*e.g.* functional test) had been selected at RACPC.

Impact on hospital encounters

22% (23/106) of patients had no identifiable CAD after RACPC review and results of CTCA or ICA. These cases would have required only one hospital encounter with the hypothetical CTCA-first pathway, extrapolating to an estimated 168 less outpatient appointments annually in our institution, at a cost saving of £26,376 against current NHS tariffs.[14] 30% (32/106) of patients had non-obstructive CAD diagnosed by CTCA or ICA. These could be discharged without further outpatient clinical review or attend a dedicated cardiovascular risk optimisation clinic. 13% (14/106) of patients had obstructive CAD diagnosed requiring at least one further hospital encounter to review results, symptoms and make a joint decision regarding further management.

DISCUSSION

In this retrospective study of real-world RACPC patients, a hypothetical CTCA-first strategy would have been feasible for patients without known pre-existing CAD meeting NICE-CG95 indications.[6] This highlights the potential to trial an evolution in the management of stable chest pain to improve patient experience and streamline care pathways. This is the first study testing the feasibility of delivering a CTCA-first strategy in a stable chest pain population, and, to the authors knowledge, is not a pathway widely used in UK practice.

A CTCA-led strategy for the assessment of new onset chest pain in patients is well-known to improve the care pathway, the detection of non-obstructive CAD and, importantly, outcomes.[9,11,15,16] This study presents the potential of a novel

Table 3. Comparison of the primary investigation selected on a per-patient basis via the actual RACPC pathway vs the proposed hypothetical pathway (in actual RACPC management, 'other pathway' included: transthoracic echocardiogram only [11], referral to arrhythmia clinic [1], DC cardioversion [2], loop recorder [1]).

	Proposed CTCA-first pathway					
Actual RACPC Pathway	*n* = 106	CTCA	Functional	ICA	Other pathway	RACPC review
	CTCA	59	0	0	1	11
	Functional	6	0	0	0	1
	ICA	5	0	0	0	0
	Otherpathway	9	0	0	2	4
	Discharge*(after RACPC review*)	5	0	0	1	2

CTCA, CT coronary angiography; ICA, invasive coronary angiography; RACPC, rapid access chest pain clinics.

approach to incorporating its use in a time-efficient manner to improve the patient journey. A hypothetical CTCA-first request prior to considering RACPC review would have been safe and appropriate in the majority of our cohort. Most referrals (96%) were appropriate for RACPC, with those not clearly recognisable from the referral enabling triage to an alternative outpatient clinic. In any subsequent real-world rollout of the proposed service, a thorough triage of all referrals and robust pathway to direct those not appropriate for a CTCA-first strategy to a clinical review first would be required. Additionally, whilst there was variation in the proportion of patients with typical and atypical chest pain as defined by GP *vs* RACPC, this equated to a near identical patient number collectively between the two groups, which is relevant given the NICE-CG95 guidelines recommend both are investigated with CTCA.[6]

Our findings align well with the recent national service evaluation of the NICE CG95 and CTCA pathway,[10] with both identifying a significant proportion of patients where CTCA reports mild or no CAD (*i.e.* CAD RADS 0 as per the Coronary Artery Disease e Reporting and Data System).[17] 36% of patients in the national audit[10] and 30% in ours had non-obstructive CAD, thus identified as potential candidates for preventive therapies. Importantly, this group is not detected with the majority of functional tests, potentially resulting in the failure to introduce important primary prevention therapy that improve outcomes.[9,18] Some functional tests do include an anatomical assessment of atheroma presence (*e.g.* a CT calcium score in nuclear myocardial perfusion imaging), though this would not detect any non-calcific plaque and its use first-line in patients without known CAD remains outside NICE guidance. Patients with atypical and non-anginal chest pain remain at risk of future major adverse cardiovascular event (MACE),[16,19,20] particularly given non-obstructive plaques are responsible for the majority of acute coronary syndromes.[21] Thus, CTCA identification of this group enables improved, personalised delivery of CVD prevention to address this risk.

The national audit authors concluded that >70% of patients referred for CTCA could be discharged to primary care after CTCA without further testing.[10] However, the ongoing presence of clear-cut symptoms may still require further clinical review and potential further assessment with other imaging modalities to assess for non-epicardial coronary causes of chest pain (*e.g.* microvascular angina or hypertrophic cardiomyopathy). Some of these may be appreciable on CT and CTCA reports would need to highlight these cases and prompt the referrer to consider alternative diagnoses. Routine reporting to CAD RADS criteria provides a reproducible, readily interpretable format that has prognostic value, which helps guide decision-making on downstream management.[13]

The RACPC pathway could be compared with 2-week-wait lung cancer services, where CT investigation follows GP assessment prior to considering specialist review. Primary care direct access to chest CT prior to secondary care review has been shown to enable more meaningful outpatient appointments, reduction in demand and waiting times.[22] A proposed CTCA-first where indicated pathway (Figure 1) could follow this model, using readily available clinical information on: chest pain type, presence of pre-existing CAD or ECG abnormality, known valve disease or presence of a murmur, cardiovascular risk factors and renal function. Cases remain where this may not be an appropriate first step, *e.g.* at extremes of age where the likelihood of CAD is high and a clinical review and trial of medical therapy may be more suitable. This suggestion could be available on referral proformas to support pragmatic, personalised decision-making. In addition, the few cases not in sinus rhythm (where a rhythm-control strategy may be considered prior to CAD assessment), are readily identifiable at referral and could be re-directed to an arrhythmia pathway.

The proposed hypothetical CTCA-first strategy would have reduced time-to-diagnosis by at least a median of 27 days. This reduction may be greater in a real-world application of this pathway due to longer waiting times for non-CTCA investigations, whilst also offloading outpatient clinics and non-CTCA waiting lists. Cases referred for ICA waited significantly longer for a definitive CAD assessment, in particular for the detection of obstructive CAD. Yet, paradoxically, referral for ICA is typically made for patients clinicians are more concerned about. Indeed, time-to-diagnosis of obstructive CAD *vs* time-to-diagnosis of any CAD did not differ via current pathways. A risk-stratification triage of likelihood of significant CAD based on risk factors and nature of pain could enable creation of pathways ('urgent' *vs* 'non-urgent' CTCA) with pre-defined acceptable time-frames—the recent GIRFT report states diagnostic imaging should be available within 6 weeks of clinical review.[12]

The increase in CTCA referrals (84 *vs* 71) observed with the hypothetical CTCA-first strategy was associated with a hypothetical reduction in referrals for ICA and functional imaging. CTCA availability may be higher in our institution relative to other UK centres, potentially making a CTCA-first pathway more practical to institute. The proposed pathway may impact resource allocation, with front-loading and potential enhancement of the workload for radiology services whilst reducing the burden on cardiology outpatients. This may be a barrier to implementation depending on local resource availability. However, CTCA has been recognised in the latest National Tariff, and the proposed change would be for local Clinical Commissioning Groups (CCG) to review and sanction. In some areas there may be a bundled tariff (*i.e.* a cost per patient encounter to reach treatment, regardless of what investigations are done), and if CTCA-first reduces layered testing then it may be cost-effective.[23] The proposed future vision to increase outpatient imaging service delivery within community diagnostic hubs (as proposed by the Richards report[24]) may also enhance scanning capacity on a national level, as will the current drive to increase the number of CTCA reporters via amendments to both radiology and cardiology training curriculums. Additionally, a CTCA-first strategy would have improved adherence to NICE-CG95[6] whilst also reducing the time-to-diagnosis *vs* functional testing, which may miss non-obstructive CAD.

The proposed increase in CTCA would lead to an increase in incidental findings, *e.g.* lung nodules. It will thus become increasingly

important that reporters provide clear guidance for when and what follow-up is required (including when it is not) to ensure appropriate and timely surveillance imaging where required. The importance of this remains whether the report is returning to the Cardiology team or the GP. Additionally, overlapping risk factors for lung cancer and CAD make this particularly pertinent for CTCA.

The proposed hypothetical strategy would have avoided 23 RACPC appointments in patients where no CAD was identified (22%), leading to an estimated cost saving of approximately £26,000 per annum. Whether cardiovascular risk factor optimisation and primary prevention for the 30% of patients where CTCA identifies non-obstructive CAD is undertaken in primary or secondary care is open to discussion and may be best assessed regionally by Clinical Commissioning Groups. Currently, these patients are typically discharged via a letter outlining investigation findings and treatment recommendations rather than further face-to-face review. The proposed novel pathway removes the prior RACPC review for patients meeting guideline-indicated CTCA criteria and replaces this with a post-investigation personalised approach to emphasising and optimising cardiovascular risk. If delivered by primary care this further reduces hospital visits, which may be preferable for patients. Internationally agreed cardiac CT reporting guidelines[17] could assist the clinician, with reports helping to guide subsequent management, *e.g.* to consider alternative causes of chest pain or microvascular dysfunction for patients with minimal or mild CAD (CAD RADS 1 or 2), and could potentially include lipid treatment targets. Alternatively, if specialist-led it could be delivered by remote consultation. Additionally, there is a diagnostic quandary as to whether a 'moderate' stenosis may or may not be causing ischaemia and symptoms. An additional potential benefit of the proposed pathway is that patients with a moderate stenosis will have the opportunity for a trial of optimal medical treatment and anti-anginal medication, alongside an optional non-invasive assessment of ischaemia probability via Fractional Flow Reserve-CT technology, prior to any consideration of invasive assessment or lesion specific management.

Patient optimisation is an important part of improving CTCA acquisition (*e.g.* targeting heart-rate below 60 beats-per-minute). The proposed pathway would need to consider the best strategy for pre-procedural prescription of rate-controlling medication relative to a patient's comorbidities and physiology, or incorporate on-arrival rate-control on the day of CTCA. One option already instituted locally for inpatient requests is a triggered electronic guidance on rate-control agents at request, which could be reproduced for GP referrals. Pre-procedural preparation instructions are already well-established in other patient groups, *e.g.* bowel preparation for CT colonoscopy.

If instituted, protocols would need to empower GPs to commence medical therapy early (*e.g.* statin, aspirin and beta-blocker[25]) where likelihood of CAD is high to reduce potential treatment delays, alongside a robust system for their discontinuation where no CAD is identified. This process could again be supported by standardised locally agreed reports.

Limitations

The study presented is limited by its single-centre, retrospective nature and use of a hypothetical management strategy rather than prospectively interrogated pathway, preventing a definitive assessment of how the proposed change would have influenced GP referral patterns when appropriate referrals are directed straight to CTCA. In addition, the study population were selected at random (rather than consecutive) from RACPC patients seen within a 2-month period, which has the potential to introduce selection bias. It is, however, strengthened by incorporating actual clinical cases, whilst the study findings match well with the recent large national audit,[10] increasing the likelihood the study population is reflective of the wider RACPC population. Assessment of the impact on waiting times is limited by the COVID-19 pandemic and post-ponement of elective services, though there was an appreciable difference in the proportion of patients waiting for a CTCA (4%) *vs* ICA (60%) at this time-point. Additionally, the study does not include full health economic modelling incorporating all down-stream impacts on patients or resource-use, which would benefit from evaluation within a prospective study. This would enable an assessment of actual CTCA referral rates and ensure any savings in upfront investigation is not offset by an escalation in investigation referral rates, though the potential for this was not suggested in this feasibility study.

CONCLUSION

In this retrospective study, a hypothetical novel pathway with CTCA-first prior to RACPC would have been feasible, safe and efficient in GP-referred patients without pre-existing CAD. In this cohort, the novel pathway would have increased referrals for CTCA (improving adherence to NICE guidance) whilst potentially reducing the burden on other services, reducing the number of hospital encounters involved in the RACPC pathway and enhancing the role of specialist review. This hypothetical novel pathway would have been consistent with NHS practices, patient wishes and NICE guidance, much as the original National Service Framework recommended for the RACPC in 2000. However, a further prospective trial of this new approach to the chest pain pathway is required for a definitive assessment.

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