Cardiac Link: a retrospective cohort study evaluating a clinical pathway for expedited cardiology referral

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Abstract

Background: Outpatients presenting with chest pain often face long wait times for cardiology consultation and subsequent investigation for obstructive coronary artery disease (CAD), during which adverse cardiovascular events may occur. Our objective was to describe the design of Cardiac Link, a coronary computed tomography angiogram (CCTA)-guided rapid-access program, and evaluate its effect on cardiology consultation wait times in patients who present to primary care physicians with stable chest pain.

Methods: We conducted a retrospective cohort study at Women's College Hospital, Toronto, Ontario, Canada, between 2017 and 2020 involving eligible patients from the Family Practice Health Centre who underwent CCTA after presenting with stable chest pain or equivalent symptoms. Referring primary care physicians decided on a patient-by-patient basis to opt into the Cardiac Link program when requesting CCTA. Our primary outcome was measure of time from CCTA to cardiology consultation, and our secondary outcomes were measures of time to diagnosis from primary care consultation and CCTA booking time.

Results: Our analysis included 148 patients (Cardiac Link $n = 98$, non–Cardiac Link $n = 50$). Mean age of the patients was 58.4 (SD 11.2) years and 72% (107/148) were women. We found that the Cardiac Link group had a shorter time from CCTA to cardiology consultation (median 7 [interquartile range {IQR} 6–20] d v. median 100 [IQR 40–138] d; $p = 0.01$), shorter time to diagnosis (median 33 [IQR 22–55] d v. median 86 [IQR 40–112] d; $p < 0.001$) and shorter CCTA booking time (median 18 [IQR 11–31] d v. median 65 [IQR 24–92] d; $p < 0.001$) compared with the non–Cardiac Link group.

Interpretation: We determined that the Cardiac Link program reduced cardiology consultation wait times for symptomatic patients who were suspected of having CAD. Our study shows the viability of CCTA-guided rapid-access programs to expedite specialist consultation and reduce unnecessary referral for patients presenting to primary care physicians with stable chest pain.

In Ontario, the wait time to see a cardiologist for the evaluation of any suspected cardiac condition can be long.[1–4] A 2014 study of data from family medicine electronic medical records in Ontario reported a median of 39 days (75th percentile of 77 d) from referral by a family physician to consultation.[2] While waiting, patients are at risk of adverse, potentially irreversible, cardiac events such as acute coronary syndrome.[5] Although presentations of chest pain may herald an urgent need to differentiate unstable angina or myocardial infarction (MI) from less urgent causes, cardiologists also receive competing referrals for several other cardiac conditions including valvular disease, cardiomyopathy, heart failure and cardiac arrhythmias.[5] The result is a long queue of patients waiting for specialized cardiac care. Canadian data from 2019 show that 351 633 emergency department visits were due to undiagnosed chest pain.[6] After acute coronary syndrome is ruled out, if the emergency department is not affiliated with a specialized chest pain clinic, these patients are often advised to see their primary care physician to organize a cardiology referral for further investigation. This sequence of events contributes to undesirably long cardiology wait times, therefore lengthening time to diagnosis and delaying appropriate management.

Previously developed rapid-access clinics for chest pain expedited cardiac care for patients with new-onset chest pain who were referred by primary care or the emergency department.[5,7,8] The benefits of rapid access to cardiology clinics include reduced total number of clinic visits and invasive investigations such as catheter angiography, reduced rates of revisits to the emergency department and reduced cardiovascular events.[5,7,9] In the United Kingdom, the National Service Framework for Coronary Heart Disease recommended specialized clinical pathways to facilitate cardiology consultation for new-onset chest pain within 2 weeks of referral from primary care.[5,10] This has manifested in rapid-access chest pain clinics, for which prospective evaluations in the UK, Australia and New Zealand have shown a dramatic decrease in both wait times for cardiology consultation and the total

number of consultations required to reach a diagnosis.[5,7] There is evidence that coronary computed tomography angiography (CCTA) is an excellent first-line test for patients presenting with stable chest pain or equivalent symptoms, and is attributed to a high negative predictive value (90%–99%) for ruling out obstructive coronary artery disease (CAD).[11–15] The recently published American Heart Association Guideline recommends CCTA as a first-line test to rule out CAD, particularly in patients at intermediate and high risk.[16] In Ontario, cardiologists (rather than primary care physicians) typically request CCTA.[17] Empowering primary care physicians to identify important CAD using noninvasive CCTA has several theoretical advantages, including minimizing unnecessary referrals and streamlining appropriate ones to reduce cardiology wait times while affording faster diagnoses to patients by ruling CAD in or out as a cause for symptoms.

Our objective was to describe the design of Cardiac Link, a CCTA-guided rapid-access program, and evaluate its effect on cardiology consultation wait times in patients presenting to primary care physicians with stable chest pain.

Methods

Setting

The study was conducted at Women's College Hospital, a tertiary care, academic outpatient hospital affiliated with the University of Toronto, Toronto, Ontario, that focuses on improving women's health. Our study population included patients who presented to primary care physicians at Women's College Hospital with stable chest pain or equivalent symptoms from January 2017 to September 2020. The Women's College Hospital Cardiology clinic is fully affiliated with the University of Toronto and offers specialized care in cardiology and access to cardiac diagnostic testing.

Design

We conducted a single-centre retrospective cohort study involving participants in the Cardiac Link program. We included all CCTAs that were flagged as "Cardiac Link" in the experimental group; we analyzed the rest as the control group. We excluded records that showed cardiology referral was started before completion of CCTA or otherwise outside of the Cardiac Link pathway. We compared outcomes in patients in the Cardiac Link program and patients not in the program. We followed the Standards for quality improvement reporting excellence (SQUIRE) 2.0 guideline for reporting quality improvement studies.[18]

The Cardiac Link program

Collaboration between the Departments of Family Practice, Radiology (Joint Department of Medical Imaging), and Cardiology at Women's College Hospital established the Cardiac Link program in 2017 as a pilot project for quality improvement. This novel rapid-access model aimed to expedite cardiology referral for patients at high risk using CCTA (Figure 1). Patients are deemed to be at high risk if
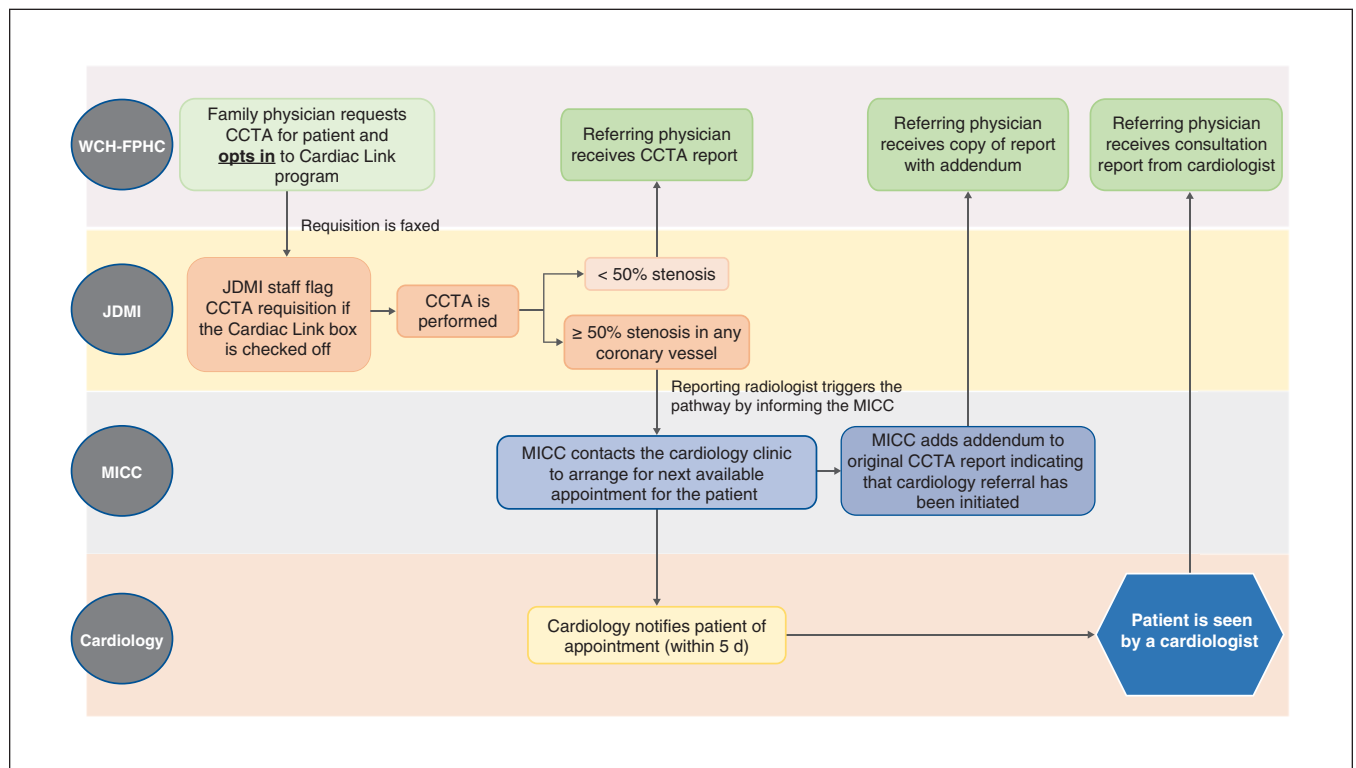
Figure 1: Flow chart of the cardiology referral process for patients in the Cardiac Link group. Physicians at the FPHC could opt in or out of the Cardiac Link program on a patient-by-patient basis. Note: CCTA = coronary computed tomography angiography, JDMI = Joint Department of Medical Imaging, MICC = Medical Imaging Call Centre, WCH-FPHC = Women's College Hospital Family Practice Health Centre.

CCTA detects 50% or more stenosis in any coronary artery, because these patients are more likely to have acute coronary syndrome or MI.[13,16,19,20] The primary goals of the Cardiac Link program were to shorten cardiology consultation wait times for symptomatic patients who are referred from primary care with suspected obstructive disease (≥ 50% stenosis in any coronary artery on CCTA) and empower primary care physicians to use noninvasive CCTA to rule out CAD as a cause for patients' symptoms, thereby minimizing unnecessary referrals.

Primary care physicians at Women's College Hospital Family Practice Health Centre contributed to the design of an "opt-in" program, where physicians decide to have their patients participate in the Cardiac Link program during the evaluation of patients with chest pain by selecting a check box on the CCTA requisition. Patients who declined to participate followed the non–Cardiac Link pathway (Figure 2). This pathway also occurs when primary care physicians do not select the Cardiac Link program on the CCTA request form. During the program's development, medical imaging faculty provided education to clinicians at the Women's College Hospital Family Practice Health Centre on criteria for appropriate use of CCTA, along with its strengths (e.g., high sensitivity and negative predictive value to rule out CAD, and ability to detect nonobstructive disease and its prognostic value) and limitations (e.g., requires β-blockers to slow heart rate to < 60 beats/min and use of intravenous contrast and radiation, although less radiation than nuclear perfusion scanning or diagnostic catheter angiography). Five stakeholder meetings were held with the departmental leads from cardiology, family medicine, medical imaging and relevant administrative support staff to design and implement the Cardiac Link program. Knowledge was disseminated to all members of the Women's College Hospital Family Practice Health Centre, cardiology and medical imaging departments through several education sessions and reminders.

Patients in the Cardiac Link program underwent CCTA and, if 50% or more stenosis was identified in any coronary artery segment, the reporting radiologists would then contact our Medical Imaging Call Centre by email or phone. The Medical Imaging Call Centre subsequently coordinated the next available cardiology appointment for the patient by contacting a central cardiology email to request consultation and issued an addendum onto the CCTA report that notified the referring physician and reporting radiologist that a cardiology consultation was requested. The next available appointment for cardiologist consultation was scheduled by administrative support personnel, while a formal cardiology referral was sent by the family medicine physician at their earliest convenience to provide further clinical details.

Patients with no (or less than 50%) stenosis in any coronary artery on CCTA have a lower risk of major adverse cardiovascular events and, therefore, do not require urgent cardiology care.[19,20] In this scenario, the CCTA report is sent to the primary care physician for optimal medical management of CAD, if appropriate, without starting a cardiology referral.
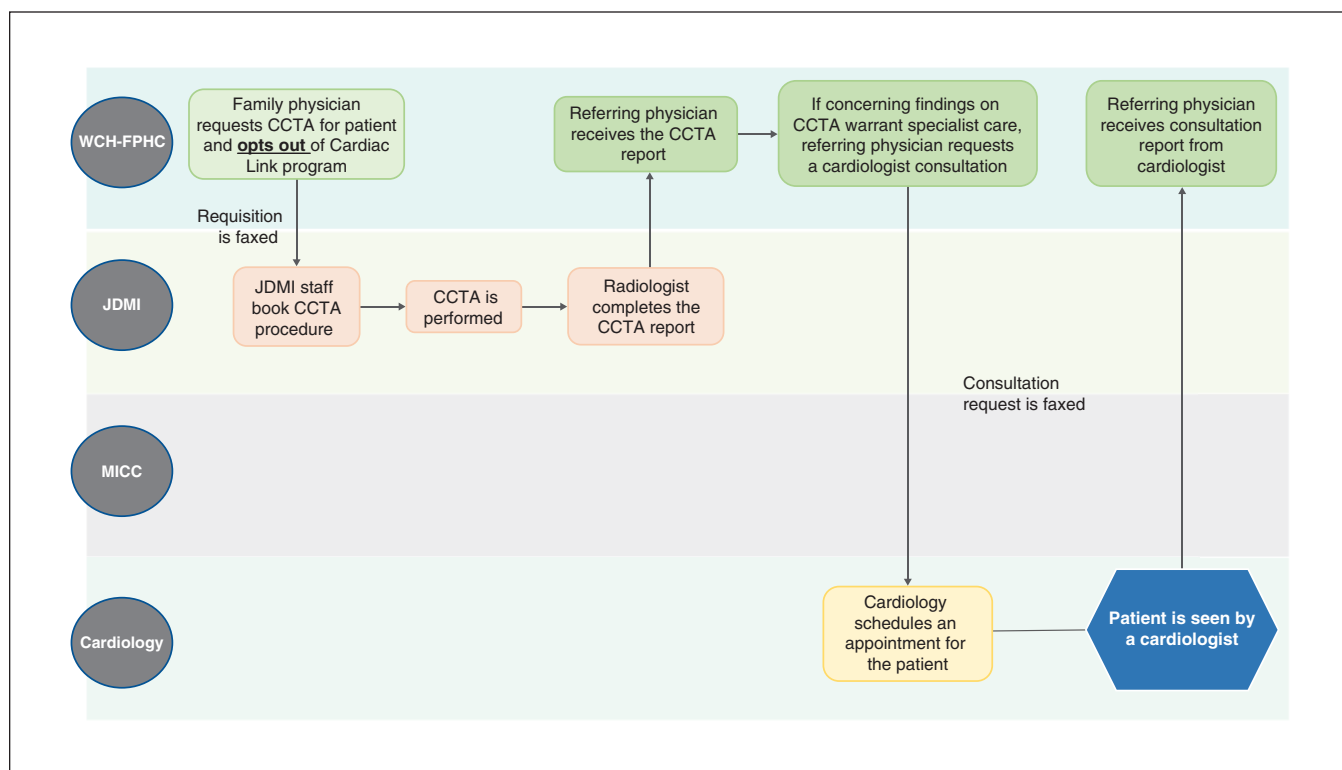
Figure 2: Flow chart of the cardiology referral process for patients in the non–Cardiac Link group. Note: CCTA = coronary computed tomography angiography, JDMI = Joint Department of Medical Imaging, MICC = Medical Imaging Call Centre, WCH-FPHC = Women's College Hospital Family Practice Health Centre.

Data sources

We used the Radiology Information Systems database to identify all completed CCTAs requested by family physicians. A review of electronic patient records was completed by 1 author (F.J.A.) for all study participants to collect demographic information and clinical features such as age, sex and primary presenting complaint.

Outcomes

Primary outcome

Our primary outcome was time to cardiology consultation after CCTA, which we defined as the time interval between CCTA and the patient's first cardiology consultation. The Cardiac Link program incorporated a workflow (Figure 1) that expedited appropriate cardiology referral based on the findings of the CCTA.

Secondary outcomes

One secondary outcome was time to diagnosis, which we defined as the time interval between the date of a patient's presentation with chest pain and the date of diagnosis. The date of diagnosis was defined as the date of follow-up appointment with the family physician or cardiologist during which CAD was officially diagnosed or excluded as a cause for symptoms. In the absence of a follow-up visit or phone call with either physician, this was the date of the last test used to investigate for CAD.

Our other secondary outcome was booking time, which we defined as the time interval between the dates of the requisition of CCTA and its completion.

The diagnosis of CAD was made based on any degree of stenosis in any coronary artery that was detected on CCTA and caused by atherosclerotic plaque. As part of this quality improvement project, 2 CCTA time slots were reserved each week for patients enrolled in the Cardiac Link program. Two weeks before each time slot, CCTA booking was reviewed and any vacant imaging slots were reallocated to referrals outside the Cardiac Link program.

Statistical analysis

We used STATA v14.1 (StataCorp, College Station, Texas) to perform the statistical analysis. We considered a 2-tailed p value of less than 0.05 to be statistically significant. We used the Shapiro–Wilk test on all continuous data to analyze for normal distribution. We described continuous data using means and standard deviations (SDs) (if normally distributed) and medians and interquartile ranges (IQRs) (if not normally distributed), and categorical data using values and percentages. We made comparisons between groups using the independent samples t test for continuous variables with normal distribution, the Wilcoxon rank–sum test for continuous variables with nonnormal distribution and the Fisher exact test for categorical variables.

Ethics approval

The Women's College Hospital Ethics Assessment Process for Quality Improvement Projects reviewed this study (REB No. 2020-0046-E).
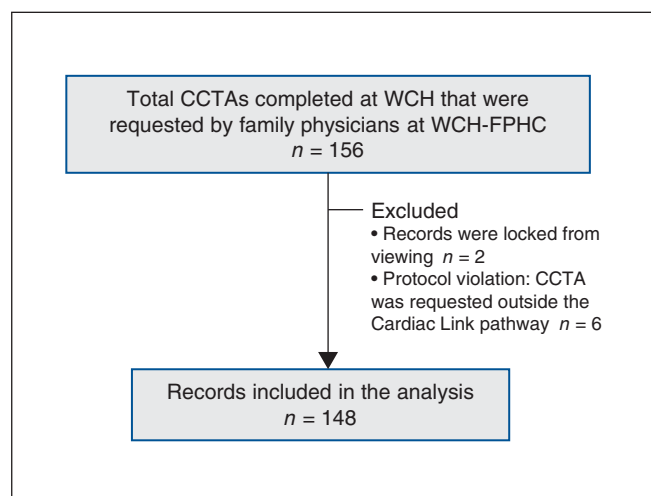
Results

Our study population included all 156 consecutive patients who received CCTA through the Women's College Hospital Family Practice Health Centre between 2017 and 2020. Of these, we excluded 8 patients from the study: 6 patients had a protocol violation and 2 had inaccessible records (Figure 3).

Of the 148 patients included in the final analysis, 98 (66%) followed the Cardiac Link pathway ("Cardiac Link Group"), while the remaining 50 ("non–Cardiac Link Group") followed the usual care pathway. We found that demographic features were comparable between groups (Table 1): mean age of patients was 58.4 (SD 11.2) years and 72.3% (n = 107) were women (67.3% and 82.0% in the Cardiac Link and non–Cardiac Link groups, respectively). The most common primary symptom was atypical chest pain (62.8%), followed by dyspnea (12.8%) and nonspecific symptoms (12.2%) such as shoulder pain, dizziness, fatigue and palpitations. We defined atypical chest pain as burning or stabbing epigastric or back pain not otherwise characteristic of cardiac disease.[21,22] We found that only 7% of all patients presented with typical ischemic chest pain or classic angina, defined as retrosternal pain or discomfort radiating to the arm or jaw, triggered by exertion or emotion, and alleviated by rest or nitroglycerine.[23,24] We found that the distribution of presenting symptoms between the 2 study groups did not differ significantly.

Outcomes

We determined that time to diagnosis in the Cardiac Link group was shorter than for the non–Cardiac Link group (median 33 [IQR] 22–55] d v. median 86 [IQR 40–112] d; p < 0.001; Figure 4). The Cardiac Link group also had shorter booking times for CCTA (median 18 [IQR 11–31] d v. median 65 [IQR 24–92] d, p < 0.001; Figure 5).

Figure 3: Flow chart of the creation of the study sample population from the original search results. Note: CCTA = coronary computed tomography angiography, WCH = Women's College Hospital, WCH-FPHC = Women's College Hospital Family Practice Health Centre.

Of the 148 patients included in our analysis, 25 required cardiology referral, comprising 17% (17/98) in the Cardiac Link group and 16% (8/50) in the non–Cardiac Link group (*p* = 1.0). We found that time from CCTA to cardiology consultation was shorter in the Cardiac Link group than in the non–Cardiac Link group (median 7 [IQR 6–20] d v. median 100 [IQR 40–138] d, *p* = 0.01; Table 2, Figure 6). Referral to cardiology was made either because of 50% or more stenosis on CCTA (*n* = 20) or because of other concerning findings such as frequent monomorphic premature ventricular contractions, repetitive supraventricular tachycardia or an excessively high coronary calcium score (*n* = 5).

Interpretation

Our findings show the benefits of an outpatient strategy that targets patients who present with stable chest pain to primary care physicians. We found that the Cardiac Link program led to a shorter referral time to cardiology, which also contributed to a reduction in overall time to diagnosis by employing a dedicated workflow that used CCTA findings to triage appropriate cardiology referral and reduce unnecessary referrals. This model has potential benefit for more timely and cost-effective investigation and improved use of health care resources, similar to previously described rapid access to cardiology clinics.[25–28] With the recent publication of the American Heart

Table 1: Demographic information, clinical presentation and investigation results for patients in both Cardiac Link and non–Cardiac Link groups

Characteristic	No. (%) of patients*			*p* value (Cardiac Link v. non–Cardiac Link)
	Total *n* = 148	Cardiac Link group *n* = 98	Non–Cardiac Link group *n* = 50	
Demographic				
Age, yr; mean ± SD	58.4 ± 11.2	58.2 ± 1.1	58.9 ± 1.6	0.7
Sex				0.08
Male	41 (28)	32 (33)	9 (18)	
Female	107 (72)	66 (67)	41 (82)	
Clinical symptom				
Asymptomatic†	8 (5)	5 (5)	3 (6)	1.0
Primary symptom	140	93	47	0.5
Typical chest pain	10 (7)	7 (7)	3 (6)	
Atypical chest pain‡	93 (63)	60 (61)	33 (66)	
Nonspecific pain and symptoms	18 (12)	15 (15)	3 (6)	
Dyspnea	19 (13)	11 (11)	8 (16)	
Secondary symptom	39	22	17	1.0
Atypical chest pain‡	7 (18)	4 (18)	3 (18)	
Nonspecific pain and symptoms	13 (33)	7 (32)	6 (35)	
Dyspnea	19 (49)	11 (50)	8 (47)	
Investigation finding				
CAD				0.08
No CAD	82 (55)	49 (50)	33 (66)	
CAD	66 (45)	49 (50)	17 (34)	
Stenosis				0.2
No stenosis	80 (54)	47 (48)	33 (66)	
< 50%	43 (29)	33 (34)	10 (20)	
≥ 50%	20 (1413.5)	15 (15)	5 (10)	
Unknown	5 (3)	3 (3)	2 (4)	

Note: CAD = coronary artery disease, CCTA = coronary computed tomography angiography.
*Unless specified otherwise.
†CCTA was completed in these patients because of a high 10-year cardiovascular risk, strong family history or for the investigation of abnormal findings on electrocardiography.
‡Atypical chest pain symptoms included shoulder pain, dizziness, fatigue, and palpitations.
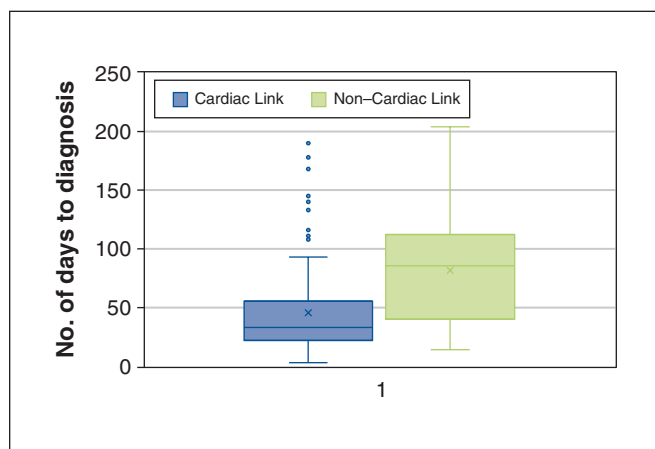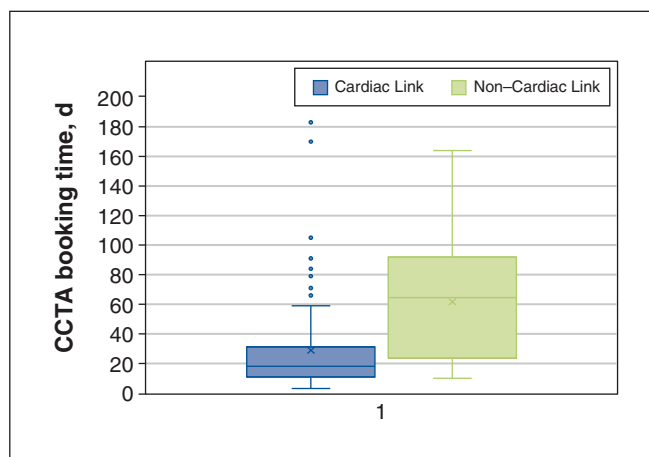
Figure 4: Plot of median (IQR) days to diagnosis for patients in the Cardiac Link group (*n* = 98) compared with those in the non–Cardiac Link group (*n* = 50). The lower and upper limits of each box denote the first and third quartile of data, respectively, in each group. The whiskers extending from the bottom and top of each box represent the range (minimum and maximum data point, respectively) of each group, excluding outliers that are represented by blue dots. The horizontal line within each box represents the median data point and the "x" represents the mean data point. Note: CCTA = coronary computed tomography angiogram, IQR = interquartile range.

Figure 5: Plot of median (IQR) booking time for CCTA (in days) for patients in the Cardiac Link group (*n* = 98) compared with those in the non–Cardiac Link group (*n* = 50). The lower and upper limits of each box denote the first and third quartile of data, respectively, in each group. The whiskers extending from the bottom and top of each box represent the range (minimum and maximum data point, respectively) of each group, excluding outliers that are represented by blue dots. The horizontal line within each box represents the median data point and the "x" represents the mean data point. Note: CCTA = coronary computed tomography angiography, IQR = interquartile range.

Association chest pain guideline[16] that recommends CCTA as the preferred first-line test for investigation of chest pain in patients at intermediate-to-high risk, we anticipate increasing future demand for CCTA.

There was a high proportion of women in both the Cardiac Link and non–Cardiac Link groups, and primary care physicians appeared to request CCTA preferentially to investigate chest pain in women compared with men. This may be due to a greater proportion of women presenting to primary care physicians for investigation of stable chest pain or equivalent symptoms at our centre (68% of presenting patients were women), a higher prevalence of atypical chest pain among women that can be challenging to differentiate from stable angina[21,29,30] and the suboptimal performance of other cardiac-testing modalities among women;[11,31–33] however, we did not explore the specific reasons for use of CCTA to investigate suspected CAD in women. A secondary analysis from the International Study of Comparative Health Effectiveness with Medical and Invasive Approaches (ISCHEMIA) trial (8518 patients enrolled; 77% were men) reported that women had more frequent angina despite having less extensive CAD and less severe ischemia than men.[34] More frequent angina symptoms may also explain why women in our study were more likely to present to primary care physicians and undergo cardiac investigations, but this requires further study to confirm. The impact of sex differences on the complex interplay between angina, atherosclerosis and ischemia are only beginning to be understood.

Our Cardiac Link program's success relied on symbiotic partnership, early engagement, open discussion and collaboration among the family practice, medical imaging and cardiology departments to develop and operationalize a clinical pathway that met the needs for all departments.

Rapid-access programs such as Cardiac Link could be expanded to include multiple referral sites and medical imaging centres to promote the inclusion of diverse patient populations (especially those who experience current barriers to accessing CCTA or cardiology care). Additional benefits of a program involving CCTA such as cost-effectiveness due to reduced downstream testing, as well as the influence of gender and cardiovascular risk scoring systems on ordering practices of primary care physicians, could be areas of future study.

Limitations

Our study was limited by selection bias introduced by primary care physicians and their criteria used for requesting a noninvasive test such as CCTA, which were not specifically explored in our study. Patients enrolled in Cardiac Link had dedicated time slots to facilitate bookings for CCTA as part of this quality improvement program, but this reduced the booking time and contributed to shorter time to diagnosis in this group. The primary outcome and goal of the Cardiac Link program remain important, as we found reduced time to cardiology referral. Our findings illustrate the benefits of effective partnerships between primary care physicians, radiologists and cardiologists, but may not be applicable in other centres where similar partnerships do not yet exist.

Conclusion

We found that patients in the Cardiac Link group had reduced time to cardiology consultation, which was the primary goal of the Cardiac Link program. Our study provides an effective clinical pathway for expedited cardiology referral based on CCTA findings that has the potential to reduce unnecessary cardiology referral while empowering primary care physicians

Table 2: Study outcome measures compared between patients in the Cardiac Link and non–Cardiac Link groups

Outcome	No. (%)* of total patients n = 148	Cardiac Link group n = 98	Non–Cardiac Link group n = 50	p value
Patients who required cardiology referral†	25 (16.9)	17 (17.3)	8 (16.0)	1.0
Outcome measure				
Time from CCTA to cardiology consult, d; median (IQR)	25	7 (6–20)	100 (40–138)	0.01
Time from primary care physician consult to diagnosis, d; median (IQR)	148	33 (22–55)	86 (40–112)	< 0.001
Time to book a CCTA, d; median (IQR)	148	18 (11–31)	65 (24–92)	< 0.001

Note: CAD = coronary artery disease, CCTA = coronary computed tomography angiogram, IQR = interquartile range.
*Unless specified otherwise.
†Twenty patients had 50% or more stenosis on CCTA and 5 had a strong family history or other cardiac concerns (despite being negative for CAD).
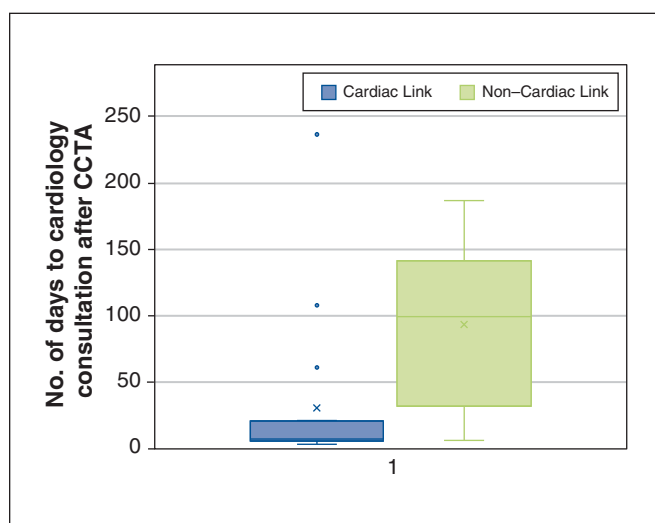
Figure 6: Plot of median (IQR) days to cardiology consultation after CCTA for patients in the Cardiac Link group (n = 17) compared with those in the non–Cardiac Link group (n = 8). The lower and upper limits of each box denote the first and third quartile of data, respectively, in each group. The whiskers extending from the bottom and top of each box represent the range (minimum and maximum data point, respectively) of each group, excluding outliers that are represented by blue dots. The horizontal line within each box represents the median data point and the "x" represents the mean data point. Note: CCTA = coronary computed tomography angiography, IQR = interquartile range.

to consider CCTA in the evaluation of stable chest pain. Fostering improved communication, education and partnership among various physician groups provides support for primary care physicians and leads to higher-quality patient care by expediting referral to the appropriate specialist.

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