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ORIGINAL ARTICLE

Coronary Computed Tomography Angiography Service in the Accident and Emergency Department: Pilot Study

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ABSTRACT

Introduction: *Studies in western countries have shown that installation of coronary computed tomography angiography (CCTA) in the accident and emergency department (AED) facilitates safe triage and early discharge of low-to-intermediate risk patients with suspected acute coronary syndrome. The aim of this pilot study was to determine whether the workflow of a CCTA service in a local hospital AED could safely discharge low-to-intermediate risk patients presenting with acute chest pain.*

Methods: *Low-to-intermediate risk chest pain patients (stratified using the HEART score), who underwent CCTA in the AED, were included. Patient health records were followed up for 2 years. Clinical variables, time needed for diagnosis, CCTA results, and major adverse cardiac events (MACE) were evaluated.*

Results: *Thirty-four patients (17 men, 17 women) were included in this study from March to August 2017. Nineteen patients (55.9%) were low-risk and 15 (44.1%) were intermediate-risk. Mean time to CCTA was 39.2 ± 27.9 hours. Twenty-four patients (70.6%) with negative CCTA results (<50% coronary artery stenosis) were discharged home from AED and 10 patients (29.4%) with positive result (≥50% stenosis) were admitted to medical wards for further assessment. In the 2-year follow-up period, no MACE was found in the negative group. For MACE in the positive group, no cardiac death, one non-fatal myocardial infarction (contraindicated for revascularisation) and five revascularisations were noted.*

Conclusion: *CCTA allows safe discharge of low-to-intermediate risk patients presenting with acute chest pain in the AED. An AED CCTA service is effective in reducing the waiting time and length of stay.*

Key Words: *Cardiology; Computed tomography angiography; Coronary artery disease; Emergency medicine; Radiology*

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Contributors: All authors designed the study and acquired the data. HHT Chau analysed the data and drafted the manuscript. All authors critically revised the manuscript for important intellectual content.

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Data Availability: All data generated or analysed during the present study are available from the corresponding author on reasonable request.

Ethics Approval: This study was carried out with approval from the Kowloon West Cluster Ethics Committee (KWC REC Ref: KW/EX-18-023(119-23)). The requirement for patient consent was waived by the committee.

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中文摘要

急診科冠狀動脈計算機斷層掃描血管造影服務:初步研究

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引言：西方國家的研究表明，在急診科中使用冠狀動脈計算機斷層掃描血管造影（CCTA）有助於進行分流和疑似急性冠狀動脈綜合徵的中低風險患者早期出院。本初步研究旨在確定本地醫院急診科CCTA服務流程是否可以使急性胸痛的中低風險患者安全地出院。

方法：納入在急診科接受CCTA的中低風險胸痛患者（使用HEART評分分層）。隨訪患者健康記錄2年，評估臨床變量、診斷所需時間、CCTA結果和主要心臟不良事件（MACE）。

結果：本研究於 2017年 3月至 8月共納入 34名患者（17名男性，17名女性）。 19名患者（55.9%）為低危患者，15名（44.1%）為中危患者。到接受CCTA的平均時間為39.2 ± 27.9小時。24名患者（70.6%）CCTA結果陰性（<50%冠狀動脈狹窄）從急診科出院，10名患者（29%）陽性結果（≥50%冠狀動脈狹窄）被送往內科病房作進進一步評估。隨訪2年，CCTA陰性組未發現MACE。 CCTA陽性組MACE結果：無心源性死亡、1 例非致死性心肌梗死（血管重建禁忌）和 5例血管重建。

結論：急診科CCTA允許急性胸痛的中低風險患者安全出院。急診科 CCTA 服務可有效減少等待時間和住院時間。

INTRODUCTION

Cardiac disease is the third leading cause of death in Hong Kong. According to the statistics of the Hong Kong Department of Health, on average 10.6 people died from coronary artery disease (CAD) per day in 2017.[1] In the same year, this disease accounted for 8.4% of all registered deaths in Hong Kong.[1]

Acute chest pain is a common presenting complaint in the accident and emergency department (AED). It is challenging for AED physicians to distinguish patients at high risk for CAD that require admission for urgent treatment and those at low risk that can be safely discharged home.[2] In traditional practice, the risk of CAD in chest pain patients is assessed by history taking, physical examination, serial electrocardiograms (ECG), and cardiac biomarkers such as troponin, creatinine kinase, and myoglobin.[3] Referral to cardiac subspecialties for further investigations and treatment usually takes time and the risk of cardiac death increases with time. Early recognition of patients at risk in the AED can allow the allocation of resources more efficiently.

Recent advances in coronary computed tomography angiography (CCTA) allow coronary vasculature to be evaluated rapidly and non-invasively, leading to an increase in its utilisation in the AED setting.[4] Multiple randomised controlled trials in the western world demonstrated that CCTA could facilitate safe triage and early discharge of low-to-intermediate risk patients with suspected acute coronary syndrome, with possible reduction of AED length of stay and cost of care.[5-8] Therefore, our radiology department installed a CCTA service in collaboration with the AED in order to improve clinical safety and to provide a more efficient way to manage patients with chest pain who were at low-to-intermediate risk for CAD.

The aim of this pilot study was to find out whether the workflow of a CCTA service in a local hospital AED could safely discharge low-to-intermediate-risk patients presenting with acute chest pain.

METHODS

A CCTA service had been set up in our hospital (Princess Margaret Hospital) AED and a team of dedicated AED physicians (Emergency Medicine Fellows) were available for arranging and booking CCTA. The service was targeted at adult patients (age ≥18 y) presenting with acute chest pain, who had two sets of normal serum troponin levels and normal or non-diagnostic ECG without dynamic changes concerning for ischaemia. All

patients who underwent CCTA in our AED from March to August 2017 were included in this pilot study.

Candidates were risk stratified by AED physicians using the HEART score and those classified as either low- or intermediate-risk for CAD were selected. The scoring system consists of five parameters: history (H), ECG (E), age (A), risk factors (R), and troponin level (T), which can be derived after a standard focused history taking and evaluation. It predicts the risk of a major adverse cardiac event (MACE) within 6 weeks after presentation: myocardial infarction (MI), need for percutaneous coronary intervention or coronary artery bypass graft, or death. Patients scoring 0 to 3 (low risk) and 4 to 6 (intermediate risk) were offered CCTA examinations in the AED.

Patients were excluded from CCTA if their first two sets of troponin were elevated, dynamic ECG changes concerning for ischaemia, intravenous contrast allergy, impaired renal function (creatinine level ≥115 μmol/L), atrial or ventricular arrhythmias with haemodynamic instability, clinically decompensated heart failure, or a normal CCTA performed within the preceding 24 months.

Ethics approval for this study was obtained from the institutional review board. Written informed consent was obtained from the patients before the procedure. Patients were prepared for the CCTA examination according to local departmental protocol, including refraining from caffeine-containing substances for 12 hours and withholding metformin for 48 hours. Steroid coverage (either oral or intravenous) was administered to those with a history of non-contrast drug allergy. Patients were fasted for 4 hours before the computed tomography examination. A large-bore intravenous access (18 G) cannula was set up in the right arm (preferably right antecubital fossa). Patients' heart rates were optimised to <65 beats per minute by rate-lowering agents such as beta blockers or calcium channel blockers in order to reduce motion artefact during the examination. After the CCTA examination, patients were transferred back to the AED for removal of the intravenous access catheter and further management.

Patient health records were reviewed for clinical variables including age, sex, risk factors for CAD (obesity, hypertension, dyslipidaemia, diabetes mellitus and current smoking) and the HEART score was calculated. The time from first evaluation by an AED physician to diagnosis by CCTA was recorded. Their CCTA results were collected and analysed. For those with CCTA-positive results, the time from first evaluation by an AED physician to angiography and intervention was calculated. Patient health records were followed up until 2 years after the presentation at the AED to assess for any major clinical outcomes, including MACE.

Excel (version 2019; Microsoft, Redmond [WA], United States) and SPSS (Windows version 22; IBM Corp., Armonk [NY], United States) were used for data analysis. All categorical variables were examined using the Mann-Whitney *U* test, Fisher's exact test, or Pearson's Chi-square test where appropriate. All continuous variables are shown as mean ± standard deviation and median (interquartile range [IQR]).

RESULTS

The HEART score[9] was proven to be a quick and reliable tool to triage chest pain patients in the AED setting, particularly in identifying low-risk patients with chest pain.[10,11] A total of 34 patients (17 men, 17 women) were recruited for this pilot study, with mean age 63.3 ± 9.0 years (range, 34-78 years). The median HEART score was 3 (IQR: 3-5). Nineteen patients were classified as low-risk (HEART score = 0-3) and 15 were intermediate risk (HEART score = 4-6). The Table shows the number of patients with each risk factor for CAD. Ten of 26 patients (38.5%) were obese (body mass index ≥ 25 kg/m^2), 19 (55.9%) were hypertensive, 18 (52.9%) had dyslipidaemia and six (17.6%) were diabetic. Only four (11.8%) were smokers. Those risk factors were taken into account when calculating the HEART score.

No patients who underwent CCTA experienced complications from the procedure. Mean time to CCTA was 39.2 ± 27.9 hours. Twenty-four patients (70.6%) with a negative CCTA result (<50% stenosis of any major coronary artery) were discharged home from the AED (Figure 1). Seventeen of the 24 patients (70.8%) were in the low-risk group and seven (29.2%) were in the intermediate-risk group.

Ten patients (29.4%) with a positive CCTA result (≥50% of stenosis on CCTA) were admitted to medical wards for further assessment by cardiologists (Figure 2). They had their symptoms, ECG and blood troponin level monitored. They also had an echocardiogram assessment. None of the patients with positive CCTA results had subsequent ECG changes during their hospital stay. Two of 10 patients with positive CCTA results had raised serum

Table. Clinical variables.*

Adverse event	All, n = 34	Coronary computed tomography angiography (CCTA)		
		Positive (≥50% of stenosis), n = 10	Negative (<50% stenosis), n = 24	p Value
Age, y	63.5 (58-69)	70 (62.5-78)	60 (57.25-67)	0.018†
Men	17 (50%)	6 (60.0%)	11 (45.8%)	0.452§
Obesity (body mass index ≥25 kg/m^2)	10/26 (38.5%)	2/7 (28.6%)	8/19 (42.1%)	0.668‡
Hypertension	19 (55.9%)	7 (70.0%)	12 (50.0%)	0.451†
Dyslipidaemia	18 (52.9%)	7 (70.0%)	11 (45.8%)	0.27‡
Diabetes mellitus	6 (17.6%)	2 (20.0%)	4 (16.7%)	1.000‡
Current smoker	4 (11.8%)	1 (10.0%)	3 (12.5%)	1.000‡
HEART score	3 (3-5)	5 (3.75-6)	3 (3-4)	0.003†
0-3 (low risk)	19 (55.9%)	2 (20.0%)	17 (70.8%)	0.010‡
4-6 (intermediate risk)	15 (44.1%)	8 (80.0%)	7 (29.2%)	

Abbreviations: DAP = dose-area-product; NRL = National Reference Levels.
* Data are shown as median (range) or No. (%), unless otherwise specified.
† Mann-Whitney *U* test.
‡ Fisher's exact test.
§ Pearson's Chi-square test.

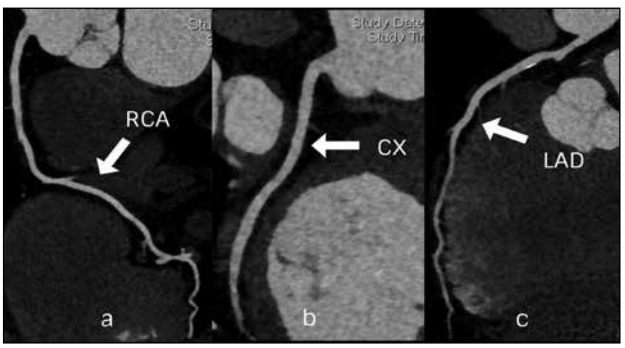

Figure 1. A 64-year-old man with a negative coronary computed tomographic angiography; <50% stenosis in all major coronary arteries. He was discharged from the accident and emergency department with no major adverse cardiovascular event over 2 years of follow-up. (a) Right coronary artery (RCA). (b) Circumflex artery (CX). (c) Left anterior descending artery (LAD).

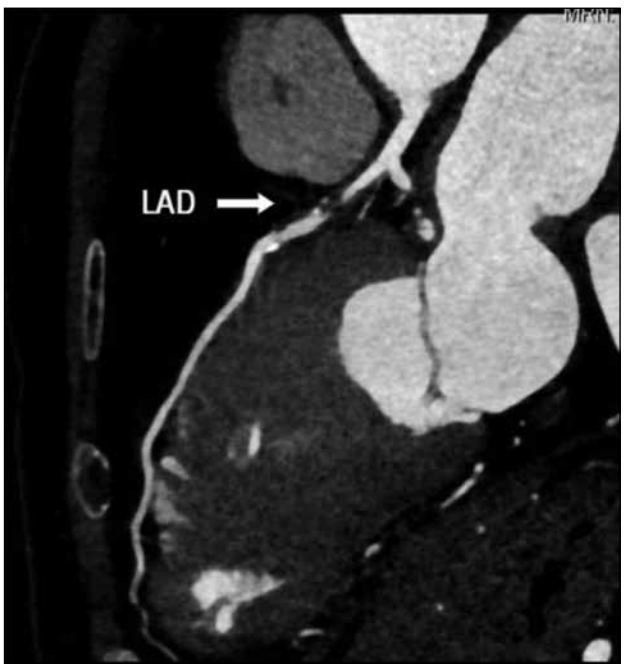

Figure 2. A 71-year-old man had a positive coronary computed tomography angiography, showing a severe to almost totally occluded proximal left anterior descending artery (LAD). He had coronary angiography 9 days later, with similar findings. Percutaneous coronary intervention of this artery was performed.

troponin level upon further testing, while one of them had a non-fatal MI 5 months later; the patient was not a candidate for percutaneous coronary intervention due to a persistently low platelet count (Figure 3). He was later diagnosed with myelodysplastic syndrome secondary to lymphoma. Two of 10 patients with positive CCTA results were classified as low-risk by HEART. Both of them showed 50% to 69% coronary artery stenosis and were managed conservatively.

In the 2-year follow-up period, none of those patients with a negative CCTA result had MACE, including cardiac death, MI, or the need for coronary revascularisation (Figure 4). In the negative CCTA group, none of the patients had died. Five of 10 patients with a positive CCTA result (50%) underwent a revascularisation procedure with no adverse events in the follow-up period. The time taken to angiography varied from 9 to 154 days, depending on the patient's symptoms and the

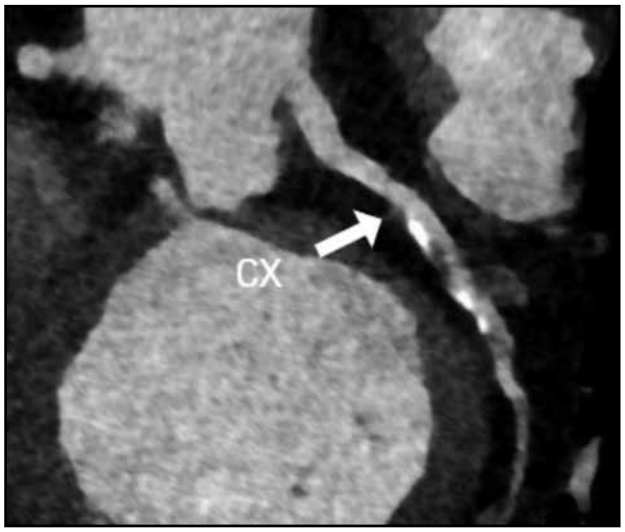

Figure 3. A 79-year-old man with moderate stenosis (50%-69% stenosis) in his mid circumflex artery (CX). He was contraindicated to angiography due to persistent low platelet count despite blood transfusion. He was then diagnosed with myelodysplastic syndrome secondary to lymphoma. He presented with a non-fatal myocardial infarction 5 months after his initial presentation.

clinician's decision. The other half who did not undergo revascularisation had contraindications to the procedure, preferred conservative treatment, or were subject to the clinician's judgement.

Two clinical variables showed significant differences between the positive CCTA group and negative CCTA group. There was a significant difference in their HEART score: low risk (0-3) with positive CCTA (20%) and negative CCTA (70.8%); intermediate risk (4-6) with positive CCTA (80%) and negative CCTA (29.2%) [p = 0.01]. The other clinical variable that was significantly different between the two groups was a higher median age in the positive CCTA group (70 y [IQR: 62.5-78 y] vs. negative CCTA: 60 y [IQR: 57.25-67 y]; p = 0.018). There was no significant difference in other clinical variables between the two groups, including gender, obesity (body mass index ≥25 kg/m^2), hypertension, dyslipidaemia, diabetes mellitus and current smoker.

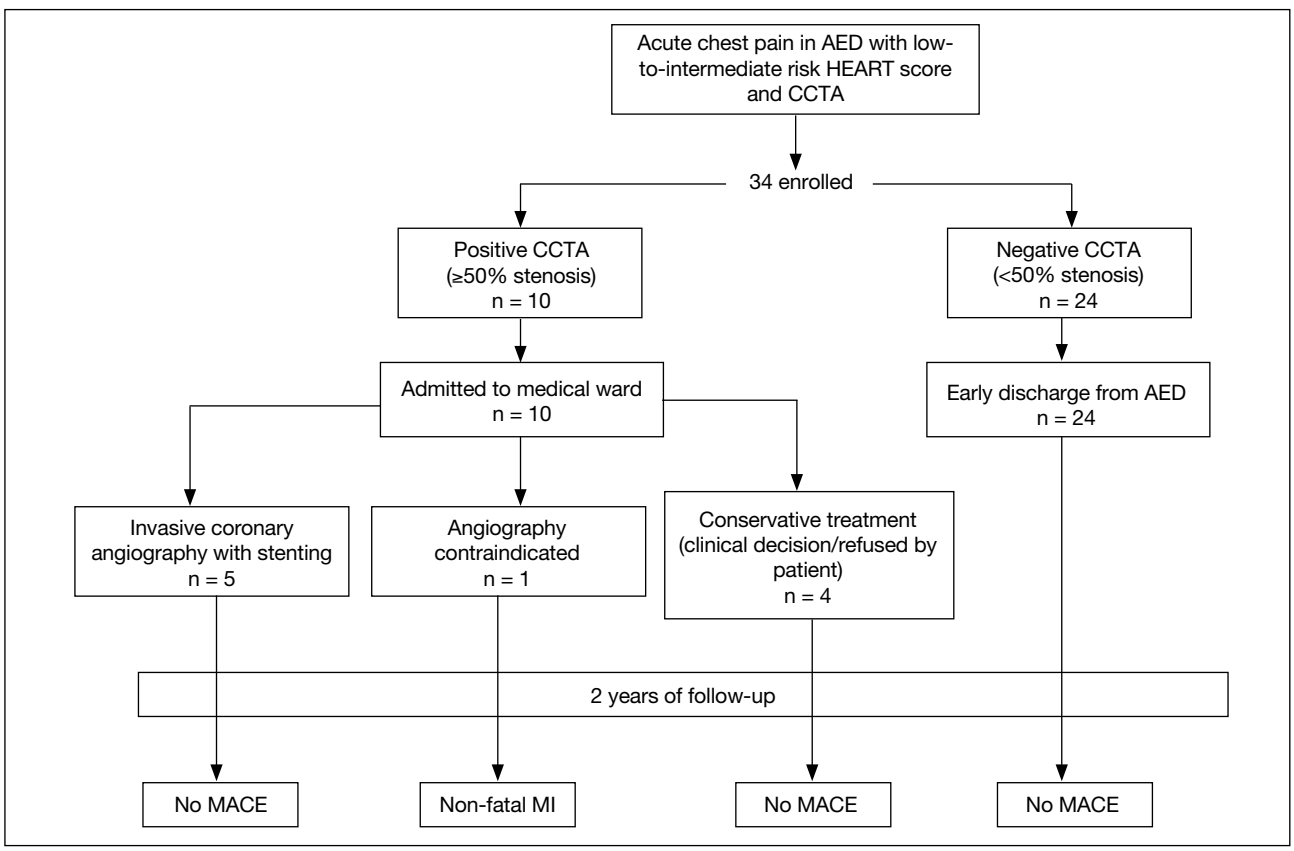

Figure 4. Clinical outcomes of 34 enrolled patients for coronary computed tomography angiography.
Abbreviations: AED = accident and emergency department; CCTA = coronary computed tomography angiography; MACE = major adverse cardiac event; MI = myocardial infarction.

DISCUSSION

Previous studies have revealed that CCTA had a relatively high negative predictive value of > 95%, which was helpful to rule out significant CAD and safely discharge low-risk patients.[12-16] This pilot study demonstrated consistent findings: no major cardiac events in 2 years of follow-up for those patients who had negative CCTA results. It suggests that CCTA would be a reliable and safe tool in identifying low-to-intermediate risk patients presenting with acute chest pain in our AED, provided that they had negative cardiac enzyme results and ECG findings. If more patients with negative CCTA findings can be discharged immediately from the AED in the future, further extensive diagnostic tests and hospital admission can be avoided, saving hospital costs.

Meta-analysis showed that CCTA was highly sensitive (98%) and moderately specific 84%) in detecting clinically significant coronary artery stenosis.[17] Using CCTA and clinical diagnosis of the MI after 2 years of follow-up as the gold standard of diagnosis of symptomatic CAD, the sensitivity and specificity of the low- and intermediate-risk HEART scores for detection of symptomatic CAD in this study were 80.0% (8/10) and 70.8% (17/24), respectively. The false-negative rate of a low-risk HEART score was 10.5% (2/19). A previous study revealed that the predictability of MACE in 6 weeks in low- and intermediate-risk HEART score patients were 2.5% and 20.3%, respectively.[9] Therefore, addition of CCTA service is beneficial to patient care.

One patient had an adverse cardiac event in the 2-year follow-up period. Although his CCTA result was positive (Figure 3), he was not a candidate for angiography due to persistent low platelet count due to lymphoma. His platelet count remained low despite chemotherapy and blood transfusions. Without definitive treatment, he had a non-fatal MI 5 months after his initial presentation with chest pain. In this trial, 10 of 34 patients (29.4%) had a positive CCTA while two of them had subsequent elevation of serum troponin levels signifying an acute MI. Since those two patients were not in the low-risk group, it further supports that CCTA allows quicker identification of patients who requires intervention to avoid future cardiac events.

When comparing the positive and negative CCTA groups, there was no statistically significant difference in most clinical variables. Patients in the positive CCTA group were comparatively older and had a higher HEART score, which were valid as age and the HEART score correlate with the risk of CAD.

There was a prolonged CCTA waiting time in this study; mean time to CCTA was 39.2 hours. This was mainly related to limited CCTA service provision with inadequate cardiovascular imaging specialists and resources for the pilot study. The service was only available on alternate days over weekdays, so selected patients could have waited for more than 2 days (in addition of weekends and/or public holidays) for the examination. Increasing manpower and daily CCTA slot provision is necessary to reduce the waiting time and length of hospital stay. This can potentially increase throughput in AED.

This is a pilot study, and therefore, did not have adequate power to demonstrate the effectiveness and cost-efficiency of CCTA service in AED. However, it was adequate to reflect the feasibility of our current workflow and to guide future study. A more comprehensive study with a larger sample size and longer period is expected to give a better reflection on long-term costs and benefits of CCTA service in AED. As stated above, provision of CCTA service was limited by resources and manpower. More imaging slots should be provided in AED so that the waiting time can be shortened, and patients can be discharged earlier. In this retrospective study, the information collected from the electronic patient record might not be comprehensive as some records were not well-documented. A prospective study is preferred in the future. Future study can also include a control group for comparison.

CONCLUSION

This pilot study demonstrated that CCTA could be used as a negative predictor of cardiovascular events. It is a reliable tool to identify and allows safe discharge of low-to-intermediate risk patients presenting with acute chest pain in the AED. Increasing manpower and daily CCTA slot provision are necessary to reduce the waiting time and length of hospital stay. A more comprehensive study in the future can give a better evaluation of the cost and the long-term benefits of application of CCTA in the emergency department.

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