Optimizing Utilization of Computed Tomography Coronary Angiography for Non-Emergency Patients at the National Hospital of Sri Lanka: A Problem-Oriented Case Study

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Abstract- Background: Computed tomography coronary angiography (CTCA) has become an important non-invasive diagnostic modality for the evaluation of suspected coronary artery disease (CAD). International guidelines recommend CTCA as a first-line investigation for patients presenting with stable chest pain and low-to-intermediate cardiovascular risk. However, optimal utilization of CTCA services in public tertiary hospitals is frequently constrained by operational limitations including equipment capacity, workforce availability, and service organization. At the National Hospital of Sri Lanka (NHSL), increasing demand for CTCA investigations has resulted in prolonged waiting times for non-emergency patients. This study aimed to analyze operational factors contributing to CTCA service delays and identify potential strategies for improving service efficiency.

Methods: A mixed-methods problem-oriented case study was conducted at NHSL between November 2025 and February 2026. Data were collected through key informant interviews, focus group discussions, direct workflow observations, and review of administrative service statistics. Root cause analysis and Nominal Group Technique were used to identify and prioritize operational bottlenecks affecting CTCA utilization.

Results: Approximately 600 patients were awaiting CTCA investigations with waiting times ranging from two to three months. CTCA examinations were mainly performed on a single CT scanner with cardiac imaging capability. Major factors contributing to service delays included limited CTCA service hours, workforce shortages, and equipment downtime related to absence of comprehensive maintenance agreements.

Conclusions: CTCA service delays at NHSL are primarily associated with operational capacity limitations and equipment maintenance challenges. Strengthening maintenance planning, optimizing workforce allocation, and expanding CTCA service sessions could significantly improve diagnostic service utilization and reduce patient waiting times.

Keywords: CT coronary angiogram; diagnostic imaging utilization; waiting time; radiology services; health systems management; Sri Lanka

I. INTRODUCTION

Cardiovascular diseases remain the leading cause of mortality worldwide and represent a major global health challenge. According to the World Health Organization, cardiovascular diseases account for nearly 17.9 million deaths each year, representing approximately one-third of all global deaths (1). Coronary artery disease (CAD) is the most common form of cardiovascular disease and contributes significantly to both mortality and long-term disability. Early detection and appropriate management of CAD therefore remain key priorities for healthcare systems around the world.

Advances in diagnostic imaging have significantly transformed the evaluation of patients presenting with chest pain and suspected coronary artery disease. Computed tomography coronary angiogram (CTCA) is a non-invasive imaging technique capable of visualizing coronary arteries with high spatial resolution. CTCA enables clinicians to detect coronary stenosis, assess atherosclerotic plaque burden, and evaluate coronary anatomy without the need for invasive catheterization procedures (2).

Several clinical studies have demonstrated the diagnostic accuracy of CTCA in detecting coronary artery disease. The technique has shown high sensitivity and negative predictive value, making it particularly useful for ruling out significant coronary

stenosis among patients with low-to-intermediate cardiovascular risk (2). As a result, CTCA has increasingly been incorporated into clinical guidelines as a first-line diagnostic investigation.

The National Institute for Health and Care Excellence (NICE) guideline on chest pain recommends CTCA as the initial diagnostic investigation for patients presenting with suspected stable angina (3). Similarly, the American College of Cardiology and the American Heart Association recognize CTCA as an effective diagnostic modality for evaluating patients with chest pain and suspected coronary artery disease (4). The European Society of Cardiology has also incorporated CTCA into its diagnostic algorithms for chronic coronary syndromes (5).

Compared with invasive coronary angiography, CTCA offers several advantages including lower procedural risk, shorter procedure time, and reduced hospital stay. In addition, CTCA provides visualization of both obstructive and non-obstructive coronary plaque, allowing clinicians to identify early stages of atherosclerosis that may not be detected by invasive angiography alone. Studies have demonstrated that CTCA-based diagnostic strategies can improve clinical decision making and reduce unnecessary invasive procedures (6).

Despite these advantages, implementation of CTCA services within public healthcare systems may face significant operational challenges. Diagnostic imaging services require substantial infrastructure investment, trained workforce, maintenance support, and efficient scheduling systems. Increasing demand for advanced imaging often places pressure on existing radiology resources.

In many tertiary hospitals, the demand for CTCA examinations has increased rapidly due to expanding clinical indications and greater physician awareness of the diagnostic value of the technique. When service capacity does not expand proportionately with demand, waiting lists for CTCA investigations may increase significantly. Prolonged waiting times for diagnostic imaging can lead to delayed diagnosis, repeated outpatient visits, and patient dissatisfaction.

Healthcare service delivery is influenced by multiple interconnected factors including infrastructure capacity, workforce availability, administrative policies, and equipment reliability. Health systems research approaches such as problem-oriented case studies provide valuable frameworks for analyzing operational challenges within healthcare organizations (7). These approaches allow researchers to identify systemic factors contributing to service inefficiencies and to propose evidence-based interventions.

The National Hospital of Sri Lanka (NHSL) is the largest tertiary care hospital in the country and serves as a major referral center for complex medical conditions. The cardiology and radiology departments of NHSL manage a large number of patients requiring advanced cardiac investigations. In recent years clinicians have observed increasing waiting times for CTCA investigations among non-emergency patients. Understanding the underlying causes of CTCA service delays is essential for improving diagnostic service delivery and ensuring timely patient care. Therefore, this study was conducted to evaluate CTCA service utilization at NHSL using a problem-oriented case study approach. The objectives were to identify key operational constraints affecting CTCA services, prioritize the most critical problems, and propose strategies for improving CTCA service efficiency.

II.METHODS

Study design

A mixed-methods problem-oriented case study design was adopted for this research. Case study methodology is widely used in health systems research to explore complex organizational and operational issues within healthcare institutions (7). This approach allows integration of qualitative and quantitative data to obtain a comprehensive understanding of service delivery challenges.

Study setting

The study was conducted at the National Hospital of Sri Lanka (NHSL) in Colombo. NHSL is the largest tertiary care hospital in Sri Lanka and functions as the primary referral center for complex medical and surgical cases. The hospital provides specialized services in cardiology, radiology, and cardiovascular surgery.

Study period

Data collection for this study was conducted between November 2025 and February 2026.

Study participants

Participants included healthcare professionals involved in CTCA service delivery. These included

consultant cardiologists, consultant radiologists, radiographers, nursing officers, hospital administrators, and biomedical engineering personnel. These individuals were selected because of their direct involvement in CTCA service planning, operation, and management.

Data collection methods

Multiple data collection methods were used to obtain comprehensive information regarding CTCA service operations.

Key informant interviews were conducted with senior clinicians and administrators to identify operational challenges affecting CTCA services. Semi-structured interview guides were used to explore issues related to service capacity, workflow processes, and equipment management.

Focus group discussions were conducted with radiographers and nursing officers involved in CT imaging procedures. These discussions aimed to explore workforce challenges, workflow bottlenecks, and practical difficulties encountered during CTCA procedures.

Observational workflow assessments were conducted within CT imaging units. These observations focused on patient flow patterns, scanner utilization rates, scheduling processes, and time required for CTCA procedures.

Administrative service data were also reviewed. These included CT scanner capacity, workforce statistics, waiting list data and service utilization records.

Root cause analysis

Root cause analysis was conducted to identify underlying factors contributing to prolonged CTCA waiting times. Root cause analysis is a systematic method used to identify fundamental causes of operational problems rather than merely addressing their symptoms.

Problem prioritization

After identifying operational problems, a Nominal Group Technique (NGT) was conducted among key stakeholders. Participants ranked each problem according to magnitude, severity of impact, feasibility of intervention, and potential benefit. This structured prioritization method helped identify the most important operational constraints affecting CTCA services.

Data analysis

Qualitative data from interviews and focus group discussions were analyzed using thematic analysis. Quantitative administrative data were summarized using descriptive statistics.

III.RESULTS

Problem Identification

Administrative service data revealed that approximately 600 non-emergency patients were awaiting CT coronary angiography examinations at NHSL. The waiting time for CTCA ranged from two to three months depending on clinical prioritization. Interviews with clinicians indicated that delays in CTCA investigations created challenges for timely diagnosis and clinical decision-making for patients presenting with chest pain.

Assessment of CT scanner utilization demonstrated that CTCA procedures were primarily performed using a single CT scanner equipped with cardiac imaging capability. Although multiple CT scanners were available in the hospital, workflow arrangements and technical capabilities limited CTCA examinations to one machine.

Table 1. CT Scanner Capacity at NHSL

CT Machine	Location	Slice Capacity	Utilization for CTCA	Reason for Non-utilization / Selection
CT-01	Main X-ray Building	16 slices	No	Insufficient slice capacity for high-quality CT coronary angiography
CT-02	Main X-ray Building	640 slices	Yes	High-resolution scanner suitable for cardiac imaging; currently used for CTCA
CT-03	Accident Service Building – Neurotrauma Unit	64 slices	No	Lower image quality compared with CT-02; primarily reserved for emergency trauma imaging
CT-04	OPD New Building	160 slices	No	Lack of trained nursing staff for CTCA procedures; no allocated cardiology slots; PACS system not connected with cardiology unit

Problem Prioritization

Following identification of operational challenges, a Nominal Group Technique session was conducted among key stakeholders including consultant radiologists, cardiologists, radiographers and administrators. Problems were ranked according to magnitude, severity, and feasibility of intervention.

Table 2. Radiographer Cadre vs In-Position

Category	Approved Cadre	In Position
Radiographers	104	68
Special Grade Radiographers	04	01

Table 3. Problem Prioritization Scoring

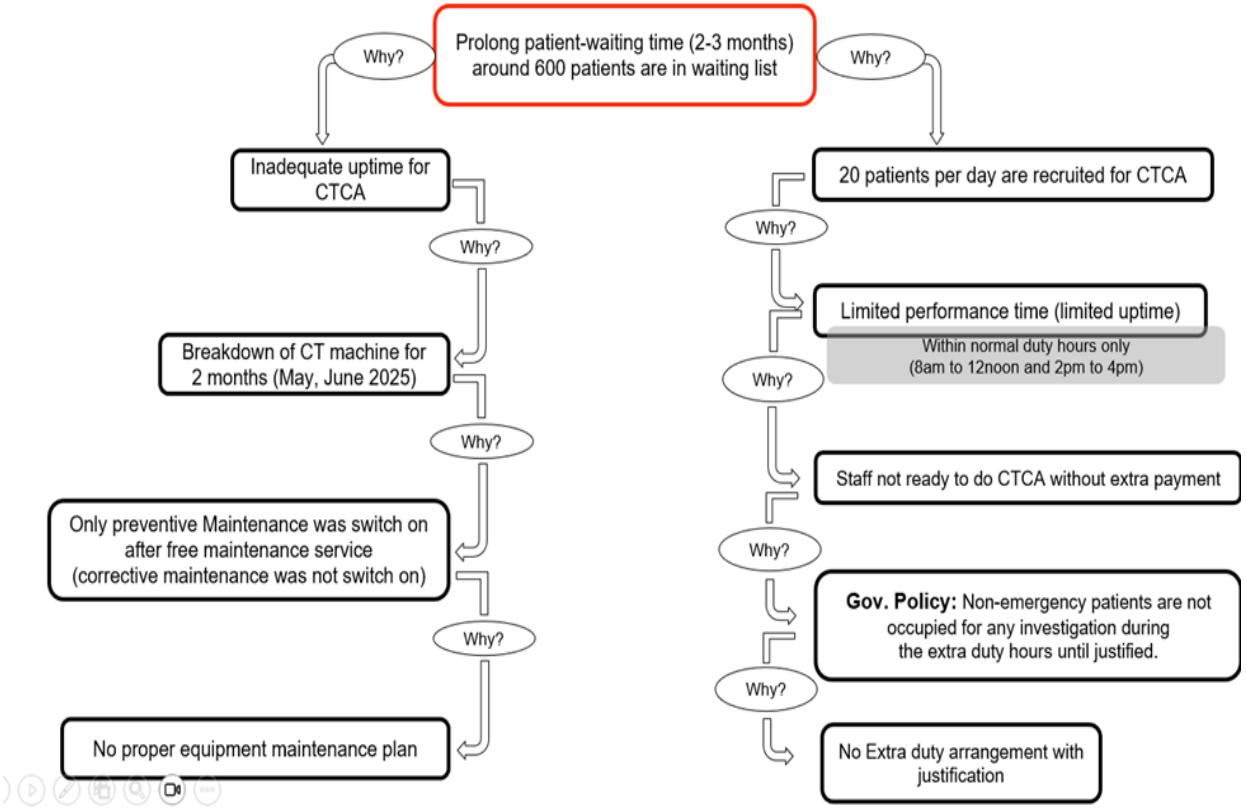
Problem	Magnitude	Severity	Feasibility	Total Score
Limited CTCA service hours	5	5	4	14
Absence of corrective maintenance agreement	4	5	4	13
Radiographer shortage	4	4	3	11

IV.PROBLEM ANALYSIS

Root cause analysis demonstrated that prolonged CTCA waiting time resulted from a combination of interrelated factors including limited-service hours, workforce shortages, and equipment maintenance gaps. CTCA procedures were mainly performed during routine duty hours, limiting the number of examinations conducted daily. Furthermore, shortage of radiographers restricted the ability to introduce additional CTCA service sessions.

Equipment maintenance issues were also identified as an important contributing factor. The absence of a comprehensive corrective maintenance agreement increased the risk of prolonged equipment downtime following technical failures.

Figure 1. Root Cause Analysis of Prolonged CTCA Waiting Time



V.DISCUSSION

The findings of this study highlight important operational challenges affecting CTCA service delivery in a large tertiary hospital. Prolonged waiting time for CT coronary angiography reflects a mismatch between increasing diagnostic demand and available service capacity.

Dependence on a single CT scanner for CTCA procedures significantly increases vulnerability to service disruptions. When equipment breakdown occurs, diagnostic services may be interrupted for extended periods of time. Similar challenges have been reported in other healthcare systems where advanced imaging services rely heavily on a limited number of specialized machines (9).

Equipment maintenance planning plays a critical role in ensuring continuity of diagnostic imaging services. Comprehensive maintenance agreements that include both preventive and corrective maintenance are essential to minimize equipment downtime and maintain service availability (10).

Limited CTCA service hours also represent a major operational constraint. Expanding diagnostic imaging services beyond routine duty hours has been shown to improve patient throughput and reduce waiting lists in several healthcare systems (11).

Workforce shortages represent another critical barrier to expanding CTCA services. Radiographers play a central role in CT imaging operations, and insufficient staffing levels can restrict optimal utilization of available imaging equipment.

International experience suggests that structured chest pain pathways and rapid access diagnostic clinics can improve efficiency of cardiac diagnostic services and reduce hospital admissions (12). Implementing similar service models may help optimize CTCA utilization in tertiary hospitals.

Addressing operational issues related to equipment maintenance, workforce allocation, and service scheduling could substantially improve CTCA utilization and reduce waiting times for patients requiring cardiac imaging.

VI.CONCLUSION

Prolonged CT coronary angiography waiting time at NHSL is primarily associated with operational capacity limitations and equipment maintenance gaps. Strengthening maintenance agreements, improving workforce allocation, and expanding CTCA service sessions may significantly improve diagnostic imaging utilization and reduce patient waiting time.

Limitations

This case study was conducted in a single tertiary care hospital and therefore findings may not be fully generalizable to other healthcare institutions. In addition, operational data were derived primarily from administrative records and stakeholder interviews, which may be subject to reporting bias. However, the mixed-methods approach used in this study allowed triangulation of multiple data sources and strengthened the reliability of findings.

Ethical considerations

The study was conducted as part of a health systems operational assessment. Institutional administrative approval was obtained prior to data collection. Participation of healthcare staff in interviews and discussions was voluntary and confidentiality of responses was maintained.

Conflict of interest

The authors declare that there is no conflict of interest.

Funding

This study did not receive any external funding.

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