Radiological Techniques in Coronary Artery Imaging: A Comparison of CT and Cardiac Catheterization

Liala Taher Issa El essawi, Fathi Sadek ALdrissi, Melek Masaud Alrabob

University of Medical Sciences and Technology / Tripoli

Lailat_elessawi1@yahoo.com

Abstract

This research aims to compare the accuracy and efficiency of both cardiac catheterization and CT in the diagnosis of coronary artery disease, given the importance of selecting the appropriate diagnostic method in improving the accuracy of the diagnosis and reducing the potential risks to patients. The study was based on the descriptive analytical approach, where the data of 80 patients who underwent one of the two examinations at Mitiga Military Hospital and Capital Hospital were collected and analyzed, and the results were evaluated according to criteria that include the percentage of obstruction, the accuracy of the diagnosis, and the risks associated with each procedure.

The results showed that the age group most likely to develop coronary artery disease ranged between 50-70 years (50%), with a higher percentage of males compared to females, reaching 55% in cardiac catheterization and 60% in tomography. The most common symptoms were chest pain and shortness of breath, with slight variations in the distribution of other symptoms. A comparison of four examined cases also showed a remarkable match between the two techniques, but the cardiac catheterization outperformed the accuracy of the diagnosis, especially in complex cases characterized by severe arterial blockages or dense vascular calcifications.

These results indicate that cardiac CT is an effective option for primary screening, especially for cases that do not require direct therapeutic intervention, as it is a non-surgical procedure characterized by speed of completion and low risk. However, cardiac catheterization remains

the gold standard for coronary artery disease diagnosis, achieving high diagnostic accuracy, particularly in cases requiring immediate therapeutic intervention such as stenting.
Based on these findings, CT is recommended as a primary screening tool in low- and medium-risk patients, while cardiac catheterization is resorted to when higher diagnostic accuracy or therapeutic intervention is needed. The research recommends future studies involving a larger sample size and deeper statistical analysis, contributing to a better understanding of the nuances between the two techniques and promoting evidence-based clinical decisions. Keywords (*CT, cardiac catheterization, coronary artery)*

Introduction

Cardiovascular disease is one of the leading causes of death globally, specifically coronary artery disease, which results from the narrowing or blockage of blood vessels that feed the heart. The accurate diagnosis of these diseases is based on advanced imaging techniques, most notably cardiac catheterization and computerized tomography coronary angiography (CTA). Both of these techniques have their own unique characteristics, warranting a comprehensive comparative study to determine their efficacy and the preference for their respective use in the diagnosis of coronary artery disease. Texas (2019, September 1). This research aims to provide a comparative analysis between cardiac catheterization and CT in terms of diagnostic accuracy, advantages, disadvantages, and the extent to which their results match clinical diagnoses. The research also addresses factors that may affect the accuracy of the diagnosis, such as patients' age, gender, obstruction rate, and comorbidities. The importance of this study lies in highlighting the extent to which cardiac catheterization, which is the gold standard in the diagnosis of coronary artery disease, can be replaced by a less invasive and safer technique, such as CT. The research concludes with a set of recommendations aimed at improving the use of these techniques in the diagnosis of coronary artery disease, while suggesting clinical guidelines for selecting the most appropriate technique for each disease condition. Through this study, we hope to make a scientific

contribution that will help enhance the accuracy of diagnosis and reduce the risks associated with interventional screening methods, which will reflect positively on the quality of health care provided to cardiac patients. Dewey, M. (2010)

Methodology

The principle of operation of the Radiology device used in cardiac catheterization:

The Cardiac Catheterization System operates through an integrated system based on X-ray Imaging and Digital Imaging technologies to see blood vessels and the heart during the procedure. The work begins by placing the patient on the Examination Table that is movable in all directions to ensure optimum shooting angles. The catheter is inserted through a blood vessel, usually from the femoral artery or radial artery, and then directed to the heart using real-time fluoroscopy. The X-ray tube installed in the frontal or lateral stand emits a beam of X-rays that penetrates the patient's body, and is absorbed to different degrees depending on the density of the tissue. The remaining rays reach the Image Intensifier or Flat-panel Detector, which converts them into an electronic signal that is digitally processed to produce a clear, high-resolution image. During the procedure, Contrast Media is injected through the catheter into the blood vessels or heart chambers, which helps improve the visibility of the cardiac structures and clearly distinguish blood flow. The resulting images are displayed in real time on ceiling-mounted or animated monitors, where the doctor can monitor changes and make an immediate diagnosis. Electrocardiogram (ECG) and blood pressure data are also displayed on additional monitors to monitor the patient's vital functions during catheterization. This integrated system allows the physician to accurately evaluate blood vessels and make appropriate treatment decisions (HTM Wiki,13 2025).

Stages of Coronary Artery Catheterization Procedure:

Coronary angiography is the gold standard in the diagnosis of coronary artery disease (CAD), allowing for the assessment of stenosis or occlusion of coronary arteries using left heart catheterization. This procedure contributes to determining the most appropriate treatment plan, whether through drug therapy, Percutaneous Coronary Intervention (PCI), or surgical revascularization. A thin, flexible catheter is inserted through the femoral or radial artery and precisely guided using X-rays to access and examine the coronary arteries.

To achieve the best diagnostic and therapeutic results, the process can be divided into three main stages:

1. Preparation phase:

This stage is an essential step to ensure the success of the catheter and reduce possible complications, including:

- **Obtaining informed consent:** The doctor explains to the patient the details of the procedure, its benefits, potential risks, and available treatment options.
- **Laboratory tests and initial evaluation:** Includes hemoglobin level analysis, electrolyte balance, kidney function, and coagulation tests. (INR, PTT)
- **ECG monitoring**: **(ECG)** to follow the stability of cardiac activity before and during the procedure.
- **Establish intravenous access (IV Access)** for the administration of necessary medications and rapid intervention in emergency cases.
- **Administer preventive medications:** Aspirin and antiplatelet agents such as Clopidogrel are given according to therapeutic protocol.
- **Final review: This** includes verifying the patient's identity, reviewing the examinations, and ensuring the availability of all necessary tools and equipment. Texas (2019, September 1)

2. The implementation phase of the procedure

- **Vascular Access:** The catheter is inserted through the femoral or radial artery and directed to the heart using fluorescence guidance.
- **Identification of radiographic angles:** to ensure clear images of coronary anatomy.

- **Contrast Injection: To enhance the** visibility of blood vessels in radiography.
- **Image analysis and diagnostic evaluation:** The extent of obstruction or stenosis is determined, which helps in making the appropriate treatment decision.

3. post-Catheterization

After completing the procedure, the patient undergoes careful monitoring to make sure his condition is stable and to detect any possible complications, such as bleeding or arrhythmias. Therapeutic steps are determined based on catheter outcomes, which may include immediate catheter intervention, drug therapy, or surgery, depending on the severity of the obstruction and the patient's clinical condition Johns. (2019, September 1).) **Radiological poses and coronary angles**

Imaging angles play an essential role in improving the quality of coronary angiography during cardiac catheterization, as each position allows for a different viewing angle that helps accurately assess blockages and stenosis. The naming of these angles depends on the position of the Image Intensifier-II relative to the patient's body. Cardiac CT scanning procedures for coronary arteries

1. Patient Preparation

A. Informed Consent

Before a coronary artery tomography (CTA) procedure, it is preferable to obtain the informed consent of the patient, as the doctor explains the nature of the procedure, its indications, its diagnostic importance, as well as possible risks, such as sensitivity to the contrast material.

B. Fasting and preparatory examinations

- The patient is required to fast for at least five hours before the examination.
- Kidney function is evaluated to avoid contrast material complications.
- An electrocardiogram (ECG) is performed before the start of the scan to ensure a regular heartbeat.

C. Heart rate control

To improve image quality, the heart rate should preferably be between 55-65 beats/min. This is achieved using:

- Beta-blockers (e.g., bisoprolol and metoprolol) orally or intravenously.
- If channel blockers are used to reduce the heart rate.

- With Dual-Source Technology, strict heart rate control has become less important in some cases (Texas, 2019, September 1).

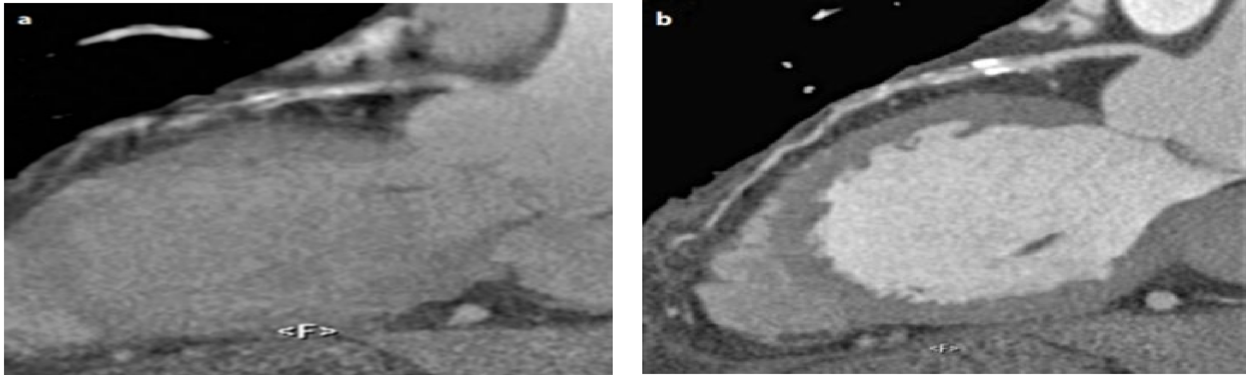


Figure 6 illustrated The effect of heart rate on the quality of CT images of the heart, where: The image (a) was taken when the heart rate was 75 beats per minute, and it shows obvious abnormalities due to the movement of the heart, making the details unclear. Picture (b) taken at a heart rate of 62 beats per minute after re-injection of contrast material, which is more pronounced with better vascular and cardiac details.

. Training the patient to hold their breath

Breath-hold training is essential to avoid kinesthetic confusion. It is recommended that the variation in heart rate during training be less than 10% to ensure the accuracy of the examination..(2010) .Dewey, M

2. Examination Procedures

a. Patient positioning and electrocardiogram (ECG) conduction

1. Patient posture: The patient lies on his back on the examination table with the arms raised above the head to ensure perfect coverage of the heart and reduce motor interference. It is ensured that the entire chest is within the field of imaging, so that it includes the heart and coronary arteries to provide clear and accurate images.

3. Electrocardiogram connection (ECG Leads): The electrocardiogram electrodes are connected to the patient's chest to synchronize the imaging with the heart's cycle, taking into account that they are placed away from the imaging path to avoid interference. ECG signal recording allows accurate selection of reconstruction stages, which reduces motor noise and improves the quality of diagnostic images.

2. Scan Range: The range of imaging starts from the top of the left coronary artery (usually from the base of the aorta - Level of Carina or slightly higher) and extends down the heart, including the branches of the coronary artery into the ventricles, and usually ends at the lower diaphragm (Texas, 2019, September 1).

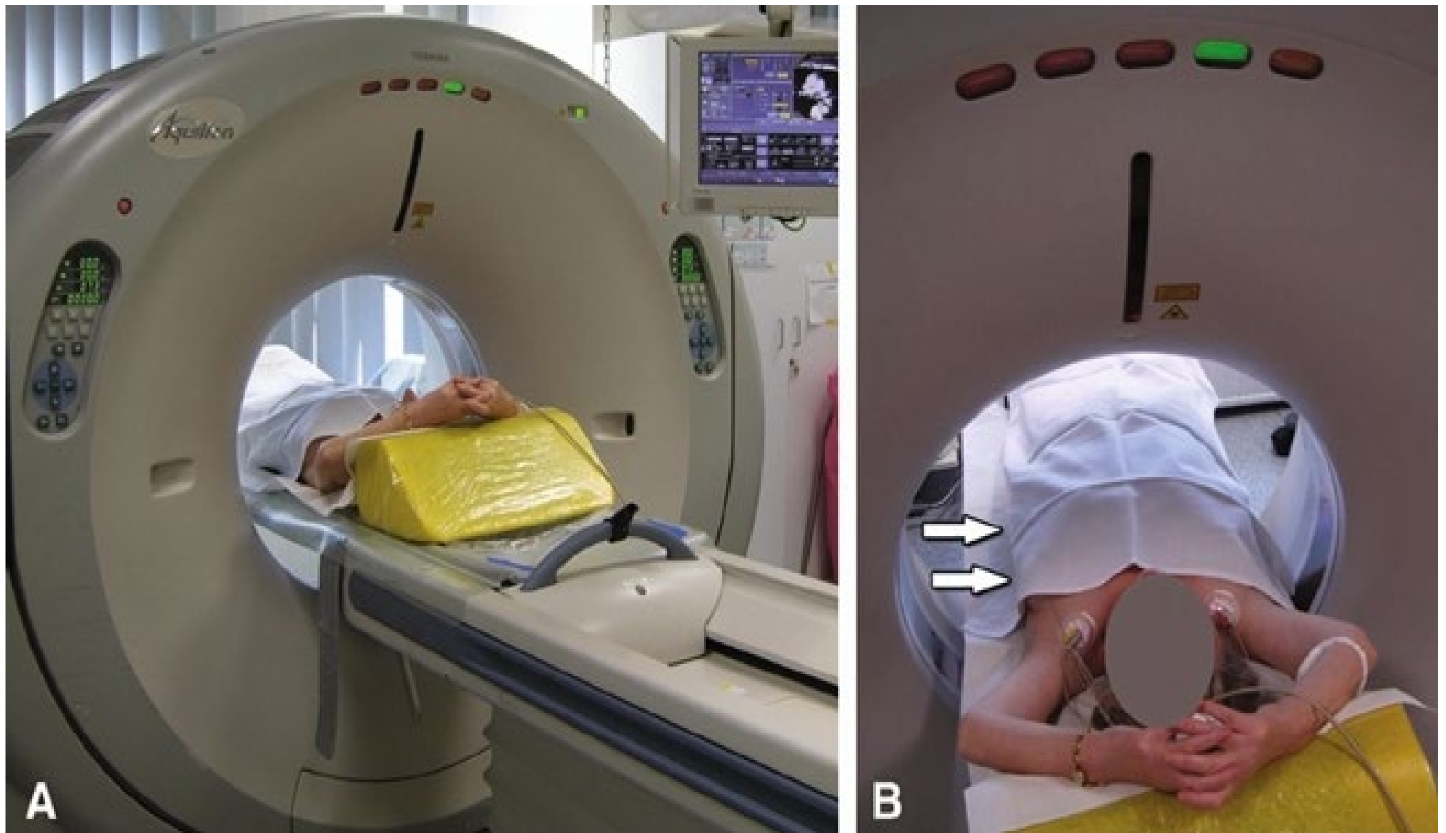


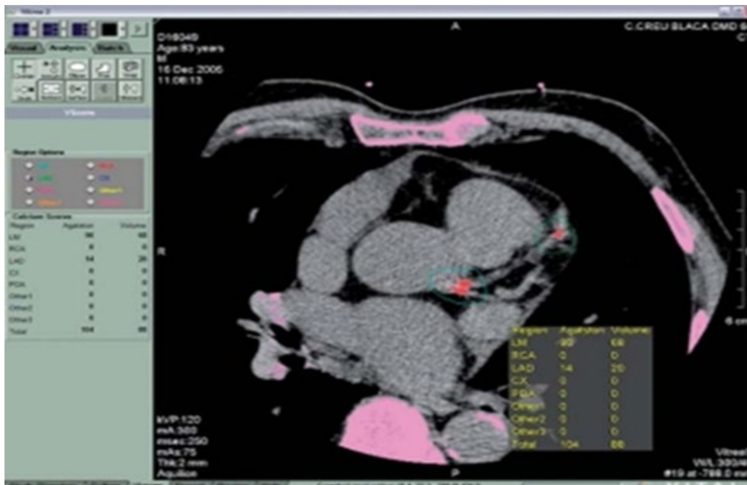
Fig. 7 illustrated Patient's posture during cardiac tomography.(Cardiac CT) A foot–first examination (Picture A) is preferred for easier access by the physician. The arms are placed over the head to improve X–ray penetration and reduce radioactive interference. The patient leans slightly to the right (Picture B) to ensure the heart is centered within the imaging range. ECG electrodes are fixed in the supraclavicular fossa to reduce the effects of muscle twitching, while avoiding placement on the biceps or

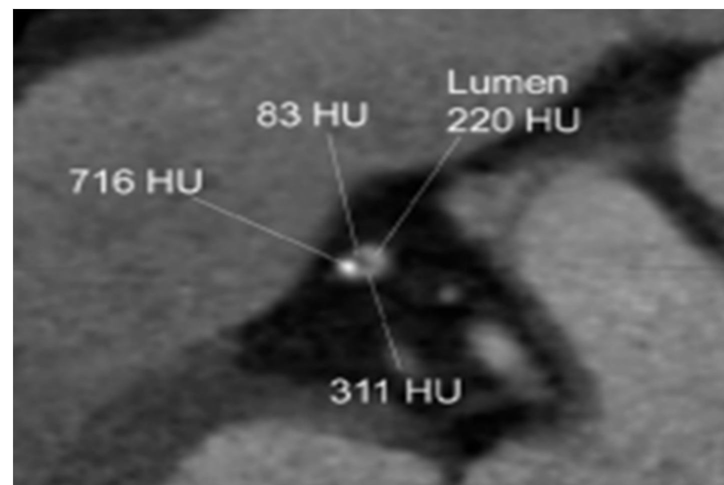
. Coronary calcium measurement: (Calcium Scoring)

- It is used to assess the extent of coronary artery calcification as an indicator of atherosclerosis and coronary heart disease.
- It is done without injecting the contrast material with a 3 mm thickness stratification to reduce the radiation dose.

- It is best not used alone for low-risk patients.

Contrast Injection





- Injection is carried out at rates of 3-8 ml/s using an auto- injector.

Figure 8 illustrated Results of a coronary artery calcification (Calcium Scoring) scan using computed tomography (CT). Image (A) shows a section of the heart highlighting where calcifications build up within the coronary arteries, while image (B) shows radial density measurements of calcification using HU, which helps assess

- Injection through the right radial vein is preferred to avoid interference with the coronary grafts. The material is pushed with saline solution to reduce visual distortion (.(Dewey, M., 2010

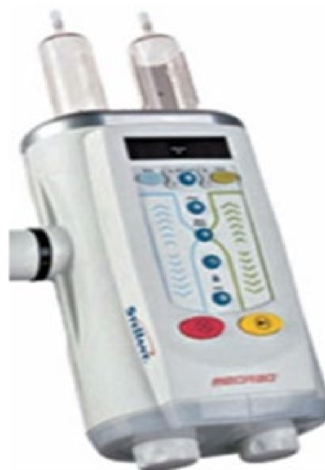


Fig 9 illustrated Auto Injector for Contrast Material

Before starting the scan, make sure that the injection system is free of air to avoid any possible complications. The patient is advised to hold the breath for a short time during the examination to avoid sudden changes in heart rate.

- The timing of the start of filming is determined in two ways: Bolus Tracking: The shooting process starts when the contrast reaches a specific intensity threshold (>100 HU).

- Test Bolus: A small dose is used to calculate circulation time and optimize the timing of imaging. The first method is preferred because it is more accurate and reduces the amount of contrast agent used.

Reconfigure images and improve quality

1. Technical standards

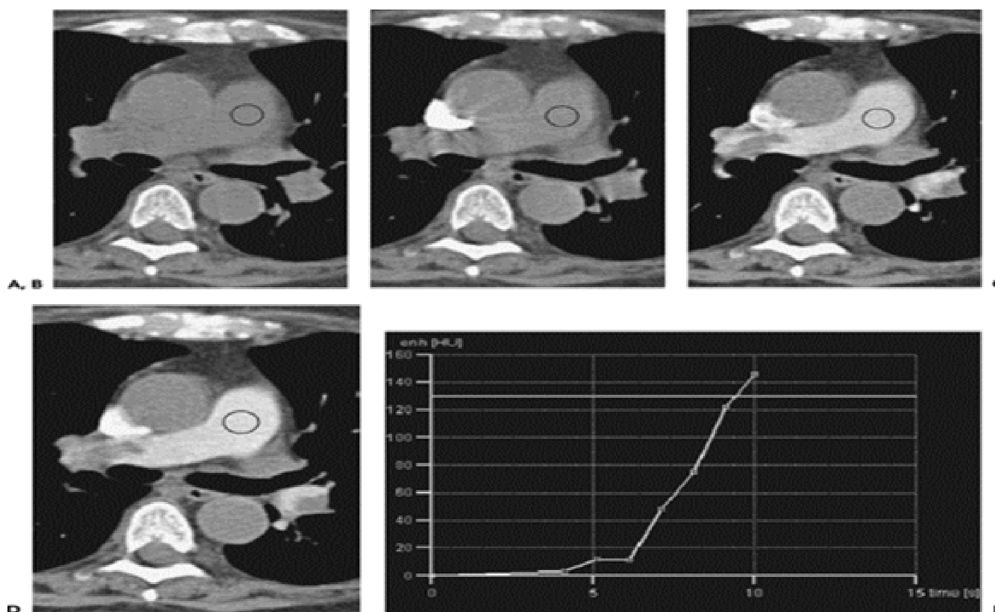
The reconstruction settings are adjusted to achieve the highest spatial resolution using a small field of view (180-200 mm) and a slide thickness of 0.5-0.75 mm, with the use of specialized cores, especially when supports are present.

2. Imaging Quality Improvement Techniques

- ECG-Gated Acquisition: Allows imaging during the tildes Olic phase to reduce motor distortion.

Figure10 illustrated Using bolus tracking technology to improve CT timing.

- Multi-part reconfiguration: used to reduce the impact of the heartbeat.



- Iterative Reconfiguration: Reduces noise with reduced radiation dose [2].

. Post-exam care

- The patient is monitored to ensure that no complications occur, especially due to nitroglycerin or beta-blockers.

- Patients are advised to drink sufficient amounts of water to help the kidneys dispose of the contrast material.
- Most patients can return to their daily activities immediately after the examination.

Results

1. Distribution of cases by age group

This table shows the distribution of patients undergoing cardiac catheterization and CT scanning by age groups, with the aim of determining the most common ages for coronary artery disease.

Age Group	Number of Patients in Cardiac Catheterization (CAG))	Number of patients in Computed Tomography (CCTA)	total of %
30 - 50	10	8	22.5%
51 - 60	12	14	32.5%
61-70	8	6	17.5%
70 +	10	12	27.5%
Total	40	40	100%

Table1. Distribution of cases by age group

- **Analysis:**

The results showed that the most represented age group among patients was 51–60 years old with 32.5%, followed by the group over 70 years old with 27.5%. The proportion of patients in the 30–50 age group was about 22.5%, while the lowest proportion in the 61–70 age group was 17.5%. This distribution indicates a high prevalence of coronary artery disease in advanced ages.

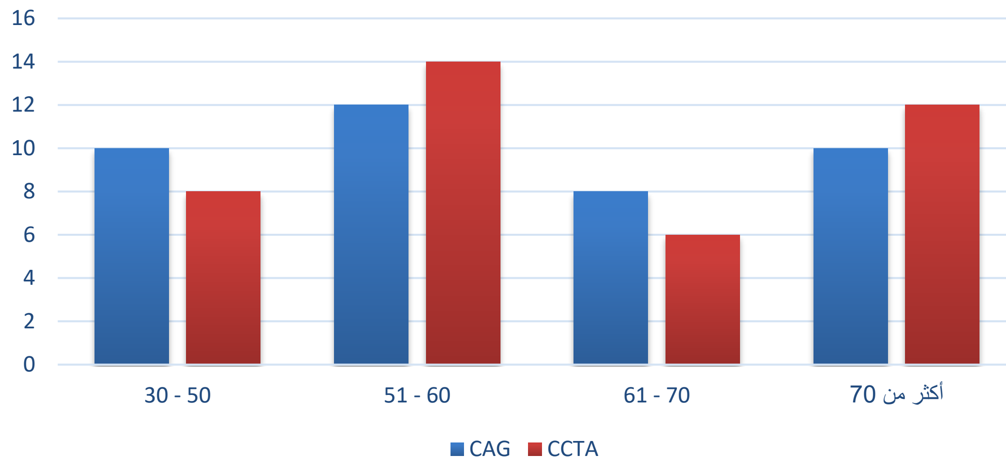


Figure1 shows the distribution of cases by age group

2. Distribution of cases by gender:

This table shows the distribution of cases between males and females in both examinations, to see if there is a difference in the incidence of coronary artery disease between the sexes.

Table.2 shows the number of cases by gender:

Gender	Number of patients in CAG	Percentage	Number of patients in CCTA	Percentage
Males	22	55%	24	60%
Females	18	45%	16	40%
Total	40	100%	40	100%

- **Analysis:**

Males were found to be the most represented in both examinations, with 55% in cardiac catheterization and 60% in tomography, while females were 45% in catheterization and 40% in imaging. This indicates that coronary artery disease is more common among males within the sampled studied.

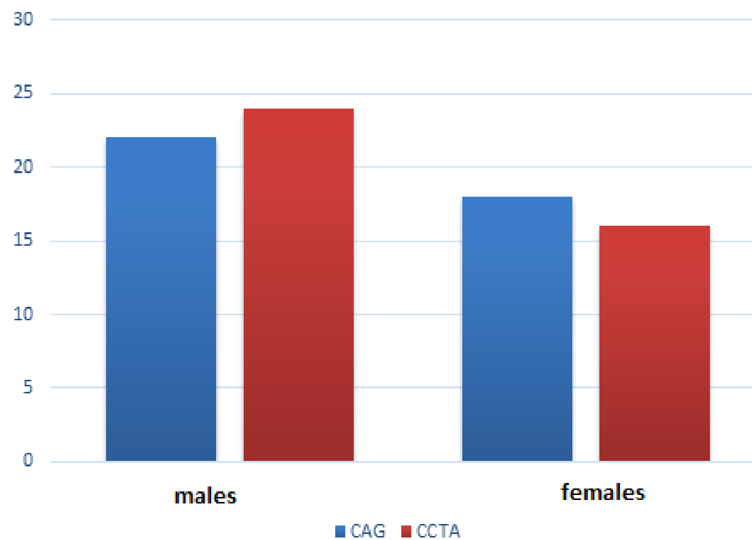


Figure2. Distribution of cases by gender

3. Distribution of cases by primary symptoms:

This table shows the symptoms that patients showed when heading for the examination, and shows the frequency of each symptom among patients who underwent cardiac catheterization and CT scanning.

Table.3 shows the distribution of the number of cases according to the initial symptoms of both procedures

Initial Symptoms	Number of patients in CAG	Percentage	Number of patients in CCTA	Percentage
Chest pain and shortness of breath	32	59%	28	59%
Unmeasurable blood pressure	13	22%	3	6%
Heartburn and nausea with coldness and sweating	10	19%	16	34%

Analysis:

The results showed that chest pain and shortness of breath were the most common symptoms at 59% on both scans. Unmeasurable blood pressure was observed to be more pronounced in patients with cardiac catheterization by 22%

compared to 6% in CT patients, while symptoms of nausea, burning, cold, and sweating were more pronounced in CT patients by 34% versus 19% in catheterization, which may indicate a difference in the severity of the condition or the pattern of symptoms when guiding patients to the appropriate type of examination.

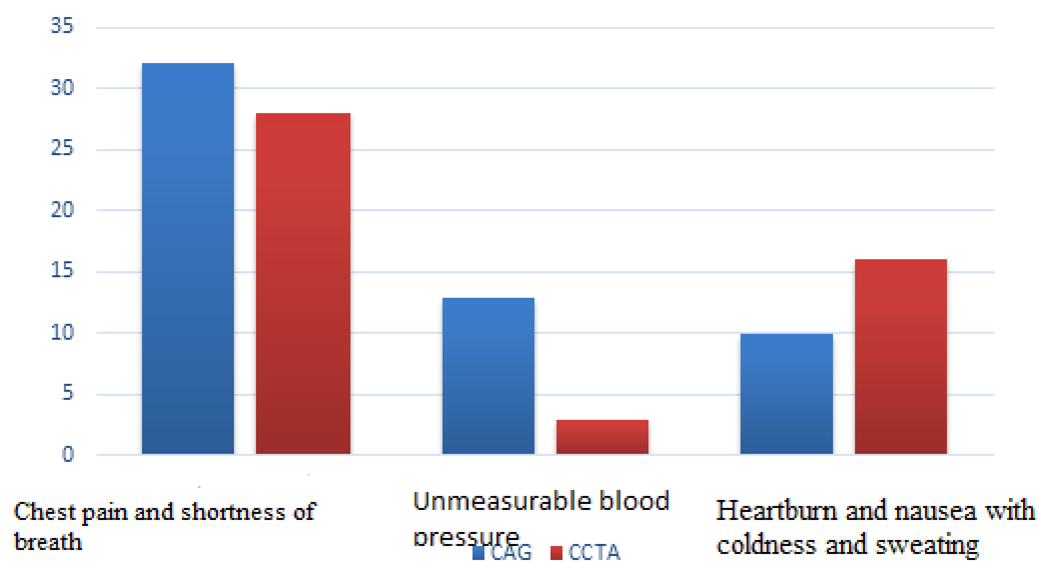


Figure3. Distribution of cases by primary symptom

4. Distribution of cases by chronic diseases

This table shows the most common concomitant chronic diseases among patients, and compares their prevalence between the two groups, with the aim of understanding the relationship between chronic diseases and the screening option used.

Table.4 shows the distribution of cases by chronic diseases and the type of each procedure

Chronic diseases	Number of patients in CAG	Percentage	Number of patients in CCTA	Percentage
Hypertension (HPN))	20	28%	18	32%
Diabetes	14	20%	13	23%
Acute coronary syndrome	12	17%	8	14%

Bronchial Asthma Syndrome	9	12%	2	4%
Family History Positive	4	6%	3	5%
Chronic renal disease	3	4%	0	0%
patients without any chronic diseases	8	11%	12	21%

- **Analysis:**

The results showed that hypertension was the most common chronic disease among patients with 28% in catheters and 32% in CT scans, followed by diabetes mellitus with 20% and 23%, respectively. No cases of chronic kidney disease were recorded in the CT group, while 4% appeared in the catheter group, while the percentage of patients without any chronic diseases was 21% in the imaging and 11% in the catheter, reflecting a difference in the characteristics of patients referred for each type of examination.

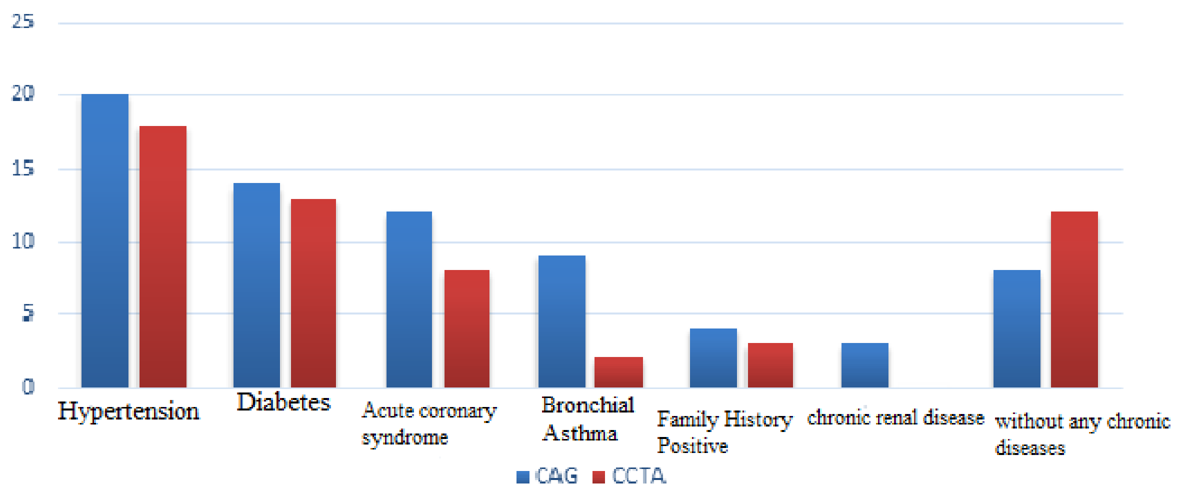


Figure 4 Distribution of cases by chronic diseases

5. Comparison of cardiac catheterization and coronary tomography results in patients who underwent both examinations:

This table shows the results of a direct comparison between coronary axial tomography (CCTA) and cardiac catheterization (CAG) in the four subjects, in order to assess the extent to which the two techniques are identical or different in detecting coronary stenosis.

Table5. Comparison of cardiac catheterization and coronary tomography results in patients who underwent both examinations

Age	Gender	Comorbidities	Reason for Examination	Diagnosis of Cardiac Catheterization (CAG)	Diagnosis of Computed Tomography (CCTA)	Match Range
60	Male	Diabetes, hypertension	Recurrent chest pain	85% stenosis of the main left artery	80% stenosis of the main left artery	Relatively identical
67	Male	Hyperlipidemia, previous heart attack	Follow up after a previous heart attack to assess the extent of the stenosis	90% anterior descending left artery stenosis	85% anterior descending left artery stenosis	Relatively identical
70	Male	Hypertension, atherosclerosis	Myocardial dysfunction and suspected ischemia	75% anterior descending artery stenosis	Unspecified stenosis due to dense calcifications	Poor CT reading due to calcifications
52	Female	Diabetic, high cholesterol	Pre-Valve Replacement Inspection	40% coiled artery stenosis	3,5% coiled artery stenosis	Relatively identical

- **Analysis:**

The results showed that there was an exact or good match in three out of four cases, while a difference was recorded in only one case as a result of the presence of dense arterial calcifications that affected the quality of the CT image, which hindered the accurate evaluation of the stenosis. This suggests that CCTA delivers high accuracy in cases without severe calcifications, while cardiac catheterization remains the closest reference in complex cases.

Discussion

When comparing the results of this study with previous studies, there is a clear consensus on the effectiveness of both coronary axial tomography (CCTA) and cardiac catheterization (CAG) in the diagnosis of coronary artery stenosis. The current study showed good compatibility between the two examinations in most cases, especially those without dense arterial calcifications, which is in line with the results of the Elagha et al study. (2021) confirmed the high sensitivity and quality of CCTA, especially in the assessment of low- and moderate-risk patients before surgical interventions.

The results also support Sajjadieh et al. (2013) showed that the accuracy of CCTA is adversely affected in cases with severe calcifications, which was observed in one case within the current study, where it was not possible to obtain an accurate diagnosis with tomography due to the intensity of calcifications, while cardiac catheterization provided a clearer diagnosis.

The present study highlights the role of CT as an effective non-interventional tool, which can be relied upon in the initial assessment, especially for patients with atypical symptoms or who do not suffer from serious chronic diseases. In contrast, cardiac catheterization remains the most accurate and comprehensive option in complex cases, or those that require therapeutic intervention at the same time.

Thus, these results emphasize the complementarity of the role of the two examinations, not the absolute superiority of one of them, but the need to choose the most appropriate method according to the patient's clinical condition, the complexity of the case, and the available technical and medical resources. (Houston Methodist. (2023, July).

Recommendations:

In light of the results of this study and compared to previous studies, the following recommendations can be made:

1. Relying on CT as an initial screening to assess coronary arteries in low- to moderate-risk patients, especially in cases that do not require immediate intervention, or in which the patient has atypical symptoms.
2. Cardiac catheterization is used in complex situations or where direct therapeutic intervention may be needed, or in the presence of severe arterial calcifications that may affect the accuracy of CT results.
3. Improve CT protocols by controlling heart rate and using advanced techniques to reduce noise from calcifications, increasing image quality, and increasing the reliability of results.

Raise awareness among health practitioners of the importance of selecting the most appropriate examination based on clinical evaluation, providing adequate training in accurately interpreting CT results, and avoiding unnecessary catheterization. Encouraging future studies, especially by new students and researchers, to expand the analysis of cases that have undergone both examinations (CAG and CCTA), as this is important in enhancing the

accuracy of comparisons and providing more in-depth and comprehensive results, especially when applied to diverse samples that include different age and gender groups.

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التقنيات الإشعاعية في تصوير الشرايين التاجية: مقارنة بين التصوير المقطعي المحوسب والقسطرة القلبية

ليلى الطاهر عيسى العيساوي، فتحي الصادق الدرسي، ملك مسعود الرابوب

المعهد العالي للعلوم والتقنيات الطبية - طرابلس

الملخص

يهدف هذا البحث إلى مقارنة دقة وكفاءة كل من القسطرة القلبية والتصوير المقطعي المحوسب في تشخيص أمراض الشرايين التاجية، نظرًا لأهمية اختيار الوسيلة التشخيصية المناسبة في تحسين دقة التشخيص وتقليل المخاطر المحتملة على المرضى. اعتمدت الدراسة على المنهج الوصفي التحليلي، حيث تم جمع وتحليل بيانات 80 مريضًا خضعوا لأحد الفحصين في مستشفى معيتيقة العسكري ومستشفى العاصمة، وتم تقييم النتائج وفقًا لمعايير تشمل نسبة الانسداد، دقة التشخيص، والمخاطر المرتبطة بكل إجراء. أظهرت النتائج أن الفئة العمرية الأكثر عرضة للإصابة بأمراض الشرايين التاجية تراوحت بين 50-70 عامًا (50%)، مع ارتفاع نسبة الذكور مقارنة بالإناث، حيث بلغت 55% في القسطرة القلبية و60% في التصوير المقطعي. وكانت الأعراض الأكثر شيوعًا ألم الصدر وضيق التنفس، مع تباينات طفيفة في توزيع الأعراض الأخرى. كما أظهرت مقارنة أربع حالات خضعت للفحصين تطابقًا ملحوظًا بين التقنيتين، إلا أن القسطرة القلبية تفوقت في دقة التشخيص، خاصة في الحالات المعقدة التي تتسم بانسدادات شريانية شديدة أو تكلسات وعائية كثيفة. تشير هذه النتائج إلى أن التصوير المقطعي المحوسب للقلب يُعد خيارًا فعالًا للفحص الأولي، خاصة للحالات التي لا تتطلب تدخلاً علاجيًا مباشرًا، نظرًا لكونه إجراءً غير جراحي يتميز بسرعة الإنجاز وانخفاض المخاطر. ومع ذلك،

فإن القسطرة القلبية تظل المعيار الذهبي لتشخيص أمراض الشرايين التاجية، حيث تحقق دقة تشخيصية عالية، لا سيما في الحالات التي تحتاج إلى تدخل علاجي فوري مثل تركيب الدعامات.

بناءً على هذه النتائج، يوصى باستخدام التصوير المقطعي كأداة فحص أولية لدى المرضى منخفضي ومتوسطي الخطورة، بينما يتم اللجوء إلى القسطرة القلبية عند الحاجة إلى دقة تشخيصية أعلى أو تدخل علاجي. ويوصي البحث بإجراء دراسات مستقبلية تشمل حجم عينة أكبر وتحليلًا إحصائيًا أعمق، مما يسهم في تحسين فهم الفروق الدقيقة بين التقنيتين وتعزيز القرارات السريرية المبنية على الأدلة.