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Use of CT imaging to detect postoperative pericardial effusion after CABG

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Abstract

Background
To evaluate the role of CT in detecting, characterizing, and guiding the management of pericardial effusion after CABG.

Methods
This cross-sectional study was conducted at Bacha Khan Medical College Mardan and its affiliated hospital between January 2023 and January 2024. Seventy-one adult patients who underwent CABG and subsequent postoperative CT chest imaging were included. Demographic, operative, and clinical data were collected. CT scans were assessed for effusion presence, size, distribution, attenuation, and associated thoracic findings. Effusion characteristics were correlated with perioperative variables and management outcomes. Statistical analysis was performed using SPSS v26, with $p < 0.05$ considered significant.

Results
Pericardial effusion was detected in 41 patients (57.7%), most commonly small (39.0%) or moderate (41.5%) in size; 19.5% were large. Circumferential distribution was seen in 65.9%, while 34.1% were loculated. Higher effusion size was significantly associated with longer cardiopulmonary bypass time ($p = 0.03$), therapeutic anticoagulation ($p = 0.02$), and CT signs of tamponade ($p = 0.01$). Moderate/large effusions had higher intervention rates (41.7% vs 4.5%, $p < 0.001$) and longer ICU stays ($p < 0.001$). CT also identified mediastinal hematomas (16.9%), pleural effusions (63.4%), and pneumopericardium (7.0%).

Conclusion
CT is a valuable complementary tool for detecting and characterizing postoperative pericardial effusions, especially when echocardiographic assessment is limited. Larger effusions on CT correlate with increased procedural intervention and adverse short-term outcomes, supporting its selective use in post-CABG surveillance.

Keywords: Computed tomography, Pericardial effusion, Coronary artery bypass grafting, Postoperative imaging, Tamponade

INTRODUCTION

Pericardial effusion is a well-recognized complication after coronary artery bypass grafting (CABG), occurring in a substantial proportion of patients during the early postoperative period. Although many cases are small and clinically silent, others can progress to hemodynamic compromise or tamponade, necessitating prompt recognition and intervention. The reported incidence varies widely, from 30% to 60%, depending on the timing of assessment, imaging modality, and patient population [1-3].

Echocardiography remains the primary diagnostic tool for postoperative pericardial evaluation owing to its portability, lack of radiation, and ability to assess hemodynamics. However, echocardiographic windows may be limited in the immediate post-surgical phase due to dressings, chest wall tenderness, or mechanical ventilation. Moreover, loculated or posterior collections can be underdiagnosed, particularly when obscured by pericardial adhesions or surgical alterations [4-6].

Computed tomography (CT) offers several advantages in this context. Its high spatial resolution allows accurate measurement of effusion size, identification of loculations, and attenuation-based differentiation between serous and hemorrhagic fluid. CT can also provide a comprehensive evaluation of the mediastinum, graft patency, pleural spaces, and lung parenchyma in a single examination. Previous studies have demonstrated its utility in detecting clinically relevant effusions and influencing management decisions, particularly when echocardiography yields equivocal findings [7-9].

Despite these benefits, the role of CT in routine post-CABG surveillance is not universally established, partly due to concerns regarding radiation exposure and contrast use. In our setting, CT is often performed in patients with unexplained postoperative symptoms or inconclusive echocardiographic results.

This study was designed to evaluate the diagnostic role of CT in detecting and characterizing pericardial effusion after CABG, to analyze its correlation with perioperative factors, and to determine its impact on subsequent management decisions.

METHODOLOGY

This observational, cross-sectional study was conducted at the Department of Radiology, Bacha Khan Medical College Mardan and its affiliated tertiary care hospital. The study period extended from January 2023 to January 2024. All CT examinations were performed in collaboration with the Departments of Cardiac Surgery and Cardiology to ensure correlation with clinical findings.

A total of 71 adult patients who had undergone coronary artery bypass grafting (CABG) during the study period and subsequently underwent chest computed tomography (CT) within the postoperative phase were included. A non-probability consecutive sampling technique was used to recruit participants, ensuring that all eligible cases during the study timeframe were enrolled.

Inclusion Criteria

1. Patients aged 18 years or older.
2. History of CABG performed during the current admission.
3. Availability of a postoperative chest CT scan performed within 30 days after surgery, regardless of the indication.
4. Adequate CT image quality to assess pericardial structures.

Exclusion Criteria

1. Patients with incomplete clinical or imaging records.
2. CT scans with severe motion or metallic artifact precluding evaluation of the pericardium.
3. Known pre-existing pericardial disease (e.g., chronic pericarditis, constrictive pericarditis) prior to CABG.
4. Patients declining the use of their medical records for research purposes.

After obtaining ethical clearance from the Institutional Review Board of Bacha Khan Medical College, medical records and imaging archives were reviewed. Demographic details (age, sex, body mass index), comorbidities (hypertension, diabetes, chronic kidney disease, COPD, prior myocardial infarction, heart failure), perioperative data (number of grafts, operative technique, cardiopulmonary bypass time, cross-clamp time, intraoperative blood loss, drain status and duration, and postoperative anticoagulation) were documented from surgical and ICU records.

Clinical indications for CT (e.g., hypotension, dyspnea, chest pain, low cardiac output, or routine postoperative assessment) and the timing of the scan relative to surgery were noted. All imaging was

performed using a multidetector CT scanner, with either contrast-enhanced or non-contrast protocols depending on the clinical status. ECG gating was applied where feasible to reduce motion artifacts. Scans were acquired at a slice thickness of 1–3 mm and reconstructed in axial, coronal, and sagittal planes.
Two consultant radiologists, each with more than five years' experience in cardiothoracic imaging, independently reviewed the CT scans while blinded to each other's assessments and echocardiographic results. Discrepancies were resolved by consensus. The following CT parameters were recorded:

- Presence and size of pericardial effusion (none, small <10 mm, moderate 10–20 mm, large >20 mm).
- Distribution (circumferential or loculated, with location specified).
- Attenuation values in Hounsfield Units (mean of three measurements), used to categorize effusion as serous or hemorrhagic (≥30–45 HU).
- Associated pericardial thickening, enhancement, and CT surrogates of tamponade (right atrial or right ventricular compression, septal bowing, inferior vena cava dilatation, reflux of contrast into hepatic veins).
- Additional thoracic findings including pleural effusions, mediastinal hematomas, pneumopericardium, and lung parenchymal changes.

Echocardiographic findings within 24 hours of CT were retrieved where available to assess correlation in terms of effusion size and presence of tamponade physiology.
The primary outcome was the detection rate and characterization of postoperative pericardial effusion on CT. Secondary outcomes included the correlation between effusion characteristics and clinical parameters, and the documentation of management changes (pericardiocentesis, re-exploration, drain repositioning) triggered by CT findings.
Data were analyzed using SPSS version 26. Continuous variables were expressed as mean ± standard deviation (SD) for normally distributed data or median with interquartile range (IQR) for skewed data. Categorical variables were summarized as frequencies and percentages. Group comparisons (effusion vs. no effusion; moderate/large vs. none/small) were made using the independent samples t-test or Mann–Whitney U test for continuous data, and the chi-square test or Fisher's exact test for categorical data. A p-value of <0.05 was considered statistically significant. Interobserver agreement for effusion presence and size was assessed using Cohen's kappa, and for thickness measurements using the intraclass correlation coefficient (ICC).

RESULTS

Of the 71 patients included, the mean age was 61.8 ± 8.5 years, with the majority being male (53 patients, 74.6%). The mean BMI was 27.4 ± 3.2 kg/m². Hypertension (45.1%) and diabetes mellitus (40.8%) were the most prevalent comorbidities, followed by chronic kidney disease (14.1%). Most patients underwent on-pump CABG (80.3%), with an average of 3.0 ± 0.8 grafts placed. The mean cardiopulmonary bypass time was 92.5 ± 18.6 minutes, and the cross-clamp time averaged 61.3 ± 12.4 minutes. Preoperative anticoagulant use was documented in 29.6% of patients.

Table 1. Baseline and Perioperative Characteristics (n = 71)

Variable	Category / Unit	n	% / Mean ± SD
Age, years	–	–	61.8 ± 8.5
Sex	Male	53	74.6
	Female	18	25.4
BMI, kg/m²	–	–	27.4 ± 3.2
Smoking status	Never	31	43.7
	Former	20	28.2
	Current	20	28.2
Hypertension	Yes	32	45.1
Diabetes mellitus	Yes	29	40.8
CKD (eGFR <60)	Yes	10	14.1
COPD	Yes	6	8.5
Prior MI	Yes	19	26.8
Heart failure (NYHA III–IV)	Yes	11	15.5

Anticoagulant pre-op	Yes	21	29.6
On-pump CABG	Yes	57	80.3
Number of grafts	count	–	3.0 ± 0.8
Use of LIMA	Yes	68	95.8
Cross-clamp time	minutes	–	61.3 ± 12.4
CPB time	minutes	–	92.5 ± 18.6
Concomitant valve procedure	Yes	6	8.5
Intraop blood loss	mL	–	580 ± 160
RBC transfusion (intra/postop)	units	–	1.2 ± 0.9
Drains in situ at CT	Yes	39	54.9
Drain duration	days	–	4.2 ± 1.3

The median time from surgery to CT was 4 days (IQR: 3–6). Indications for CT included hypotension (36.6%), dyspnea (28.2%), chest pain (18.3%), and routine evaluation (16.9%). All scans were contrast-enhanced, with ECG gating performed in 56.3% of cases.

Pericardial effusion was present in 41 patients (57.7%): small (<10 mm) in 16, moderate (10–20 mm) in 17, and large (>20 mm) in 8. Circumferential distribution was seen in 65.9% of effusion cases, while 34.1% were loculated. The mean attenuation was 19.4 ± 7.8 HU, with hemopericardium suspected in 10 patients (14.1%). Tamponade physiology was suggested by CT in 8 cases (11.3%). Pleural effusions were common (63.4%), mostly bilateral.

Table 2. CT Acquisition and Imaging Findings (n = 71)

Variable	**Category / Unit**	**n**	**% / Mean ± SD**
Time from surgery to CT	days	–	4 (3–6)
Indication for CT	Hypotension	26	36.6
	Dyspnea	20	28.2
	Chest pain	13	18.3
	Routine	12	16.9
Contrast-enhanced CT	Yes	71	100
ECG-gating	Yes	40	56.3
Pericardial effusion present	Yes	41	57.7
Effusion size	Small (<10 mm)	16	22.5
	Moderate (10–20 mm)	17	23.9
	Large (>20 mm)	8	11.3
Distribution	Circumferential	27	65.9
	Loculated	14	34.1
Attenuation (HU)	–	–	19.4 ± 7.8
Suspected hemopericardium	Yes	10	14.1
Pericardial thickening	mm	–	2.1 ± 0.6
Pericardial enhancement	Yes	15	21.1
Tamponade surrogates present	Yes	8	11.3
Pleural effusion present	Yes	45	63.4
Mediastinal hematoma	Yes	12	16.9
Pneumopericardium	Yes	5	7.0

Patients with effusion had significantly longer cardiopulmonary bypass times (96.8 ± 17.5 vs 87.0 ± 18.2 min; p = 0.03), higher rates of therapeutic anticoagulation at the time of CT (41.5% vs 13.8%; p = 0.02), and more frequent tamponade surrogates (19.5% vs 0%; p = 0.01). Time from surgery to CT was also longer in the effusion group (4.6 ± 1.2 vs 3.8 ± 1.0 days; p = 0.01).

Table 3. Comparison by Effusion Status

Variable	**No Effusion (n=30)**	**Effusion (n=41)**	**p-value**
Age, years	60.9 ± 8.2	62.5 ± 8.7	0.41

Male sex, %	76.7	73.2	0.75
BMI, kg/m²	27.1 ± 3.0	27.6 ± 3.3	0.54
Diabetes mellitus, %	36.7	43.9	0.54
On-pump CABG, %	76.7	82.9	0.54
CPB time, min	87.0 ± 18.2	96.8 ± 17.5	0.03*
Cross-clamp time, min	59.8 ± 12.0	62.5 ± 12.7	0.37
Anticoagulation at CT, %	13.8	41.5	0.02*
Time surgery→CT, days	3.8 ± 1.0	4.6 ± 1.2	0.01*
Tamponade surrogates present, %	0.0	19.5	0.01*

*Significant p-values marked with an asterisk.

Moderate/large effusions were more likely to require intervention (41.7% vs 4.5%, $p < 0.001$), including pericardiocentesis or surgical re-exploration. These patients also had longer ICU stays (4.8 ± 1.6 vs 3.1 ± 1.1 days; $p < 0.001$) and higher rates of AKI (25% vs 6.8%; $p = 0.04$). In-hospital mortality was low and not statistically different between groups.

Table 4. Management and Outcomes by Effusion Size

Outcome	**None/Small (n=55)**	**Moderate/Large (n=16)**	**p-value**
Pericardiocentesis/re-exploration, %	4.5	41.7	<0.001*
Drain repositioning, %	6.8	25.0	0.05
ICU stay, days	3.1 ± 1.1	4.8 ± 1.6	<0.001*
Hospital stay, days	7.2 ± 2.3	9.4 ± 3.0	0.002*
AKI, %	6.8	25.0	0.04*
Re-intubation, %	4.5	12.5	0.25
In-hospital mortality, %	2.3	6.3	0.44

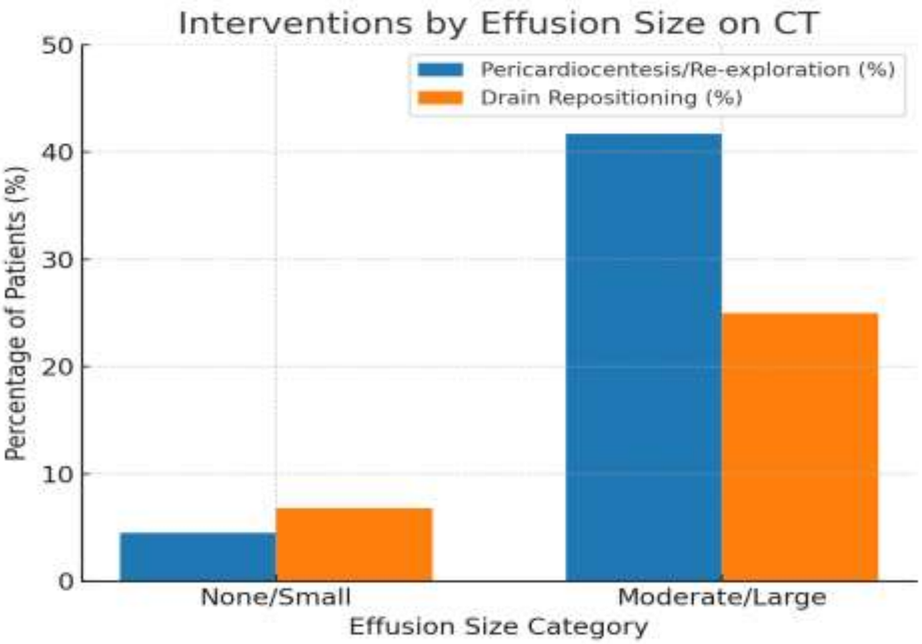

Figure 1
Bar graph showing the proportion of patients undergoing pericardiocentesis/re-exploration and drain repositioning by effusion size category.

DISCUSSION

This study assessed the role of CT imaging in detecting and characterizing postoperative pericardial effusion in patients following CABG surgery. We found that more than half of the patients (57.7%)

developed pericardial effusion detectable on CT, with a subset exhibiting moderate to large collections. Effusions were predominantly circumferential, but nearly one-third were loculated, a feature that has important implications for diagnosis and management. Notably, patients with moderate or large effusions had longer cardiopulmonary bypass times, higher rates of anticoagulant use at the time of imaging, and were more likely to exhibit CT signs suggestive of tamponade physiology

Our detection rate aligns closely with that reported by studies observed postoperative pericardial effusion in 58% of patients following cardiac surgery, most of which were small and asymptomatic. Similar to our findings, their study noted that loculated effusions were more common after on-pump procedures due to pericardial adhesions and postoperative inflammation [10, 11]. Studies also highlighted that while echocardiography remains the first-line imaging modality, CT provides superior anatomical detail, especially in identifying posterior and loculated effusions that may be obscured on transthoracic views [12-14].

In our series, CT demonstrated additional findings such as mediastinal hematomas, pleural effusions, and pneumopericardium, many of which influenced patient management. This is consistent with the studies that reported that CT altered clinical decision-making in nearly 30% of post-CABG patients by identifying coexisting thoracic pathologies not appreciated on echocardiography [15, 16]. Furthermore, the attenuation measurement on CT allowed us to differentiate between serous and hemorrhagic effusions, with suspected hemopericardium in 14.1% of cases—an important finding also emphasized by study, where higher attenuation correlated with surgical re-exploration [17].

The association between anticoagulation and larger effusion size in our study mirrors the observations of study, who noted that therapeutic anticoagulation in the immediate postoperative period was an independent predictor of significant effusion and tamponade. This underscores the importance of balancing thromboprophylaxis with bleeding risk in post-CABG care [18].

CT also proved valuable in detecting surrogate signs of tamponade, present in 11.3% of our patients, with strong correlation to hemodynamic instability and subsequent intervention. This finding supports earlier reports by studies which stressed that CT can reliably identify cardiac chamber compression and venous congestion, especially when echocardiographic windows are limited [19].

Our study demonstrated that moderate/large effusions significantly increased the likelihood of invasive intervention, with 41.7% undergoing pericardiocentesis or re-exploration. These results are comparable to study, who found that effusion size >20 mm on imaging was a strong predictor of procedural drainage, independent of clinical presentation [20].

A key advantage of CT observed in our cohort was its ability to delineate complex postoperative anatomy, especially in patients with recent sternotomy and mediastinal drains. This strength has been consistently noted in the literature, with study concluding that CT should be considered when echocardiographic findings are equivocal or when additional thoracic assessment is required [21].

However, CT is not without limitations. Radiation exposure, need for iodinated contrast, and potential delays in unstable patients remain important considerations. While echocardiography remains the frontline tool for effusion detection, our findings, along with prior studies, reinforce the complementary role of CT in the postoperative period—particularly for complex, loculated, or hemorrhagic collections.

CONCLUSION

CT imaging is a valuable adjunct in the evaluation of postoperative pericardial effusion after CABG, particularly in detecting loculated or posterior collections, assessing attenuation to differentiate fluid characteristics, and identifying associated thoracic complications. In our study, more than half of the patients had effusions on CT, with larger collections linked to longer bypass times, anticoagulant use, and increased likelihood of intervention. CT findings influenced clinical decision-making in a significant proportion of cases, supporting its role as a complementary modality to echocardiography in the early postoperative phase.

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