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Original Article

Evaluating Clinical Outcomes and Complications of Left Heart Catheterization as a Therapeutic Procedure in Acute Coronary Syndrome

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Abstract

Objective: This study aimed to assess the prevalence and types of complications related to cardiac catheterization in patients with acute coronary syndrome (ACS), identify the most common adverse events such as bleeding, infections, pulmonary edema, contrast-induced nephropathy, arrhythmias, and stroke, and provide recommendations for their prevention, early detection, and management.

Methods: A prospective study was conducted at Hameed Latif Hospital, Lahore, involving 220 patients diagnosed with ACS who underwent cardiac catheterization. Participants aged 18–75 years were selected through simple random sampling. Patients with prior CABG, bleeding disorders, advanced renal disease, pregnancy, or psychiatric illness were excluded. Data were collected on common post-catheterization complications, including vascular bleeding, infections, arrhythmias, contrast-induced nephropathy, stroke, and death. Ethical approval was obtained from the Institutional Review Board, and informed consent was secured from all participants. Data were analyzed using SPSS version 26, with results expressed as means, standard deviations, frequencies, and percentages, applying a significance level of 0.05.

Results: The patients had a mean age of 59.42 ± 9.36 years, with a slight male predominance (55.3%). Key complications identified included access site bleeding (0.9%), hematoma formation (2.6%), pulmonary edema (0.9%), cardiac arrhythmias (0.9%), cerebrovascular accidents (0.4%), acute stent thrombosis (0.4%), and death (0.4%). Radial access was used in 82.9% of procedures. No cases of contrast-induced nephropathy were reported.

Conclusion: The detailed focus on coronary angiography provided valuable insights into specific outcomes and significant complications. This research underscores the importance of specialized techniques and risk management in cardiac catheterization to better overall patient outcomes.

Keywords: Cardiac catheterization, Acute coronary syndrome, Therapeutic, Complications

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Introduction

Cardiac catheterization procedure involve various techniques such as right heart catheterization (RHC) and left heart catheterization (LHC), out of which we will only be considering left heart catheterization for this research. LHC procedure includes aortic angiography, coronary angiography; graft angiography and left ventricular angiography.It can trigger arrhythmias such as atrial fibrillation, ventricular tachycardia or bradycardia. RHC arrhythmias' may include supraventricular arrhythmias, ventricular arrhythmias as well as right bundle branch block and complete heart block. During left heart catheterization (LHC) ventricular

arrhythmias can occur but are generally transient and do not have a significant impact on long-term outcomes.[1] Bleeding at the catheter insertion site or within blood vessels is a frequent complication. Hematomas, accumulations of blood outside the vessels, may require intervention or blood transfusion. Strategies such as meticulous hemostasis techniques and the utilization of closure devices have been shown to minimize bleeding complications.[2] Infections can be of both type local or systemic. Cardiac catheterization, particularly femoral catheterization, poses a risk of infection. Factors such as frequent arterial puncture, leaving sheaths in place, age above 60, diabetes and obesity increase the likelihood of bacteremia. These infections can lead to severe complications and may require further surgical intervention and prolonged antibiotic treatment. To prevent and control catheter-related infections, strict adherence to aseptic procedures, appropriate antibiotic prophylaxis and constant observation for infection indicators are imperative.[3]

Contrast-Induced Nephropathy (CIN) is another important problem. The use of contrast agents during cardiac catheterization can potentially cause kidney damage, particularly in those with pre-existing renal impairment. To mitigate the risk of CIN, adequate hydration, limiting contrast volume and considering alternative imaging modalities have been recommended.[4] A retrospective study on primary PCI in Rome and Milan showed that using a transradial (TR) approach for PCI may reduce the risk of acute kidney injury (AKI) compared to a transfemoral (TF) approach. The frequency of AKI was lower in the TR group while TF access has higher risk of AKI. This suggests that adopting the TR approach could help mitigate the risk of AKI in emergent PCI procedures.[5] Cerebrovascular accidents (CVA) following percutaneous coronary intervention (PCI) occur in around 1 in 300 procedures. Patients with elevated risk include those with hypertension, diabetes, prior CVA history, and impaired renal function. CVA following PCI is linked with a higher risk of death, acute renal failure and dialysis. The use of thrombolytics, intravenous heparin, urgent or emergent catheterization and higher contrast use during the procedure are also associated with CVA.[6]

Radial artery access has gained fame due to reduced bleeding complications compared to femoral access.[7] Physician-owned specialty hospitals show better outcomes for certain procedures, but adjusting for patient risk factors diminishes the advantage, suggesting that patient complexity plays a role.[8] Other rare complications include myocardial infarction and death but are overall less than 1%.[9]

The objectives of this study are to determine the prevalence and types of complications associated with cardiac catheterization in patients with acute coronary syndrome (ACS) admitted over a 6-month period; to identify and quantify the most common complications, including vascular access site bleeding, infections, pulmonary edema, contrast-induced nephropathy, arrhythmias, myocardial infarction, cardiogenic shock, hematoma formation, stroke, and death; and to provide evidence-based insights and recommendations for the prevention, early detection, and management of these complications in ACS patients undergoing cardiac catheterization.

Methods

A prospective study was conducted at Hameed Latif Hospital, Lahore, a tertiary care facility recognized for its advanced cardiology services and interventional procedures. The study included 220 patients diagnosed with ACS, comprising ST-elevation myocardial infarction (STEMI), non-ST-elevation myocardial infarction (NSTEMI), and unstable angina, who underwent cardiac catheterization during the study period. Patients were selected using a simple random sampling technique to minimize selection bias and enhance the representativeness of the sample. Eligible participants were aged between 18 and 75 years, of either gender, and had a confirmed diagnosis of ACS requiring catheterization. Exclusion criteria included a history of coronary artery bypass graft surgery (CABG), known bleeding disorders or coagulopathies, significant renal impairment (eGFR <30 mL/min) or dialysis dependency, pregnancy, and any psychiatric or cognitive condition that could interfere with informed consent or study compliance.

The procedures performed ranged from diagnostic catheterizations to complex interventions, including primary percutaneous coronary intervention (PCI), chronic total occlusion (CTO) management, bifurcation stenting, and percutaneous transluminal coronary angioplasty (PTCA) with stent placement. Data were collected on the occurrence of post-

catheterization complications, including vascular access site bleeding, access site infections, pulmonary edema, contrast-induced nephropathy (defined as a ≥25% or ≥0.5 mg/dL increase in serum creatinine within 48–72 hours), arrhythmias (ventricular or supraventricular tachyarrhythmias), myocardial infarction, cardiogenic shock, hematoma formation, stroke (neurological deficit persisting ≥24 hours), and all-cause mortality.

The study was approved by the Institutional Review Board of Hameed Latif Hospital. All participants provided written informed consent after being briefed about the purpose, procedures, risks, and benefits of the study. Strict confidentiality was maintained throughout the research process; personal identifiers were removed, and data were encrypted and securely stored with access limited to the research team. Statistical analysis was performed using SPSS version 26. Descriptive statistics were used to summarize the data, with quantitative variables presented as mean ± standard deviation and categorical variables expressed as frequencies and percentages. An alpha level of 0.05 was set for statistical significance.

Results

Based on the data presented across various tables detailing characteristics, procedural aspects, complications, and post-procedural management of patients undergoing therapeutic and diagnostic left heart catheterization (LHC), in our setting coronary angiography was performed as a coronary catheterization procedure. Several key findings emerge. The baseline characteristics of patients undergoing therapeutic LHC procedures (Table 1) indicate a predominantly older population (mean age 59.42 ± 9.36 years), with a slight male predominance (55.3%) and a significant prevalence of hypertension (88.2%) and diabetes mellitus (67.5%) as comorbidities. The procedural characteristics of diagnostic LHC (Table 1) highlight that radial access was more frequently used (82.9%), and most patients had involvement of multiple coronary arteries (36.0% with 2 vessels, 31.1% with 3 vessels). Complications related to diagnostic LHC (Table 2) were generally low, with notable occurrences including access site bleeding (0.9%) and hematoma formation (2.6%). Post-procedural management and patient satisfaction (Table 3) indicate high rates of complication recognition (99.1%) and compliance with post-catheterization instructions (100%), with a majority of patients rating communication with healthcare providers positively (79.4% rating as excellent or good). Overall, these data underscore the effective

Table 1: *Baseline Characteristics of Patients Undergoing Therapeutic LHC Procedures*

Characteristics		Mean ± Standard deviation or n (%)
	Age	59.42±9.36
Gender	Male	126(55.3)
	Female	102(44.7)
	Smoker	60(26.3)
	Alcoholic	0(0)
Diagnosis at presentation	Exertional Angina	37(16.2)
	Unstable Angina	47(20.6)
	Non St-Segment Elevation Myocardial Infarction	30(13.2)
	Inferior Wall Myocardial Infarction	12(5.3)
	Anterior Wall Myocardial Infarction	28(12.3)
	Single Vessel Coronary Artery Disease	9(3.9)
	Double Vessel Coronary Artery Disease	27(11.8)
	Triple Vessel Coronary Artery Disease	49(21.5)
Comorbidities	Hypertension	201(88.2)
	Diabetes Mellitus	154(67.5)
	Osteoarthritis	8(3.5)
	Chronic Kidney Disease	19(8.3)
	Asthma	5(2.2)
	COPD	9(3.9)
Procedural Characteristics of Patients Undergoing Diagnostic LHC Procedures		
Site of Access	RADIAL	189(82.9)
	FEMORAL	39(17.1)
No of Diseased Vessels	0	38(16.7)
	1	37(16.2)
	2	82(36.0)
	3	71(31.1)

Table 1: *Baseline Characteristics of Patients Undergoing Therapeutic LHC Procedures*

Characteristics		Mean ± Standard deviation or n (%)
Coronary Artery Involved	Right Coronary Artery Involved(RCA)	124(54.4)
	Left Circumflex Artery Involved(LCX)	96(42.1)
	Left Anterior Descending Artery Involved(LAD)	137(60.1)
	Obtuse Marginal Artery Involved(OM)	20(8.8)
	Left Marginal Artery Involved(LM)	19(8.3)

procedural outcomes and high patient satisfaction associated with LHC procedures in this cohort.

Table 2: *Complications Related to Diagnostic LHC Procedures*

Variables	n (%)
Access Site Infection	0(0)
Access Site Bleeding	2(0.9)
Vascular Complications	0(0)
Hematoma Formation	6(2.6)
Pulmunary Edema	2(0.9)
Contrast Induced Nepheropathy	0(0)
Allergic Reaction	0(0)
Cardiac Arrythmias	2(0.9)
Myocardial Infarction	2(0.9)
Pericardiatis	0(0)
Cerebral Vascular Event	1(0.4)
Acute Stent Thrombosis	1(0.4)
Death	1(0.4)

Discussion

This study offers a contemporary assessment of major complications associated with Left Heart Catheterization procedures at a high-volume center. Chandrasekar et al. previously reported complication rates in 7,953 diagnostic angiograms from the 1990s, noting 0.1% deaths, 0.1% myocardial infarctions and 0.05% emergency coronary artery bypass grafts (CABG). Earlier CASS data recorded MI and death rates at 0.25% and 0.2%, respectively. The Society for Cardiac Angiography and Interventions registry documented complication rates of 0.11% for death, 0.06% for MI, and 0.05% for stroke.[10,11,12] Our study

Table 3: *Post-Cardiac Catheterization Management and Patient Satisfaction*

Variables		n (%)
Any complication was promptly recognized?	Yes	226(99.1)
	No	2(0.9)
Any additional intervention done?	Yes	1(0.4)
	No	227(99.6)
Instruction given by doctors to avoid post catheterization complications?	Yes	228(100)
	No	0(0)
Does instructions followed by patients?	Yes	182(80.5)
	No	0(0)
	Partially Compliant	44(19.5)
Rate overall communication by doctors and other hospital staff	Excellent	115(50.4)
	Good	68(29.8)
	Average	39(17.1)
	Poor	6(2.6)
	Very Poor	0(0)
Hospital stay duration	Discharge On Same Day	106(46.5)
	Discharge After 1 Day	118(51.8)
	Discharge After 2 Days	4(1.8)

exclusively focused on coronary angiography, omitting other procedures such as aortic angiography, graft angiography, left ventricular angiography, and transseptal catheterization that were reported in previous studies. This focused approach allowed us to specifically analyze outcomes and complications associated with coronary angiography within our cohort. our study predominantly involved LAD disease, consistent with our study design. we observed consistent rates with the reported percentages and frequencies for major complications such as death (0.31%), MI (0.65%), stroke (0.2%).However, noteworthy major complications specific to our study included access site bleeding, hematoma formation, pulmonary edema, cardiac arrhythmias, MI, cerebrovascular accident, acute stent thrombosis, and death.[9] The trans radial (TR) approach offers several advantages, particularly for patients at high risk of acute kidney injury (AKI), assuming the operator is skilled.[13] Further extensive studies are necessary to confirm whether TR intervention prevents or complicates fistula formation in patients who may require future dialysis. Additionally, more research is needed to understand the incidence of renal atheroembolic events during PCI contributing to procedural AKI. Notably, our study did not report any cases of AKI or contrast-induced nephropathy.[14] Trans radial access (TRA) has become widely favored globally for its safety and feasibility compared to transfemoral access (TFA), supported by robust data. It offers anatomical advantages, facilitates rapid patient recovery, and reduces healthcare costs by enabling earlier discharge. Despite its widespread adoption, challenges like radial artery occlusion (RAO) and rare complications such as arterial perforation.[15] Stent thrombosis results from patient factors, lesion characteristics, and procedural methods. Modern guidelines advocate personalized treatment using advanced drug-eluting stents and tailored implant techniques. Individualized antiplatelet therapy, guided by ischemic and bleeding risks, is recommended. Intravascular imaging enhances stent placement precision and identifies thrombosis mechanisms. These approaches aim to minimize stent thrombosis long-term by leveraging improved understanding, innovative stents, and advanced imaging.[16] Our study identified a 0.4% incidence of post-catheterization stroke. This contrasts with previous findings where stroke rates were higher: one study reported 1.4% of all code stroke activations and approximately 19% of in-hospital activations, while another found about 6% of in-hospital strokes occurred in specialized units. Variations may stem from differences in coronary procedures performed.[17] Our findings contribute to the existing evidence supporting the benefits of specialty hospitals in treating cardiovascular diseases. Previous research has demonstrated improved outcomes for tertiary care hospitals in procedures such as percutaneous coronary intervention (PCI), bypass surgery, acute myocardial infarction, and congestive heart failure. However, these benefits diminished somewhat after adjusting for patient case mix and hospital procedural volume. A significant limitation of earlier studies was their reliance solely on administrative data, which insufficiently captured patient complexity.[8]

This study has several limitations. Conducted at Hameed Latif Hospital in Lahore, its single-center design limits generalizability. Resource constraints and non-response bias could affect data completeness. The sample size may be insufficient to capture rare complications and confounding variables such as comorbidities may influence outcomes. Ensuring consistent patient follow-up and addressing potential subjectivity in complication definitions are challenges. In order to alleviate resource constraints and enhance our research capabilities, we seek additional funding or partnerships.

Conclusion

Our exclusive focus on coronary angiography provided detailed insights into specific outcomes and highlighted significant complications, including access site bleeding, hematoma formation, pulmonary edema, cardiac arrhythmias, cerebrovascular accidents, acute stent thrombosis, and death. Our study found lower rates of adverse outcomes in specialty hospitals for PCI, although risk adjustment somewhat diminished these results. These findings suggest that the expertise developed in physician-owned specialty hospitals could inform practices in general hospitals, potentially improving overall patient outcomes. This research contributes to a better understanding of the risks and challenges associated with cardiac catheterization procedures, aiding in the development of targeted interventions to mitigate complications and improve patient care.

Ethical Approval: The IRB/EC approved this study via letter no. HLH/IRB/2023-003 dated September 11, 2023.

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Authors' Contribution

MSD: Conception

SA, SM: Design of the work

MARB,MKR,MG: Data acquisition, analysis, or interpretation

MARB,MKR,MG,SM: Draft the work

MSD,SA: Review critically for important intellectual content

All authors approve the version to be published

All authors agree to be accountable for all aspects of the work

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