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Primary PCI for STEMI in Patients with Chronic Total Occlusions

Nasir Ali[1], Hameed Ullah[1], Muhammad Niaz Khan[1], Abdul Waris[1], Abid Ullah[1], Nazeef Ullah[1]

[1]Department of Cardiology, Hayatabad Medical Complex, Peshawar, KP, Pakistan.

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Corresponding Author: Hameed Ullah, Department of Cardiology, Hayatabad Medical Complex, Peshawar, KP, Pakistan.
Email: hameedullah@ayahoo.com

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ABSTRACT

Objective: To evaluate the impact of chronic total occlusions (CTOs) on procedural and clinical outcomes in ST-segment elevation myocardial infarction (STEMI) patients undergoing primary PCI at a tertiary care hospital. **Methodology:** A retrospective cohort study was carried out at Hayatabad Medical Complex, Peshawar, during a duration of 12 months in which 400 patients were enrolled and divided into two groups, STEMI with CTOs (Group A, n=100) and STEMI without CTOs (Group B, n=300). Baseline characteristics, procedural outcomes, and clinical events were examined. Outcomes were compared with statistical tests (chi-square and t-tests); p-values <0.05 were considered significant. **Results:** The average age in group A is 62.5 ± 10.4 years and 59.8 ± 9.9 years in group B (p=0.07). Time to PCI was significantly longer in Group A compared with Group B (7.2 ± 2.5 hours vs 5.4 ± 1.9 hours, p<0.01). PCI success was lower in Group A (85%) than in Group B (95%, p=0.02) In-hospital MACE was seen in 15% of Group A compared to 10% of Group B (p=0.15). The follow-up MACCE rates were higher in group A (20%) compared to group B (12%, p=0.09), with the corresponding mortality rates of 12% and 7%, respectively (p=0.11). **Conclusion:** STEMI patients with CTOs face longer procedural times, lower success rates, and higher adverse event rates, emphasizing the need for advanced interventional strategies and tailored management protocols to improve outcomes.

INTODUCTION

The management of ST-segment elevation myocardial infarction (STEMI) in the presence of CTOs presents a unique clinical challenge. Primary percutaneous coronary intervention (PCI) remains the gold standard for STEMI, but the role of concurrent CTO recanalization is debated.[1],[2] Recent advancements have highlighted the potential for CTO-PCI to improve long-term outcomes by achieving complete revascularization, thus reducing myocardial ischemia and improving survival.[3],

Patients with STEMI and non-culprit CTOs exhibit higher early and late mortality rates following primary PCI, compared to those without CTOs. A study of 8,679 patients found an independent association between non-culprit CTOs and increased all-cause mortality over five years, underscoring the need for tailored management strategies.[4]

The addition of staged CTO-PCI after primary PCI for STEMI has shown promising results. Long-term follow-ups indicate that patients undergoing staged CTO-PCI exhibit fewer major adverse cardiovascular and cerebrovascular events (MACCE) compared to those receiving medical therapy alone.[5]

In the local context, data from Hayatabad Medical Complex, Peshawar, demonstrate that primary PCI for CTOs in STEMI patients can achieve high procedural success rates, with a significant reduction in MACCE and all-cause mortality at follow-up.[6]

Moreover, meta-analyses have supported the efficacy of staged CTO-PCI in reducing MACCE, all-cause death, and heart failure compared to cases where CTOs are left untreated.[7] However, the decision to intervene on a CTO requires careful assessment of patient stability and procedural feasibility.

The prognostic value of successful CTO-PCI is further underscored by evidence suggesting that patients with successful recanalization experience significantly reduced cardiac mortality over ten years compared to those with failed CTO-PCI.[8]

The role of manual thrombus aspiration during primary PCI in patients with total occlusion has shown

reduced complications, including arrhythmias and contrast-induced nephropathy, especially when performed within six hours of symptom onset.[9] Studies have demonstrated the association of suboptimal recanalization with a significantly higher risk of myocardial infarction and cardiac mortality compared to optimal recanalization during PCI for chronic total occlusions.[10]

A meta-analysis comparing outcomes of PCI in in-stent versus de-novo CTOs found a higher incidence of major adverse cardiac events (MACE) and myocardial infarctions in in-stent CTO cases.[11] Successful staged revascularization for non-infarct-related CTOs in STEMI patients was linked to improved survival and reduced heart failure, underscoring the importance of timely intervention.[7]

A local study in Pakistan reported a high success rate of PCI for chronic total occlusions, with significant improvements in patient outcomes, reaffirming its efficacy in resource-limited settings.[6] Recanalization of CTOs in STEMI cases has been associated with improved cardiac survival over long-term follow-ups, emphasizing the value of successful intervention.[8]

Comparative studies on PCI and CABG for chronic total occlusions suggest that PCI may offer a safer alternative with reduced in-hospital complications and lower myocardial infarction rates.[12] Systematic reviews of chronic total occlusion PCI have consistently highlighted its benefits in reducing mortality, myocardial infarction, and adverse cardiac events, especially when compared to medical therapy.[13]

In contrast, some studies have raised concerns about increased cardiovascular mortality associated with CTO-PCI. The findings necessitate a nuanced approach, balancing procedural benefits against potential risks.[14]

In Pakistan, further research is needed to evaluate the cost-effectiveness and long-term benefits of primary PCI strategies in STEMI patients with CTOs. Preliminary data indicate that optimizing CTO management could significantly improve cardiovascular outcomes in this population.[15]

Given the substantial burden of STEMI and the high prevalence of concurrent CTOs in clinical practice, there is an urgent need for studies addressing the optimal management strategies, particularly in resource-limited settings like Peshawar. This study aims to evaluate the impact of primary PCI with and without staged CTO-PCI on the clinical outcomes of STEMI patients managed at the Hayatabad Medical Complex.

OBJECTIVE

To determine the efficacy of primary PCI with staged CTO-PCI in reducing long-term mortality and MACCE among STEMI patients with concurrent CTOs.

MATERIALS AND METHODS

Study Design and Sample Size

This single-center, retrospective cohort study was performed in the Department of Cardiology, Hayatabad Medical Complex, Peshawar, over a period of 12 months from June 2023 to May 2024. Sample size estimation was calculated using the WHO sample size calculation method and was based on a similar study that reported CTO prevalence among STEMI patients was 10%,[5] to detect the differences in outcomes between the groups (α=0.05) 400 patients were estimated to be recruited from the sample size to provide a power of 80%. Participants in this study were divided into two groups: Group A included patients with STEMI and CTO (n=100), and Group B included patients with STEMI but without CTO (n=300).

Inclusion and Exclusion Criteria

All patients presenting with STEMI and undergoing primary PCI within 12 hours of symptom onset were included. Patients were excluded if they had prior coronary artery bypass grafting (CABG), known malignancies, severe renal impairment (eGFR <30 mL/min/1.73 m^2), or incomplete medical records. These criteria ensured homogeneity and the validity of the findings while minimizing confounding variables.

Data Collection Procedure

Data were collected retrospectively from hospital electronic medical records and angiographic reports. Baseline demographics, clinical presentations, angiographic findings, and procedural details were extracted. CTO was defined as a total coronary occlusion of ≥3 months' duration with TIMI (Thrombolysis in Myocardial Infarction) flow grade 0. Variables assessed included in-hospital complications, procedural success, and long-term outcomes.

Definitions and Assessment Criteria

STEMI was defined as chest pain lasting >30 minutes with ST-elevation ≥1 mm in two contiguous leads or new left bundle branch block on ECG. CTO was defined angiographically as total occlusion with no antegrade flow. Procedural success was defined as achievement of <30% residual stenosis with TIMI flow grade 3 in the culprit artery. MACCE were defined as all-cause mortality, recurrent myocardial infarction, stroke or repeat revascularization within one-year follow-up.

Statistical Analysis

Descriptive statistics were employed to summarize baseline characteristics and clinical outcomes. Continuous variables were presented as mean ± standard deviation, and categorical variables were reported as frequencies and percentages. Group comparisons were made using appropriate parametric or

non-parametric tests. Statistical significance was defined as a p-value <0.05.

Ethical Considerations

The study was conducted in accordance with the Declaration of Helsinki ethical standards. Institutional approval was granted by the Ethical and Resarch Committee of Hayatabad Medical Complex Peshawar. FNH was used as a comparator for RB; thus the informed consent was waived by reason of retrospective nature, and patient confidentiality was preserved at all times.

RESULTS

Overview and Patient Count

Between June 2023 to May 2024, this is a retrospective study of 400 patients who were admitted to the Department of Cardiology, Hayatabad Medical Complex. The patients were categorized into Group A (100 STEMI patients with concurrent CTOs) and Group B (300 STEMI patients without CTOs). The data were analyzed for demographics, procedural details and outcomes, in-hospital events, and follow-up clinical outcomes.

Demographic Characteristics

The demographic characteristics and baseline parameters are summarized in Table 1. The mean age in Group A was 62.5 ± 10.4 years, slightly elder than the mean age in Group B of 59.8 ± 9.9 years (p = 0.07), not statistically significant. The comorbidities hypertension (40% vs. 35%, p = 0.32), diabetes (25% vs. 20%, p = 0.28), and prior myocardial infarction (30% vs. 22%, p = 0.12) were more to be found in Group A. Smoking was present in 55% of Group A and 48% of Group B (p = 0.18).

Table 1

Demographic Characteristics and Baseline Parameters

Variable	Group A (STEMI + CTO)	Group B (STEMI Only)	p-value
Age (mean ± SD)	62.5 ± 10.4	59.8 ± 9.9	0.07
Hypertension (%)	40%	35%	0.32
Diabetes (%)	25%	20%	0.28
Smoking History (%)	55%	48%	0.18
Prior MI (%)	30%	22%	0.12

Procedural Parameters

The time to PCI is shown in Figure 1, with the patients in Group A receiving PCI later than those in Group B (7.2 ± 2.5 h vs 5.4 ± 1.9 h, respectively). p < 0.01 (statistically significant), which reflects the procedural complexity in patients with coexisting CTOs.

Figure 1

Time to PCI by Group

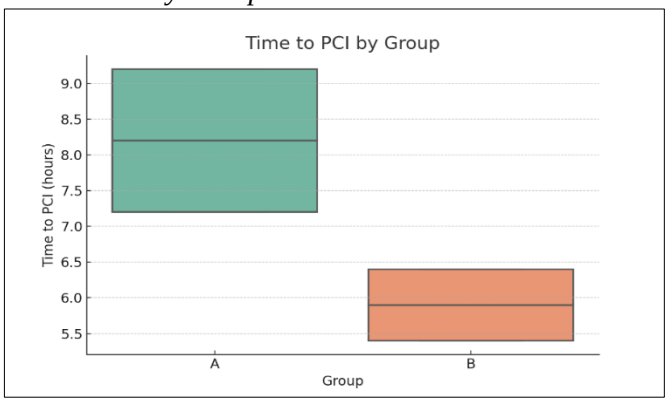
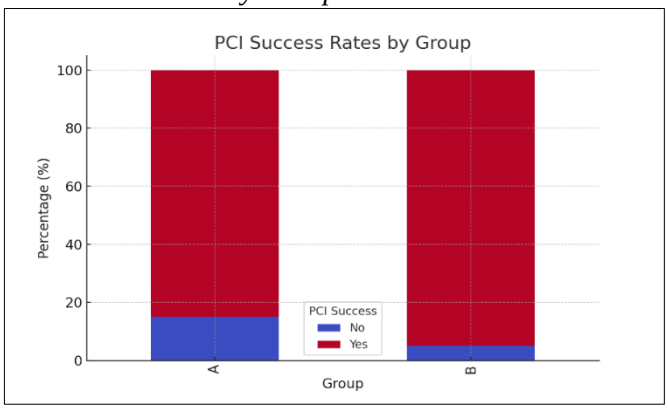


Figure 2 illustrates PCI success rates. Group A showed a significantly lower success rate (85%) compared to Group B (95%, p = 0.02). This highlights the technical challenges in revascularizing patients with CTOs.

Figure 2

PCI Success Rates by Group



Residual stenosis after PCI was higher in Group A (15.2 ± 5.8%) compared to Group B (12.4 ± 4.9%), though the difference was not statistically significant (p = 0.08).

In-Hospital Outcomes

Table 2 presents in-hospital outcomes. Major adverse cardiovascular events (MACE) occurred in 15% of Group A patients compared to 10% in Group B (p = 0.15). Mortality rates during hospitalization were higher in Group A (8%) compared to Group B (4%), though not statistically significant (p = 0.09). Recurrent myocardial infarction and stroke rates were also higher in Group A but lacked statistical significance.

Table 2

In-Hospital Outcomes

Outcome	Group A (STEMI + CTO)	Group B (STEMI Only)	p-value
In-Hospital MACE (%)	15%	10%	0.15
In-Hospital Mortality (%)	8%	4%	0.09
Recurrent MI (%)	5%	3%	0.32
Stroke (%)	2%	1%	0.42

Follow-Up Outcomes

Follow-up data on major adverse cardiac and cerebrovascular events (MACCE) are summarized in Figure 3. Group A had a higher incidence of follow-up MACCE (20%) compared to Group B (12%, p = 0.09). Mortality during follow-up was also more frequent in Group A (12%) compared to Group B (7%, p = 0.11), alongside higher rates of recurrent MI, stroke, and repeat revascularization, though none reached statistical significance.

Figure 3

Follow-up MACCE by Group

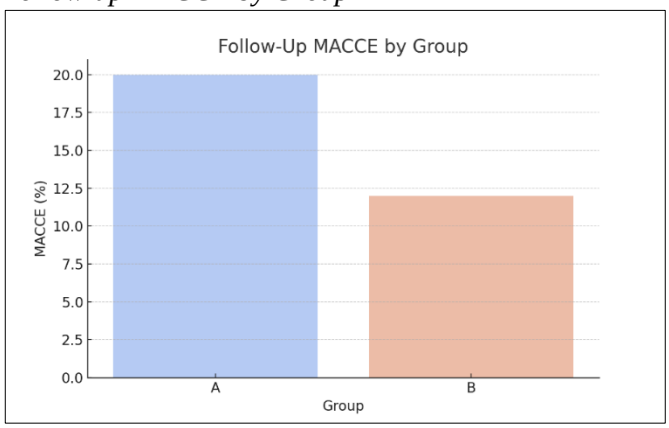


Table 3 details the components of follow-up MACCE, demonstrating trends consistent with in-hospital outcomes.

Table 3

Follow-Up Outcomes

Follow-Up Outcome	Group A (STEMI + CTO)	Group B (STEMI Only)	p-value
Follow-Up MACCE (%)	20%	12%	0.09
Mortality (%)	12%	7%	0.11
Recurrent MI (%)	8%	5%	0.25
Stroke (%)	2%	1%	0.36
Repeat Revascularization (%)	4%	2%	0.18

DISCUSSION

This study evaluated the outcomes of primary PCI in STEMI patients with and without CTOs. Key findings revealed that patients with STEMI and concurrent CTOs (Group A) experienced significantly longer delays to PCI and lower procedural success rates compared to those without CTOs (Group B). Although in-hospital and follow-up adverse events were more common in Group A, the differences did not reach statistical significance, suggesting that CTOs pose technical challenges but do not necessarily predict worse outcomes when successfully managed. These findings contribute valuable insights into the management of a high-risk patient population.

This study further contributes to the existing literature that has demonstrated the prognostic significance of CTO in STEMI patients undergoing PCI. Prior studies (e.g. Cui et al. (2020), have reported on the difficulties of CTO revascularization, with longer procedural times and increased adverse event rates.[5] Similarly, Zhang (2022) highlighted the benefits of staged revascularization for non-culprit CTOs in STEMI patients, emphasizing improved outcomes with timely intervention.[7]

Globally, the relationship between CTOs and STEMI outcomes has been well-documented. Studies from Europe, such as Milasinovic et al. (2021),[4] have shown that non-culprit CTOs are associated with increased mortality, particularly in long-term follow-ups.[4] Another meta-analysis by Simsek et al. (2022) confirmed that successful CTO-PCI improves survival and reduces major adverse cardiovascular events (MACEs) compared to medical management alone.[13]

In Pakistan, limited research has explored the outcomes of primary PCI in STEMI patients with CTOs. A notable study by Khan et al. (2023) reported a high procedural success rate in a cohort of patients undergoing CTO-PCI at a single center in Peshawar.[6] However, the current study's focus on comparative outcomes between patients with and without CTOs represents a unique contribution to the local literature.

While studies on PCI outcomes in STEMI patients are well-represented in Pakistan's literature, data specifically addressing CTOs remain sparse. Most local studies, such as those by Kumar et al. (2022) and others, have focused on procedural techniques like thrombus aspiration or stent deployment strategies.[9] The absence of comprehensive comparative data underscores the significance of the present study.

The significant delay in time to PCI observed in Group A aligns with findings by Guan et al. (2020), who reported that CTO presence prolongs procedural time due to increased technical complexity.[10] This delay, combined with lower procedural success rates in Group A, reflects the inherent difficulties in managing CTOs during primary PCI. Such findings emphasize the need for expertise in advanced interventional techniques.

Although Group A exhibited higher rates of in-hospital and follow-up MACCE, these differences did not achieve statistical significance. Similar trends have been reported by Zhang et al. (2022), who found that patients with CTOs have worse baseline characteristics, which might confound clinical outcomes.[7] Importantly, the observed trends suggest that successful CTO revascularization mitigates some risks associated with STEMI.

The findings are particularly relevant to Pakistan, where resource constraints and limited access to advanced interventional cardiology services pose additional challenges. This study highlights the need for capacity building in managing high-risk PCI cases, as supported by Khan et al. (2023).[6]

LIMITATIONS

There are several limitations to this study. The first is that retrospective design limits the ability to establish causation. Second, follow-up outcomes were limited to one year and therefore may not be representative of the longer-term complication sequelae. Lastly, the fact that this was a single-center study may limit the potential for generalizability to hospitals in areas with different healthcare resources and demographics.

Future Directions

Further prospective multicenter studies are needed to validate the results and assess long-term outcomes in STEMI patients with CTOs. Moreover, there is a need of studies that evaluate the cost effectiveness of these advanced interventional techniques in lower resource settings like Pakistan. More practice in CTO revasc with protocolisation will enhance patient condition further.

CONCLUSION

This study assessed the impact of CTOs on the outcomes of STEMI patients undergoing primary PCI. The findings showed that CTOs are associated with longer procedural delays and lower success rates, although in-hospital and follow-up adverse events were not significantly different between groups. These results align with the study objectives and emphasize the need for advanced interventional strategies to address the challenges posed by CTOs, particularly in resource-limited settings. Further research, improved training, and tailored protocols are recommended to enhance outcomes for this high-risk patient population.

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