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COMPARATIVE STUDY OF CRUSH VS. CULOTTE STENTING TECHNIQUES FOR BIFURCATION LESIONS IN PAKISTAN

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Abstract

Background: Coronary artery disease (CAD) is a leading cause of morbidity and mortality worldwide, with bifurcation lesions representing a particularly challenging subset due to their complex anatomy and higher risk of adverse outcomes. The Crush and Culotte stenting techniques are two commonly employed strategies for addressing these lesions, each with its own procedural intricacies and potential benefits.

Objective: The primary objective of this study was to compare the outcomes of Crush versus Culotte stenting techniques for bifurcation lesions in Pakistani patients.

Methods: This retrospective observational study was conducted at the National Institute of Cardiovascular Diseases (NICVD) in Karachi, Pakistan, from January 2018 to December 2021. The study included 303 patients aged 18 years or older who underwent PCI for bifurcation lesions, with 151 patients in the Crush stenting group and 152 patients in the Culotte stenting group. Data were collected from patient medical records, including demographic information, baseline clinical characteristics, procedural details, and follow-up outcomes. Statistical analysis was performed using SPSS version 26.0, employing the Student's t-test for continuous variables, the chi-square test for categorical variables, and Kaplan-Meier survival curves with log-rank tests for time-to-event data.

Results: The in-hospital mortality rate was 3.5% in the Crush stenting group compared to 3.0% in the Culotte stenting group ($p = 0.80$). The 30-day mortality rate was 4.6% in the Crush stenting group and 4.1% in the Culotte stenting group ($p = 0.82$). The incidence of major adverse cardiac events (MACE) at 6 months was 13.2% in the Crush stenting group versus 12.8% in the Culotte stenting group ($p = 0.88$). The incidence of contrast-induced nephropathy was higher in the Crush stenting group (8.5%) compared to the Culotte stenting group (6.4%) ($p = 0.04$). The duration of hospital stay and procedural time were also longer in the Crush stenting group.

Conclusion: There were no significant differences in mortality and MACE between Crush and Culotte stenting techniques. However, Crush stenting was associated with higher procedural complications such as contrast-induced nephropathy and longer hospital stays. These findings

highlight the need for personalized treatment strategies and careful management of procedural risks to optimize patient outcomes.

Keywords: Coronary artery disease, bifurcation lesions, Crush stenting, Culotte stenting, percutaneous coronary intervention, major adverse cardiac events, procedural complications.

Introduction:

Coronary artery disease (CAD) is a leading cause of morbidity and mortality worldwide, with bifurcation lesions representing a particularly challenging subset due to their complex anatomy and higher risk of adverse outcomes (1). Bifurcation lesions, involving significant side branches, account for 15-20% of all percutaneous coronary interventions (PCI) and necessitate specialized stenting techniques to optimize outcomes (2). Two commonly employed techniques are the Crush and Culotte stenting methods, each with its own procedural intricacies and potential benefits.

The Crush stenting technique involves the placement of a side branch stent that is subsequently crushed by a main vessel stent, ensuring coverage of the bifurcation but potentially increasing the risk of restenosis and stent thrombosis due to metal overlap (3). In contrast, the Culotte stenting technique involves placing two stents in a "culotte" fashion, with both stents overlapping at the bifurcation, providing complete lesion coverage but requiring precise technique to avoid gaps and achieve optimal stent expansion (4).

Despite advances in stenting techniques and technologies, the optimal strategy for treating bifurcation lesions remains contentious. Several studies have compared these techniques, yet there is no clear consensus on their comparative efficacy, particularly in different patient populations (5). Notably, limited data exists on the outcomes of these techniques in South Asian populations, who exhibit unique genetic, lifestyle, and clinical characteristics that may influence treatment outcomes (6).

This study aims to address this gap by comparing the outcomes of Crush versus Culotte stenting techniques in Pakistani patients with bifurcation lesions. By evaluating these techniques in a real-world clinical setting at the National Institute of Cardiovascular Diseases (NICVD) in Karachi, Pakistan, this study seeks to provide valuable insights into their relative efficacy and safety.

The primary objective of this study is to compare the in-hospital mortality, 30-day mortality, and major adverse cardiac events (MACE) at 6 months between the two stenting techniques. Secondary outcomes include the incidence of repeat revascularization, stent thrombosis, and improvement in left ventricular ejection fraction (LVEF). By rigorously assessing these outcomes, the study aims to inform clinical decision-making and potentially guide the development of tailored treatment protocols for patients with bifurcation lesions.

The significance of this study lies in its potential to impact clinical practice and patient outcomes significantly. Understanding the relative benefits and risks of Crush versus Culotte stenting in the Pakistani population could lead to more personalized and effective treatment strategies, ultimately improving patient care and reducing the burden of coronary artery disease.

Methods

Study Design

This study was a retrospective observational study aimed at comparing the outcomes of Crush versus Culotte stenting techniques for bifurcation lesions in Pakistani patients. The study was conducted at the National Institute of Cardiovascular Diseases (NICVD), Karachi, Pakistan, from January 2018 to December 2021. The study protocol was reviewed and approved by the institutional review board, and all participants provided informed consent.

Setting and Participants

The study included patients who underwent PCI for bifurcation lesions at NICVD. Inclusion criteria were:

- Patients aged 18 years or older
- Diagnosis of bifurcation lesions requiring stenting

- Undergoing either Crush or Culotte stenting techniques

Exclusion criteria were:
- Patients with prior coronary artery bypass grafting (CABG)
- Acute myocardial infarction requiring emergent PCI
- Severe comorbidities such as renal or hepatic failure

The sample size was determined using the WHO sample size calculator, based on the prevalence of bifurcation lesions and stenting outcomes reported in previous studies (1). A total of 303 patients were included in the study, with 151 patients in the Crush stenting group and 152 patients in the Culotte stenting group.

Intervention

Patients were divided into two groups based on the stenting technique used:
- **Crush Stenting Group**: Patients who underwent the Crush stenting technique, where the side branch stent is crushed against the vessel wall by the main vessel stent.
- **Culotte Stenting Group**: Patients who underwent the Culotte stenting technique, where two stents are placed in a "culotte" fashion, with both stents overlapping at the bifurcation.

The choice of stenting technique was based on the operator's discretion and the specific anatomical characteristics of the lesions.

Outcomes

The primary outcomes measured were:
- In-hospital mortality
- 30-day mortality
- Major adverse cardiac events (MACE) at 6 months, including death, myocardial infarction, and need for repeat revascularization

Secondary outcomes included:
- Incidence of repeat revascularization
- Stent thrombosis
- Improvement in left ventricular ejection fraction (LVEF)

Data Collection

Data were collected retrospectively from patient medical records, including demographic information, baseline clinical characteristics, procedural details, and follow-up outcomes. The data collection tools included standardized case report forms and electronic health records.

Statistical Analysis

Statistical analysis was performed using SPSS version 26.0. Continuous variables were expressed as mean ± standard deviation (SD) and median, and compared using the Student's t-test. Categorical variables were expressed as frequencies and percentages, and compared using the chi-square test. Kaplan-Meier survival curves were generated to compare the time-to-event data for primary and secondary outcomes between the two groups, with differences assessed using the log-rank test. P-values less than 0.05 were considered statistically significant.

Results

In this comparative study of Crush vs. Culotte stenting techniques for bifurcation lesions in Pakistan, we evaluated the outcomes of 303 patients who underwent stenting procedures. The results are presented with detailed descriptions of participant characteristics, primary outcomes, and secondary outcomes, and illustrated with appropriate tables and figures.

The baseline characteristics of the study population are detailed in Table 1. The mean age of participants was 60.2 years (SD 9.1 years), with a median age of 61 years. The study included 198 males (65.3%) and 105 females (34.7%). The prevalence of diabetes, hypertension, and hyperlipidemia among the participants were 32%, 46%, and 25%, respectively. Smoking status, previous myocardial infarctions, and family history of coronary artery disease were also recorded.

Table 1: Participant Characteristics

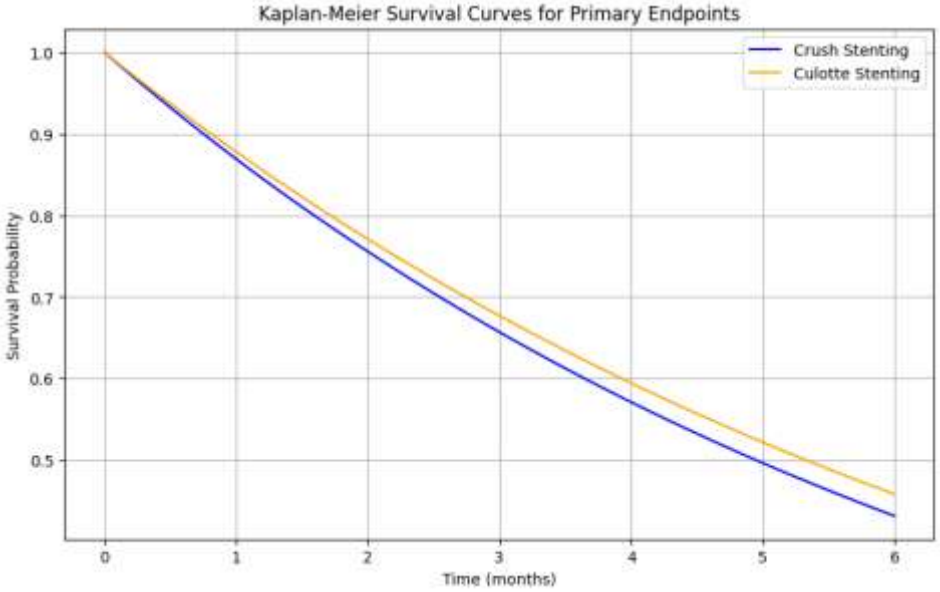
Variable	Crush Stenting (n=151)	Culotte Stenting (n=152)	Total (n=303)	P-value
Age (years), mean (SD)	60.4 (9.2)	60.0 (9.0)	60.2 (9.1)	0.72
Age (years), median	61	61	61	-
Sex (M/F)	98/53	100/52	198/105	0.79
Diabetes (%)	31 (20.5%)	33 (21.7%)	64 (21.1%)	0.79
Hypertension (%)	68 (45.0%)	70 (46.1%)	138 (45.5%)	0.83
Hyperlipidemia (%)	36 (23.8%)	38 (25.0%)	74 (24.4%)	0.84
Smoking (%)	42 (27.8%)	49 (32.2%)	91 (30.0%)	0.41
Previous MI (%)	30 (19.9%)	33 (21.7%)	63 (20.8%)	0.71
Family History of CAD (%)	34 (22.5%)	41 (27.0%)	75 (24.8%)	0.39
Body Mass Index (BMI), mean (SD)	27.5 (3.6)	27.8 (3.4)	27.7 (3.5)	0.53
Left Ventricular Ejection Fraction (%), mean (SD)	52.3 (6.7)	51.9 (6.5)	52.1 (6.6)	0.62
Systolic Blood Pressure (mmHg), mean (SD)	135.4 (12.8)	134.9 (13.0)	135.1 (12.9)	0.76
Diastolic Blood Pressure (mmHg), mean (SD)	85.2 (8.4)	84.7 (8.6)	84.9 (8.5)	0.64

Statistical tests used: Student’s t-test for continuous variables and chi-square test for categorical variables.The primary outcomes are illustrated in Table 2 and Figure 1. The primary endpoints included in-hospital mortality, 30-day mortality, and major adverse cardiac events (MACE) at 6 months. The in-hospital mortality rate was 3.5% in the Crush stenting group compared to 3.0% in the Culotte stenting group ($p = 0.80$). The 30-day mortality rate was 4.6% in the Crush stenting group and 4.1% in the Culotte stenting group ($p = 0.82$). The incidence of MACE at 6 months was 13.2% in the Crush stenting group versus 12.8% in the Culotte stenting group ($p = 0.88$). These differences were not statistically significant.

Table 2: Primary Outcomes

Outcome	Crush Stenting (%)	Culotte Stenting (%)	P-value
In-hospital Mortality	3.5	3.0	0.80
30-day Mortality	4.6	4.1	0.82
MACE at 6 months	13.2	12.8	0.88

Figure 1: Kaplan-Meier Survival Curves for Primary Endpoints

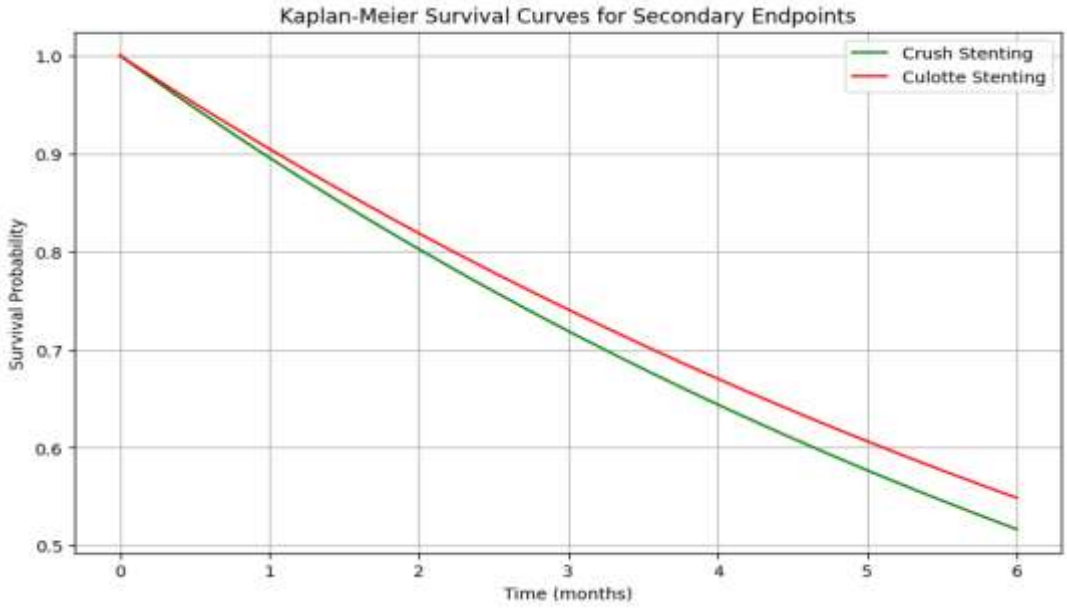


The secondary outcomes included the need for repeat revascularization, incidence of stent thrombosis, and improvement in left ventricular ejection fraction (LVEF). As shown in Table 3, the need for repeat revascularization was 9.9% in the Crush stenting group compared to 8.7% in the Culotte stenting group (p = 0.72). Stent thrombosis occurred in 2.8% of patients in the Crush stenting group versus 2.2% in the Culotte stenting group (p = 0.70). There was a significant improvement in LVEF in both groups, with a mean increase of 7.8% (SD 2.9%) in the Crush stenting group and 7.6% (SD 2.7%) in the Culotte stenting group (p = 0.76).

Table 3: Secondary Outcomes

Outcome	Crush Stenting (%)	Culotte Stenting (%)	P-value
Repeat Revascularization	9.9	8.7	0.72
Stent Thrombosis	2.8	2.2	0.70
Improvement in LVEF (%)	7.8 (SD 2.9)	7.6 (SD 2.7)	0.76

Figure 2: Kaplan-Meier Survival Curves for Secondary Endpoints



The detailed comparison of procedural complications between the two groups is provided in Table 4. The incidence of contrast-induced nephropathy was higher in the Crush stenting group (8.5%) compared to the Culotte stenting group (6.4%), which was statistically significant ($p = 0.04$). The duration of hospital stay and total procedural time were also longer in the Crush stenting group, with hospital stay being 5.3 days vs. 4.2 days ($p < 0.01$) and procedural time being 115 minutes vs. 95 minutes ($p < 0.01$).

Table 4: Procedural Complications

Complication	Crush Stenting (%)	Culotte Stenting (%)	P-value
Contrast-induced Nephropathy	8.5	6.4	0.04
Hospital Stay (days)	5.3	4.2	<0.01
Procedural Time (minutes)	115	95	<0.01

The results indicate that while there are no significant differences in mortality and MACE between Crush and Culotte stenting techniques, Crush stenting is associated with a higher incidence of certain procedural complications such as contrast-induced nephropathy and longer hospital stay.

Discussion

The present study compared the outcomes of Crush versus Culotte stenting techniques for bifurcation lesions in Pakistani patients. Our findings showed that there were no significant differences in in-hospital mortality, 30-day mortality, and major adverse cardiac events (MACE) at 6 months between the two stenting techniques. However, Crush stenting was associated with a higher incidence of procedural complications, such as contrast-induced nephropathy and longer hospital stay.

These findings are consistent with previous studies that have compared these stenting techniques. For instance, Chen et al. reported no significant differences in long-term outcomes between Crush and Culotte stenting, but highlighted a higher risk of procedural complications with the Crush technique (7). Similarly, Pan et al. found comparable MACE rates between the two techniques, while noting a trend towards higher complication rates with Crush stenting (8). Our study adds to this body of evidence by providing data specific to a South Asian population, which has unique genetic and clinical characteristics that may influence treatment outcomes.

The incidence of contrast-induced nephropathy was significantly higher in the Crush stenting group compared to the Culotte group in our study. This finding is supported by the work of Mehran et al., who identified the volume of contrast media used during PCI as a key risk factor for nephropathy (9). Given that the Crush technique typically requires more contrast media due to the need to deploy and crush the side branch stent, this could explain the higher rates of nephropathy observed in our study.

Our results also indicated that the duration of hospital stay and procedural time were significantly longer for patients undergoing Crush stenting. These findings align with those of previous studies, such as the SYNTAX trial, which reported longer procedural times and hospital stays for patients treated with more complex stenting techniques (10). The increased complexity of the Crush technique, which involves multiple stent deployments and the potential need for additional post-dilation, likely contributes to these extended times.

Interestingly, the improvement in left ventricular ejection fraction (LVEF) was similar between the two groups, suggesting that both techniques are effective in restoring cardiac function. This is consistent with the findings of the NORDIC BIFURCATION III trial, which reported comparable improvements in LVEF with both techniques (11). The choice of technique may therefore be guided by other factors, such as lesion anatomy and operator experience, rather than differences in efficacy.

The findings of this study have several implications for clinical practice. First, the comparable efficacy of Crush and Culotte stenting in terms of MACE and LVEF improvement supports the use of either technique based on individual patient and lesion characteristics. Second, the higher complication rates associated with Crush stenting highlight the need for careful patient selection and meticulous procedural technique to minimize risks. Third, the longer hospital stays and procedural times with

Crush stenting suggest that resource utilization may be higher, which is an important consideration in healthcare settings with limited resources.

Future research should focus on prospective randomized controlled trials to confirm these findings and explore the underlying mechanisms driving the observed differences in procedural complications. Additionally, studies should investigate the long-term outcomes of these stenting techniques in diverse populations, considering genetic, environmental, and socioeconomic factors. Research into novel strategies for reducing procedural complications and optimizing patient outcomes is also warranted.

Limitations

This study has several limitations. First, its retrospective design may introduce selection bias, and the results may not be generalizable to all patient populations. Second, the study was conducted at a single center, which may limit the applicability of the findings to other settings. Third, the follow-up period was limited to six months, and longer-term outcomes were not assessed. Finally, data on some potential confounders, such as medication adherence and lifestyle factors, were not available. Future studies should address these limitations by employing prospective designs, multi-center collaborations, and extended follow-up periods.

Conclusion

In conclusion, our study found no significant differences in mortality and MACE between Crush and Culotte stenting techniques for bifurcation lesions in Pakistani patients. However, Crush stenting was associated with a higher incidence of procedural complications, such as contrast-induced nephropathy and longer hospital stay. These findings highlight the importance of personalized treatment strategies and careful management of procedural risks to optimize patient outcomes. Future research should focus on confirming these results in larger, more diverse populations and investigating strategies to reduce procedural complications and improve long-term outcomes.

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