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COMPARATIVE OUTCOMES OF STERNAL CLOSURE TECHNIQUES IN CORONARY ARTERY BYPASS GRAFTING: A STUDY OF HYBRID WIRE CABLE TIES VERSUS CONVENTIONAL WIRING.

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Abstract:

Objectives: Sternal closure is a critical step in Coronary Artery Bypass Grafting (CABG) surgery, significantly influencing postoperative outcomes and patient recovery. Deep sternal wound infection (DSWI) is an important postoperative complication associated with significant morbidity. This study aimed to find out the association between DSWI and the type of sternal closure (hybrid wire cable ties or wiring) in the patients.

Methods: This single centre, comparative study was conducted at a tertiary care centre from 2021 to 2024. Data was collected from 262 patients who underwent sternal closure following sternotomy for CABG. The collected data was analysed for descriptive statistics (mean, standard deviation, etc.), and the Chi-square test was used to find the association between DSWI and the type of sternal closure.

Results: Patients were classified into two groups based on the sternal closure procedure. Group A had sternal closure done with hybrid wire cable ties and Group Bhad conventional steel wiring method for the same. Both the groups had similar ages but different comorbidity percentages. Out of 262, only 10(3.82%) patients had DSWI, and all were from Group B. The wiring method was found to be significantly associated with DSWI ($Z=10.40$, $p=0.001$). Moreover, the presence of diabetes was significantly associated with overall post-operative DSWI ($Z=4.37$, $p=0.048$).

Conclusions: DSWIs were not observed in the patients with sternal closure of median sternotomy with cable ties. These findings suggest that hybrid wire cable ties are superior to conventional stainless-steel wires for sternal closure in terms of reducing the risk of DSWI.

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Keywords:

Sternalclosure, cable-ties, wiring, CABG, Deep sternal wound infection (DSWI)

Introduction:

The midline sternotomy remains the primary incision technique for cardiac surgeries, such as Coronary Artery Bypass Grafting (CABG) (1). Sternal closure is a critical step in CABG, significantly affecting postoperative outcomes and patient recovery (2). Various sternal closure methods are employed, including wiring, interlocking systems (e.g., sternal synthesis or talon devices), cementing, fixation with plates and screws, vacuum-assisted closure, and cable ties (3,4).

For over five decades, median sternotomy closure using wires has been the gold standard due to its simplicity, speed, safety, and cost-effectiveness (4). However, changing patient demographics, characterized by multimorbid individuals with conditions such as diabetes, obesity, smoking habits, dialysis dependency, high transfusion requirements, and poor nutrition, pose challenges to traditional methods. These factors compromise bone strength and healing, making wires less effective for weaker sternal bones. Forceful coughing in such patients can cause wires to tear through bone, leading to complications like deep sternal wound infections (DSWIs), dehiscence, and potentially life-threatening mediastinitis (3–5).

Deep sternal wound infections, resulting in sternal dehiscence and mediastinitis, occur in 0.5–2% of postoperative patients and are associated with significant morbidity, prolonged hospital stays, and mortality rates as high as 25% (3,6,8). These infections necessitate additional surgical interventions, such as debridement or rewiring (6). Obesity, diabetes, smoking, high transfusion needs, and dialysis further increase the risk of wound infections (6,7).

Recent advancements have introduced alternative sternal closure techniques, including the use of cable ties. These hybrid wire cable ties, made from Polyether-Ether-Ketone (PEEK), offer superior strength, flexibility, and fatigue resistance compared to stainless steel wires (4,9). PEEK is a high-performance thermoplastic known for its durability in simulated "in vivo" conditions, withstanding lipid exposure and degradation. Cable ties feature a blunt-tipped needle on one end and a self-locking ratchet on the other. They are initially finger-tightened and then tensioned using a specialized instrument, which trims the

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excess cable flush with the ratchet housing (4,9. Biomechanical research has demonstrated that hybrid wire cable ties possess superior strength, flexibility, and fatigue resistance compared to stainless steel wires(9).

Laboratory studies suggest that cable ties, being 5 mm wide, are less likely to cut through osteoporotic bone compared to traditional wires, making them a promising alternative for patients with compromised bone integrity (2). Preliminary evidence and biomechanical research indicate that cable ties may provide better stability and load distribution, reducing complications. However, comprehensive comparative studies remain limited.

This comparative study examines clinical outcomes of sternal closure using cable ties versus wires in patients undergoing CABG. The primary objective is to determine whether cable ties result in fewer postoperative complications and improved overall patient outcomes compared to traditional wiring. By analysing infection rates, rewiring rates, and other relevant metrics, this study aims to contribute to the evolving discussion on optimal sternal closure techniques, ultimately supporting the integration of more effective methods in clinical practice. Our study includes a thorough examination of infection and rewiring rates. Through this comprehensive evaluation, we aim to establish evidence-based recommendations for sternal closure techniques that can enhance patient care and surgical outcomes in CABG procedures.

Materials and Methods:

Study design and population-

This comparative study was conducted at a tertiary care centre between May 2021 and January 2024. Data for all patients who underwent sternal closure following primary sternotomy for coronary artery bypass grafting (CABG) were reviewed (n = 262). Patients aged 18 years or older undergoing first-time CABG via median sternotomy were included in the study. Patients younger than 18 years or those who underwent redo surgery, re-exploration, or cardiac surgeries other than CABG were excluded.

All patients received standard preoperative care, including aseptic measures. Median sternotomy was performed, and after the grafting procedure was completed and hemostasis confirmed, sternal closure was carried out. Postoperative follow-ups were conducted to

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monitor complications such as sternal instability and sternal infections. Based on the surgical procedure used, patients were divided into two groups:

- Group A: Patients who underwent sternal banding using cable ties (n = 131).
- Group B: Patients who underwent sternal wiring (n = 131).

Data analysis-

Data were entered into Microsoft Excel 2016 (©Microsoft Corporation) and analyzed using SPSS version 21 (©IBM Corporation). Descriptive analysis was performed for normally distributed continuous data (mean ± standard deviation [SD]) and non-normally distributed continuous data (median and interquartile range [IQR]). Normality was assessed using the Shapiro-Wilk test.

For comparisons between the two groups:

- Independent t-tests were used for normally distributed data.
- Mann-Whitney U tests were used for non-normally distributed data.
- Chi-square tests were applied to compare categorical variables and assess associations between variables.
- Fisher's Exact Test was used alongside the Chi-square test where applicable.

A two-tailed p-value of <0.05 was considered statistically significant.

Results:

The study on data of 262 patients yielded the following results.

Baseline patient characteristics-

All 262 patients were classified into two groups based on the surgical procedure for sternal closure. Group A patients had a mean age of 57.56±9.49 years, whereas group B patients had a mean age of 56.21±8.90 years. Group A had 19.85% females and 80.15% males, whereas Group B had 26.00% females and 74.00% males. Table 1shows detailed baseline characteristics, including comorbidities of patients.

Both groups did not have significant difference in mean ages (t=1.118, df=260, p=0.236, Independent t test) of the patients and Ejection fraction (EF) (Z=-0.571, p=0.568, Mann-Whitney U test). However, percentage of comorbidities significantly differ in both the

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groups. Percentage of Diabetes Mellitus (DM) (70.23%) and smoking (40.46%) was statistically greater in Group A than in Group B ($p<0.001$, Chi-square test).

Operative findings-

Group A patients (n=131) underwent sternal closure using hybrid wire cable ties, whereas group B (n=131) underwent sternal closure by wiring method. In Group A, 32.06% of patients had >4 grafts, whereas only 16.79% of patients in group B had >4 grafts. Re-exploration was done in seven (5.34%) patients and 22 (16.92%) patients of group A and group B respectively.

In Group A, 33 (25.2%) patients had a Bilateral. Internal mammary artery (BIMA) graft used for coronary revascularisation, 92 (70.2%) patients had a Left Internal mammary artery (LIMA) graft, and 6 (4.6%) patients had a Right Internal mammary artery(RIMA) graft used for revascularisation as the LIMA artery was diseased and had inadequate blood flow. In Group B, 21 (16%) patients had coronary revascularisationusing a BIMA graft ,105 (80.2%) used a LIMA graft, and in 5 (3.8%) patients ,RIMA was used for revascularisation as the LIMA was diseased and had insufficient blood flow.

Deep Sternal Wound Infection (DSWI) and associated risk factors-

Out of 262 patients, a total of 10 (3.82%) patients had DSWI. All these patients were from Group B. There was no such case in Group A despite Group A having a statistically moresignificant number of diabetics and more number of patients where BIMA was used which are independently in itself a risk factor for DSWI. The patients with DSWI were managed by rewiring for sternal closure. Out of the total DSWI in Group B, in 5patients (50%) BIMA was used as a graft for coronary re-vascularisation. The chi-square test showed that the proportion of patients with DSWI was significantly higher in Group B (n=10, 7.63%) thanin Group A (n=0). It can be stated that there was a weak association between the type of surgery and post-operative DSWI, which was statistically significant ($Z=10.40$, $p=0.001$, Cramer's $V=0.199$) (Table 2). Further association analysis showed that presence of DM was statistically significantly associated with overall post-operative DSWI ($Z=4.37$, $p=0.048$, Cramer's $V=0.129$). The rest of the comorbidities or baseline characters did not show any significant association with post-operative DSWI. As Group A did not have any patient with post-operative DSWI, its association with different variables could not be computed. In Group B, post-operative rewiring was found to have statistically significant association with DM ($Z=8.52$, $p=0.006$, Cramer's $V=0.255$) as per Fisher Exact Test. Hence it contributed to the overall significant association of DM with post-operative DSWI.

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Discussion

Conventionally, stainless steel wires have been employed to close midline sternotomy after CABG. There are many new methods introduced for sternal closure.(3). In the present study of 262 patients, Group A patients in whom cable ties were used for sternal closurehad a mean age of 57.56±9.49 years and Group B patients in whom stainless steel wires were used had a mean age of 56.21±8.90 years. DSWI was observed to be 10(3.82%) in Group B while none were seen in Group A. A similar study was conducted by Melly et al. with 680 patients with mean age of 66 years to compare conventional methods of sternal closure with cable ties. They observed sternal infections in 36patients (6.1%) of the total studied over a period of one year with no statistically significant difference between the two groups .Similarly,no significant difference in incidence of sternal dehiscence wasseen in the two groups compared by Altinay et al. and zero cases of sternal dehiscence was observed by Stelly et al(10–12). Out of the 36 patients with DSWI observed in Melly et al., various other post-operative complications like deep wound infection, pneumothorax, myocardial infarction, delirium and renal failure were observed in the two groups, which was not statistically significant(10). Diabetes mellitus was a co-morbidity found to be significantly associated with DSWI in the present study while Melly et al. found higher BMI, smoking and pulmonary disease to be significantly associated. In their study, no sternal instability was observed in cable ties as compared to conventional wiring(10). Insulin Dependent Diabetes Mellitus (IDDM), BMI>30, peripheral vascular disease, longer operative duration, poor LVEF and longer mechanical ventilation were found as risk factors for sternal wound infections according to Lu et al(13). A review of 140 papers conducted by Tompoulis et al. identified 24 papers which showed that Bilateral Internal Thoracic Artery (BITA) grafting, also known as BIMA grafting had 2.5 to 5 times higher risk of mediastinitis as compared to Single Internal Thoracic Artery (SITA) grafting post-CABG with rates being higher in diabetics(14–16). In the present study in group A, among 33 (25.2%) patients BIMA graft was used for coronary revascularisation, yet no case of mediastinitis was observed. Whereas in group B, where stainless steel wires were used, 10 (3.82%) cases of DSWI were reportedof which, BIMA was used as a graft for coronary revascularisationin 50% of the cases. In their study, post operative complications were observed by conducting ultrasound examination of the sternum after 48 hours,whereas in the present study,DSWI was used for comparison between cable ties and wiring(2).

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Despite advancements in perioperative care, DSWI continues to be a significant problem in cardiac surgery. Prophylactic antibiotic therapy is vital for prevention, but there is still debate over the best choice of antibiotic, dosage, duration, serum and tissue levels and timing(17). Lu et al. studied pathogens causing infection. *Staphylococcus epidermidis* was the most common pathogen, followed by *S. aureus* and Methicillin Resistant Staphylococcus Aureus. Among gram negative bacteria, *enterococci* and *pseudomonas* were observed. Also, in-hospital mortality of 25% for DSWI was seen compared to 2.5% for superficial sternal wound infections and 2.2% for patients without infections. Prolonged stay in infected patients was also noted(13). This is an important factor for correct antibiotic therapy for sternal wound infection.

Grapow et al. observed a gradual reduction in the mean implantation time, decreasing from 15 minutes for initial cases (like sternal closure with wires) to 7 minutes for the last 20 cases with no bleeding incidents related to intercostal or internal mammary artery lesions on usage of cable ties system. At discharge,they observed and confirmed with clinical examinations,sternal stability in all the patients, and 47 out of 49 patients showed stability in 30 days postoperatively. However, two patients developed mediastinitis, requiring the removal of the cable ties on 24th and 30th day, along with antibiotic treatment(4). A certain brand producing these cable ties has inferred that cable ties offer enhanced resistance to cutting through the sternum in weaker bones compared to stainless steel wire. They also concluded that the fatigue load was better survived by the cable ties. They survived around 300N cycles as compared to stainless steel wires, making them a more reliable option(9). This finding was consistent with Grapow et al(4)concluding that cables ties are a more reliable option for sternal closure.

However, Khoury et al. reviewed the Figure 8 Flat Wire Sternal Closure System which was observed to be stronger and found to significantly decrease sternal cut-through and postoperative pain when compared to traditional wire **cerclage** similar to the observations of Tekumit et al(18,19). However, there was no notable difference in the length of hospital stay or the average cost of hospitalization despite increasing the operation duration(18). Özen et al. recommended cable ties in patients with risk factors for sternal instability. They observed significantly shorter stay and better drainage in patients with cable ties and sternal dehiscence in only three patients with cable ties as compared to five with steel wires(20).

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Treatment for DSWI ranges from surgical revision with primary closure to the use of open dressings, closed irrigation and negative pressure wound therapy (NPWT). NPWT has proven effective and safe both as a standalone treatment and as a precursor to final surgical closure. However, there are no universally accepted guidelines for DSWI management. Controlling risk factors, proper antimicrobial prophylaxis, and validated treatment methods are key to reducing DSWI rates(17).

Compared to rewiring, a new technique called vacuum assisted sternal closure was recommended by Tang et al(21). Sternal healing after sternal osteotomy would be governed by the three main principles for bone healing namely approximation, compression, and rigid fixation. Gerdisch et al. reviewed various techniques and concluded that a combination of cable ties and sternal wiring didn't report any incidence of sternal dehiscence(22).

Conclusion:

In conclusion, sternal closure of median sternotomy with cable ties has no cases of DSWI reported as compared to closure with stainless steel wires in this comparative study. A study with greater sample size would yield more conclusive results.

Study limitations:

In the present study, it was observed that usage of cable ties had lesser incidence of DSWI compared to traditional wiring techniques. However other factors like duration of surgery, hospital stay and cost of the method employed should be considered for a better understanding.

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Conflict of interest: none declared.

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Table 1: Baseline pre-operative characteristics of patients in group A and group B including socio-demographic information and comorbidities.

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	Group A (n=131)	**Group B (n=131)**	**p value**	**Total (n=262)**
Age (mean±SD) years	57.56±9.49	56.21±8.90	0.236	56.88±9.21
Sex, N(%) Female Male	 26(19.85%) 105(80.15%)	 34(26.00%) 97(74.00%)	 0.240	 60(22.90%) 202(77.10%)
Diabetes mellitus (DM) No Yes	 39(29.77%) 92(70.23%)	 71(54.20%) 60(45.80%)	 <0.001	 110 (41.98%) 152(58.02%)
Smoking No Yes	 78(59.54%) 53(40.46%)	 106(81.54%) 25(18.46%)	 <0.001	 184(70.23%) 78(29.77%)
Chronic Kidney Disease (CKD) No Yes	 125(95.42%) 6(4.58%)	 100(76.34%) 31(23.66%)	 <0.001	 225(85.88%) 37(14.12%)
EjectionFraction (mean±SD) %	45.66±13.45	45.52±11.13	0.568	45.53±12.32

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Table 2: Association of post-operative rewiring with different variables along with group-wise statistics.

Association with sex of the patients				
		Female	Male	**Total**
Post-operative Rewiring	No	59(98.33%)	193(95.54%)	**252(96.18%)**
	Yes	1(1.67%)	9(4.46%)	**10(3.82%)**
	Total	**60(100%)**	**202(100%)**	**262(100%)**
Z=0.98, p=0.463*, Cramer's V=0.061				
Association with DM				
		DM (No)	DM (Yes)	**Total**
Post-operative Rewiring	No	109(99.09%)	143(94.08%)	**252(96.18%)**
	Yes	1(0.91%)	9(5.92%)	**10(3.82%)**
	Total	**110(100%)**	**152(100%)**	**262(100%)**
Z=4.37, p=0.048*, Cramer's V=0.129				
Association with Smoking				
		Smoking (No)	Smoking (Yes)	**Total**
Post-operative Rewiring	No	176(95.65%)	76(97.44%)	**252(96.18%)**
	Yes	8(4.35%)	2(2.56%)	**10(3.82%)**
	Total	**184(100%)**	**78(100%)**	**262(100%)**
Z=0.48, p=0.728*, Cramer's V=0.043				
Association with CKD				
		CKD (No)	CKD (Yes)	**Total**
Post-operative Rewiring	No	218(96.89%)	34(91.89%)	**252(96.18%)**
	Yes	7(3.11%)	3(8.11%)	**10(3.82%)**

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	Total	**225(100%)**	**37(100%)**	**262(100%)**
Z=2.16, p=0.154*, Cramer's V=0.091				

*Fisher Exact test is applied.

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Fig 1. Sternal cable ties

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Fig 2. Applicator Gun

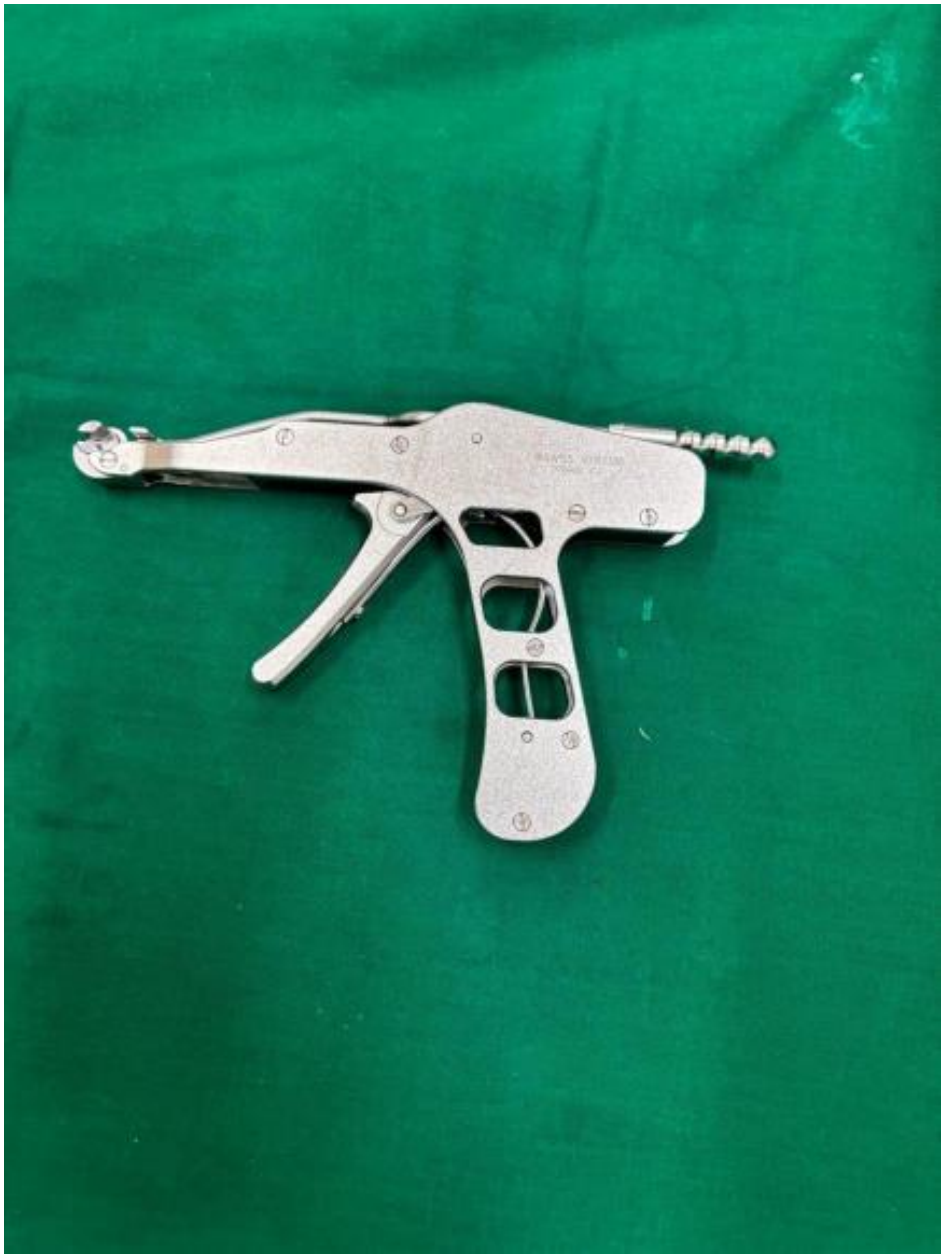

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Fig 3. Hybrid Technique of sternal closure using cable ties and wires

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Fig 4. Final sternal closure using hybrid technique