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Hybrid Revascularization vs Conventional CABG in Triple Vessel Disease: Mini Systematic Review

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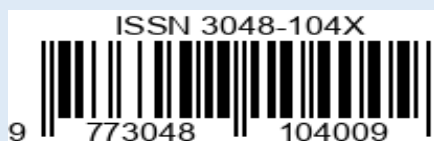
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ABSTRACT

Background: Hybrid coronary revascularisation (HCR) integrates minimally invasive coronary artery bypass grafting (CABG) with percutaneous coronary intervention (PCI), presenting a viable alternative for managing severe triple-vessel disease (TVD). Although conventional CABG is the benchmark for multivessel disease, HCR has arisen as a method intended to diminish surgical morbidity while preserving long-term revascularisation advantages. This systematic study assesses the long-term clinical results of HCR in comparison to CABG. **Methods:** A computerised literature search was conducted across three search engines (Google Scholar, PUBMED, Crossref) for the years 2014-2025, with the keywords: CABG, Hybrid, TVD, and Triple Vessel. Quality of studies assessed using the Mixed Methods Appraisal Tool (MMAT) version 2018. **Results:** Initially, 1339 papers were retrieved; utilizing the PRISM algorithm, 2 articles were ultimately reviewed. Basman et al. (2020) discovered that the 8-year survival rates were comparable between HCR (5.0%) and CABG (4.0%), with no significant disparity in Major Adverse Cardiovascular Events (MACE) rates. Esteves et al. (2020) observed a greater incidence of adverse events in HCR (19.3%) compared to CABG (5.9%) at two years, primarily due to increased unexpected revascularisation; however, HCR demonstrated feasibility with acceptable safety. Both studies indicated that HCR is most appropriate for specific patients in whom PCI can successfully enhance minimally invasive bypass methods. **Conclusions:** HCR has benefits like reduced hospital durations and diminished surgical morbidity; however its long-term results do not surpass those of CABG. Increased revascularisation rates in HCR prompt apprehensions over its longevity in comparison to normal CABG. Future extensive randomised trials are necessary to formulate definitive clinical recommendations for patient selection.

Keyword : CABG, Hybrid, Triple-Vessel Disease, TVD

INTRODUCTION

Hybrid coronary revascularisation (HCR) has surfaced as a viable approach for managing individuals with multivessel coronary artery disease (CAD). This method generally integrates minimally invasive direct coronary artery bypass (MIDCAB) with percutaneous coronary intervention (PCI), facilitating the efficient management of intricate coronary lesions while reducing surgical trauma and recuperation duration. The amalgamation of these two techniques capitalises on their respective advantages, notably the enduring benefits linked to arterial grafting and the prompt effectiveness of PCI. A key benefit of HCR is the use of the left internal mammary artery (LIMA) for grafting to the left anterior descending artery (LAD) through MIDCAB. This approach demonstrates enhanced long-term patency relative to saphenous vein grafts, rendering it a compelling choice for patients with substantial LAD disease. Ruel et al. (2014); Repossini et al. (2013). The LIMA-LAD graft is advantageous due to its reduced susceptibility to atherosclerosis, resulting in improved clinical outcomes (Wang et al., 2016). Research indicates that individuals receiving HCR have reduced rates of angina recurrence and major adverse cardiac events (MACE) in comparison to those treated only with PCI (Wang et al., 2016). A study comparing HCR to off-pump coronary artery bypass graft (OPCABG) concluded that both methods are viable and produce similar short-term clinical outcomes, however HCR may provide benefits regarding recovery and duration of hospital stay (Hu & Cui, 2015). Moreover, HCR has demonstrated cost-effectiveness, especially in patients with intricate coronary architecture, where conventional surgical methods may be less advantageous (Cohen et al., 2014). Patients with triple vessel disease (TVD) are at an increased risk of major adverse cardiac events (MACE) and have a higher death rate compared to those with double vessel disease (DVD) or single vessel disease (Tsai et al., 2017; Dighikar & Singh, 2021). The existence of TVD correlates with an increased ischaemic burden and a more intricate clinical scenario, frequently requiring more intensive therapeutic measures such as coronary artery bypass grafting (CABG) instead of percutaneous coronary intervention (PCI) (Dighikar & Singh, 2021; Basman et al., 2020). Additionally, several risk factors have been recognised that predispose individuals to the development of TVD. Diabetes

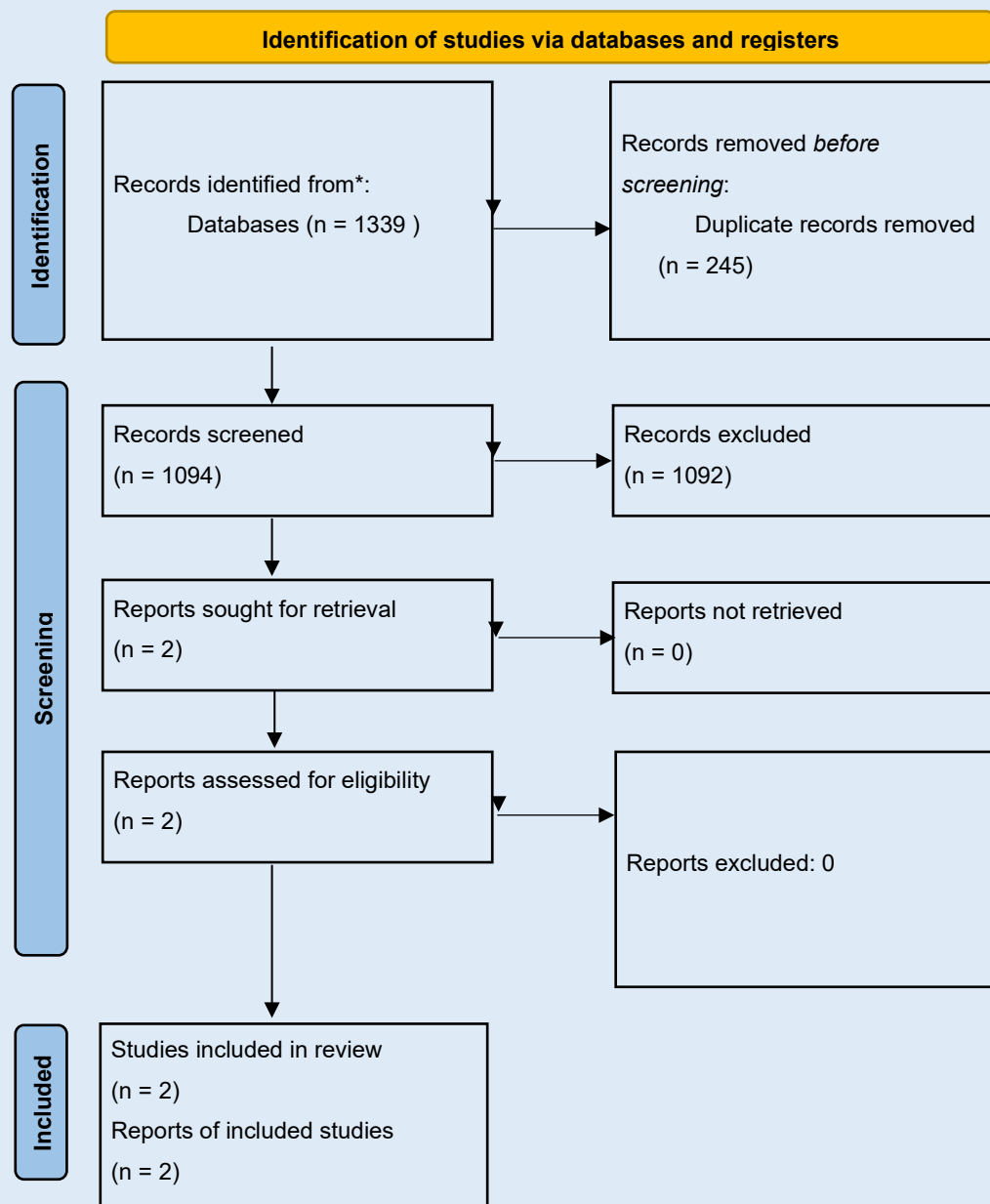
mellitus considerably elevates the probability of triple vessel involvement compared to non-diabetics (Shakya et al., 2019; Pathak et al., 2021). Moreover, research has shown that psychological variables, including depression, are more common in patients with TVD, potentially complicating their therapeutic management (Das et al., 2022). This indicates that the pathophysiology of TVD may be affected by both metabolic and psychological factors, hence distinguishing it from MVD. Moreover, the anatomical and functional ramifications of TVD compared to MVD may result in divergent clinical results. Patients with TVD frequently exhibit a diminished ejection fraction, signifying compromised heart function, which may affect both short- and long-term survival chances (Suri et al., 2023). The SYNTAX score, which evaluates the intricacy of coronary artery disease, has proven to be a robust predictor of clinical outcomes, especially in individuals with triple vessel disease (Manzil et al., 2015). This highlights the necessity of precisely categorizing the degree of coronary artery involvement to inform treatment decisions efficiently.

METHODS

Author conducted computerized search of the literature in 3 search engines from 2014-2025 (Google Scholar, PUBMED, Crossref), with the searched keywords arranged with the boolean terms including:

("Coronary Artery Bypass Grafting"[MeSH] OR "CABG")
AND ("Hybrid Coronary Revascularization" OR "Hybrid Surgery")
AND ("Major Adverse Cardiovascular Events" OR "MACE"
OR "Mortality" OR "Myocardial Infarction" OR "Stroke"
OR "Repeat Revascularization")
AND ("Long-Term Outcomes" OR "Short-Term Outcomes")
AND ("Triple Vessel Disease" OR "TVD")

Figure 1 PRISMA algorithm



Quality of the studies conducted with Mixed Methods Appraisal Tool (MMAT)

RESULTS

A systematic review was conducted using two key studies: (1) Basman et al. (2020) analyzed 8-year survival outcomes in TVD patients undergoing HCR, CABG, or multivessel PCI, comparing mortality rates, major adverse cardiovascular events (MACE), and revascularization rates . (2) Esteves et al. (2020) provided a randomized comparison of HCR vs. CABG in the MERGING

clinical trial, focusing on 2-year follow-up data, including death, myocardial infarction, stroke, and repeat revascularization. Quality of 2 articles review with MMAT 2018 version.

Table. 1 Studies included in the review

	Esteves et al. (2020)	Basman et al. (2020)
Study Type	RCT	Cohort
Sample Size	60 patients (HCR: 40, CABG: 20)	300 patients (HCR: 100, CABG: 100, PCI: 100)
Follow-up Duration	2 years	8 years
Primary Endpoint	MACE (Death, MI, Stroke, Repeat Revascularization)	All-cause mortality
MACE Rate	HCR: 19.3%, CABG: 5.9% (p = 0.2)	HCR: 21%, CABG: 15% (p = 0.36), PCI: 25% (p = 0.60)
Mortality Rate	HCR: 5.0%, CABG: 0%	HCR: 5.0%, CABG: 4.0%, PCI: 9.0% (p = NS)
Hospital Length of Stay	HCR: 8.6 days, CABG: 8.2 days (p = 0.7)	HCR: 5.7 days, CABG: 7.5 days (p = 0.01), PCI: 2.0 days (p < 0.0001)
Bleeding Complications	HCR: 7.5%, CABG: 5.0%	HCR: 7.5%, CABG: 5.0% Not reported
Repeat Revascularization	HCR: 14.5%, CABG: 5.9% (p = 0.4)	HCR: 16%, CABG: 11%, PCI: 18% (p = NS)

RCT: Randomized Controlled Trial, NS: Not Stated

Table. 2 Appraisal based on MMAT 2018

	Esteves et al. (2020)	Basman et al. (2020)
Randomization properly performed?	Yes	—
Groups comparable at baseline?	Yes	—
Complete outcome data available?	Yes	—
Blinded outcome assessment?	No	—
Adherence to assigned intervention?	Yes	—
Representative of target population?	—	Yes
Appropriate measurements used?	—	Yes
Confounders accounted for?	—	Yes
Intervention administered as intended?	—	Yes
Risk of bias	Moderate (blinding not stated)	Moderate (Confounders partially controlled)

Esteves et al. (2020) conducted a randomized controlled trial (RCT) comparing HCR vs CABG in 60 patients over 2 years, using MACE as the primary outcome. This study found that HCR group had significantly higher MACE rate (19.3%) compared to CABG (5.9%). However, the difference was not statistically

significant ($p=0.2$). The most common event in HCR was unplanned repeat revascularization (14.5%), compared to 5.9% in the CABG group ($p=0.4$). Major bleeding complications of HCR patients (7.5%) are higher than CABG patients (5.0%; $p>0.99$). Repeat vascularizations occurred in HCR patients are also higher (16% vs 11%). Length of stay was similar in both groups (8.6 days vs 8.2 days; $p=0.7$).

Basman et al. (2020) conducted a retrospective propensity-matched study comparing HCR, CABG, and PCI in cohort of 300 patients within 8 years of follow-up. The primary outcome of this study are long term survival rates, revascularization rates, and residual SYNTAX scores. This study found that all-cause mortality, MACE, and repeat revascularization rate in HCR population are higher compared to CABG; however all of the result gave no significant statistics (5.0% vs 4.0%, $p=NS$; 21% vs 15%, $p=0.60$; 6% vs 11%, $p=NS$). Residual SYNTAX score and length of stay of HCR significantly lower than CABG (4.5 vs 5.2; $p=0.001$; 5,7 days vs 7.5 days; $p=0.01$), length of stay of HCR significantly lower.

DISCUSSION

The comparison of HCR and CABG for TVD highlighted significant factors about short-term and long-term clinical results, procedural feasibility, and patient selection. Esteves et al. (2020) conducted a short-term (2-year) randomised experiment, while Basman et al. (2020) presented long-term (8-year) retrospective data, facilitating a more thorough assessment of these two revascularisation procedures. In the short-term analysis conducted by Esteves et al., HCR exhibited a markedly elevated incidence of MACE (19.3%) relative to CABG (5.9%), mostly attributable to a greater occurrence of myocardial infarction (12.5% vs. 5.9%) and repeat revascularisation (14.5% vs. 5.9%). Although CABG exhibited superior early outcomes, HCR nevertheless offered viable revascularisation without elevating stroke risk. Significantly, no instances of stroke were recorded in either cohort, and although mortality was marginally elevated in HCR (5.0% vs to 0%), this was ascribed to surgical problems that transpired prior to the PCI phase. These findings indicate that CABG continues to be the favoured choice for complex TVD in the near term, but HCR presents an elevated risk of recurrent ischaemic episodes.

Conversely, the extended follow-up by Basman et al. revealed similar survival rates between HCR and CABG at 8 years (95% vs. 96%), suggesting that HCR may serve as a feasible alternative for certain patients over time. The repeat revascularisation rate for HCR was marginally elevated at 16% in contrast to 11% for CABG; however, this discrepancy lacked statistical significance. Notably, HCR attained a markedly lower residual SYNTAX score compared to PCI (4.5 vs. 7.1, $p = 0.001$), underscoring that HCR offers more comprehensive revascularisation than PCI, however is somewhat less durable than CABG in the long run. Furthermore, the duration of hospital stay was reduced in HCR (5.7 days) relative to CABG (7.5 days, $p = 0.01$), underscoring a possible benefit of the hybrid method. The viability of HCR as a minimally invasive substitute for CABG is a significant factor to consider. The integration of CABG for LAD lesions with PCI for non-LAD lesions has become increasingly popular, especially among patients with multivessel disease (Fan et al., 2015). This method facilitates the prompt revascularisation of essential regions while managing less critical lesions with PCI, which is minimally invasive and linked to reduced recovery durations (Fan et al., 2015). Evidence indicates that HCR is beneficial in achieving favourable clinical results, including decreased morbidity and death rates in comparison to standard CABG alone (Fan et al., 2015). Both studies possess drawbacks. Esteves et al., albeit a randomised controlled trial (RCT), had a limited sample size ($n = 60$), which constrains its generalisability. Furthermore, the result assessors were unblinded, which may have introduced bias. Conversely, Basman et al. incorporated a more extensive cohort ($n = 4,805$), however its retrospective approach poses the danger of unmeasured confounders. The brief follow-up of Esteves et al. (2 years) may inadequately reflect the long-term advantages of HCR, while Basman et al. (8 years) offers more robust long-term evidence but is weaker than RCT in terms of strength of evidence. These data indicate that CABG continues to be the preferred revascularisation approach for patients with complex triple-vessel disease, especially those with elevated SYNTAX scores.

CONCLUSION

HCR may be a feasible alternative for certain patients with intermediate SYNTAX scores and advantageous coronary architecture, providing comparable

long-term survival to CABG using a less invasive method. Due to the elevated short-term risk of myocardial infarction and subsequent revascularisation in high-risk patients, careful patient selection is essential to enhance results. Future extensive, multicenter randomised controlled trials comparing CABG with HCR with prolonged follow-up exceeding 8 years are essential to formulate solid guidelines and identify the optimal patient demographic for HCR.

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