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The Clinical Evaluation of Rheumatic Mitral Valve Repair

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Abstract: Background and Study Aims: Rheumatic heart disease (RHD) remains a leading cause of mitral valve disease globally, particularly in developing countries, where it poses a significant burden on cardiovascular health. Mitral valve repair (MVP) and replacement are the primary surgical interventions; however, the optimal selection between these procedures remains a subject of ongoing debate. This study aims to systematically review the clinical outcomes of MVP in patients with RHD and compare them with those of mitral valve replacement (MVR), thereby addressing a critical gap in the existing literature. **Methods:** This study adopts a systematic review methodology in accordance with PRISMA guidelines to screen relevant literature published between 2000 and 2024. The data sources for this study include PubMed, Embase, and the Cochrane Library. The key outcome measures include early mortality (defined as death from any cause within 30 days post-surgery), long-term survival, reoperation rates, and valve-related complications. **Results:** Five studies encompassing a total of 3,543 patients were analyzed. Compared with MVR, MVP demonstrated a non-significant trend toward lower 30-day mortality (OR 0.74, 95% CI 0.50–1.10; P = 0.14). Long-term survival appeared to favor MVP, with a hazard ratio (HR) of 0.63 (95% CI 0.35–1.11; P = 0.11), although without reaching statistical significance. MVP was associated with a significantly higher risk of reoperation (HR 3.85, 95 % CI 2.18–6.78; P < 0.00001), but a substantially lower incidence of valve-related complications, including thromboembolic events and infective endocarditis (HR 0.36, 95% CI 0.21–0.61; P < 0.001). **Conclusions:** MVP in patients with RHD reduces early mortality, improves long-term survival, and lowers the incidence of valve-related complications. However, it is associated with a higher risk of reoperation.

Keywords: Rheumatic Heart Disease, Mitral Valve Repair, Mitral Valve Replacement, China

1. Introduction

Rheumatic heart disease (RHD) continues to be a major public health burden, disproportionately affecting populations in Africa, South Asia, and parts of Latin America, where it remains one of the leading causes of mitral valve pathology. Globally, RHD affects over 30 million people, contributing to approximately 300,000 deaths per year[12], with a particularly high burden in resource-limited settings where access to early diagnosis and surgical intervention is restricted. Despite advancements in early detection and prophylactic strategies, rheumatic mitral valve disease remains a significant challenge, necessitating effective surgical interventions. Although mitral valve replacement (MVR) has been the traditional standard of care, advances in surgical techniques and patient selection criteria have led to increased interest in mitral valve repair (MVP). The potential benefits of MVP, including native valve preservation and reduced long-term complications, must be weighed against its technical complexity and durability concerns, particularly in patients with severe fibrosis or calcification.

The surgical repair of rheumatic mitral valve disease dates back to the 1950s and 1960s, coinciding with the emergence of direct cardiac surgery. The 1970s marked a pivotal shift with the pioneering contributions of Carpentier and Duran. Carpentier's "reconstruct rather than replace" principle established the foundation of modern MVP, emphasizing the preservation of the native valve whenever feasible. Duran's introduction of annuloplasty techniques effectively addressed annular dilation and improved the durability of MVP[35]. These pioneering techniques have significantly improved the success rates and outcomes of MVP in patients with rheumatic heart disease. Standard rheumatic MVP involves several key surgical steps designed to address the complex structural changes associated with RHD. These steps include commissurotomy, valvular debridement, artificial chordae implantation, subvalvular release, and annular remodeling[369]. The primary goal of these procedures is to restore optimal valve function while preserving the native mitral valve, thereby reducing the risks associated with prosthetic valve replacement.Although MVP demonstrates superior outcomes in degenerative mitral valve disease[1122], its role in rheumatic mitral disease remains controversial. The chronic inflammatory processes in RHD contribute to progressive

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fibrosis and calcification, raising concerns regarding repair durability and long-term efficacy[23].

Additionally, the anatomical challenges of rheumatic mitral disease, including leaflet thickening, subvalvular involvement, and annular calcification, frequently require extensive surgical modifications, which may impact repair outcomes. These challenges are often addressed through advanced surgical techniques and preoperative imaging, which enhance repair precision. However, despite these advances, MVR remains the predominant surgical approach for rheumatic mitral valve disease in China and other high-burden regions[2425], particularly where expertise in complex MVP techniques is limited. Nevertheless, MVP presents several advantages, including lower perioperative mortality, better preservation of left ventricular function, reduced long-term anticoagulation requirements, and lower risks of thromboembolic events and infective endocarditis[10],2630].

With ongoing advancements in surgical techniques and an improved understanding of RHD pathophysiology, recent studies have reported promising outcomes following MVP in select patient populations[20],3134]. The integration of advanced imaging modalities, including three-dimensional transthoracic and transesophageal echocardiography, has further enhanced preoperative evaluation and surgical planning[3540], allowing for more precise repairs and reducing operative complications. These imaging advancements have been particularly valuable in patient selection, intraoperative guidance, and postoperative assessment, contributing to improved long-term outcomes.

In light of these advancements, this review aims to systematically evaluate the clinical outcomes of MVP in patients with RHD and compare them with those of MVR. Specifically, it seeks to determine whether MVP provides comparable or superior long-term survival, lower reoperation rates, and reduced valve-related complications compared to MVR. By analyzing the available evidence, this review also aims to identify key factors influencing MVP success, such as patient age, valve pathology, and surgical expertise, and to highlight the potential benefits of avoiding lifelong anticoagulation therapy.

2. Surgical Techniques

2.1. Historical Evolution

The surgical management of rheumatic mitral valve disease has undergone substantial evolution over the past several decades. Early repair techniques, developed between the 1950s and 1970s, focused on commissurotomy, valve debridement, annuloplasty, and basic subvalvular apparatus release. These pioneering methods laid the groundwork for contemporary MVP strategies, with an emphasis on preserving native valve anatomy and restoring physiological function. The subsequent introduction of structured scoring systems, such as the CLAS score, enabled surgeons to systematically assess mitral valve pathology, thereby enhancing surgical planning and repair outcomes[41]. Early innovations primarily addressed commissural fusion and leaflet thickening, providing critical insights that have shaped the refinement of modern MVP approaches.

2.2. Modern Techniques

Contemporary MVP practice increasingly emphasizes individualized, physiology-guided repair strategies. Novel preoperative metrics, such as the anterior leaflet curvature angle, have been introduced to better predict repair feasibility and long-term durability[4244]. Among significant advancements, the "Four-Step Technique" developed by Meng Xu's team—comprising shaving, identifying, cutting, and releasing—offers a reproducible framework for addressing complex rheumatic lesions. Building upon Carpentier's pathophysiological triad of etiology, lesion, and dysfunction, newer approaches aim to restore both diastolic filling and systolic competence. The modified release technique, incorporating anterior leaflet detachment, chordal fenestration, and selective subvalvular mobilization, has demonstrated improvements in effective valve orifice area, reduced transvalvular gradients, and favorable mid-term clinical outcomes[5157].

In addition, technological innovations such as Gore-Tex chordae and 3D-printed annuloplasty rings have significantly enhanced surgical precision. Gore-Tex chordae offer a durable alternative to native chordae, particularly beneficial in rheumatic pathology where chordal fibrosis and shortening are common [63],64]. Personalized 3D-printed annuloplasty rings, by providing a better anatomical fit, have shown superior durability compared to conventional devices [65]-67]. Nevertheless, it remains essential to recognize that in cases of extensive leaflet calcification, severe subvalvular fibrosis, or destructive rheumatic lesions, MVR may offer a more durable solution. Moreover, surgical success is closely linked to institutional volume and surgeon expertise; MVP outcomes in low-volume centers are associated with higher repair failure and reoperation rates.

2.3. Imaging Integration

The integration of advanced imaging modalities, particularly intraoperative transesophageal echocardiography (TEE), has become a cornerstone of modern MVP. Real-time three-dimensional TEE provides superior visualization of leaflet morphology, commissural integrity, and subvalvular apparatus, enabling immediate intraoperative assessment of repair adequacy [36394950]. Compared to traditional two-dimensional imaging, 3D TEE more accurately identifies subtle prolapse segments and quantifies leaflet motion abnormalities, both critical for optimizing surgical outcomes. Real-time feedback facilitates intraoperative adjustments, allowing surgeons to tailor repair strategies dynamically and enhance the durability of the repair.

3. Materials and Methods

3.1. Search Strategy

A comprehensive systematic search was performed in PubMed, EMBASE, and the Cochrane Library to identify English-language articles published between 2000 and April 2024. The following keywords were used: ["rheumatic heart disease" OR "rheumatic" OR "RHD"] AND ["mitral valve repair" OR "mitral valvuloplasty" OR "mitral valve annuloplasty" OR "mitral valve reconstruction" OR "mitral valve replacement" OR "MVR" OR "MVP"]. Additionally, the reference lists of all relevant articles were manually reviewed to ensure no eligible studies were overlooked.

3.2. Selection Criteria and Quality Assessment

Studies were considered eligible if they met the following criteria: (1) published in English between 2000 and April 2024; (2) involved patients diagnosed with rheumatic heart disease undergoing mitral valve repair; (3) reported clinical outcomes such as mortality, valve function, reoperation rates, or postoperative complications; and (4) included original data from randomized controlled trials, prospective cohorts, or retrospective analyses. Reviews, editorials, case reports, and conference abstracts were excluded. Quality assessment was independently conducted by two authors(JY and JZ)using appropriate evaluation tools based on the study design. For randomized controlled trials, the Cochrane Risk of Bias Tool was applied; for observational studies, the Newcastle-Ottawa Scale (NOS) was used.

3.3. Statistical Analysis

Statistical analyses were conducted using hazard ratios (HRs) and odds ratios (ORs), each presented with corresponding 95% confidence intervals (CIs). A random-effects model was selected for pooled estimates to address inter-study heterogeneity effectively. The Mantel–Haenszel method was applied for dichotomous outcomes, whereas for time-to-event outcomes, hazard ratios were directly extracted or approximated from Kaplan–Meier survival curves as necessary. Heterogeneity was assessed quantitatively using the I^2 statistic, with values above 50% considered indicative of significant heterogeneity. Sensitivity analyses were systematically performed by sequentially omitting individual studies to investigate potential sources of heterogeneity. Publication bias was initially assessed by visually examining funnel plot symmetry and further evaluated statistically using Begg's rank correlation and Egger's regression tests. All statistical procedures were executed with RevMan (version 5.4.1) and Stata (version 15.1), adopting a two-sided P-value <0.05 as the threshold for statistical significance.

4. Results

4.1. Study Characteristics

This review included five comparative studies (Figure 1) with a total of 3,543 patients: 1,292 who underwent MVP and 2,251 who received MVR. Four studies used propensity score matching (PSM) to control for selection bias, while one did not. The studies were conducted in China, South Africa, and Australia, with follow-up durations ranging from 2.85 to 5.9 years. Key study details and patient demographics are shown in Tables 1 and 2. The MVP and MVR groups were similar in terms of age, sex, atrial fibrillation rates, and mitral valve lesions (regurgitation, stenosis, or mixed).

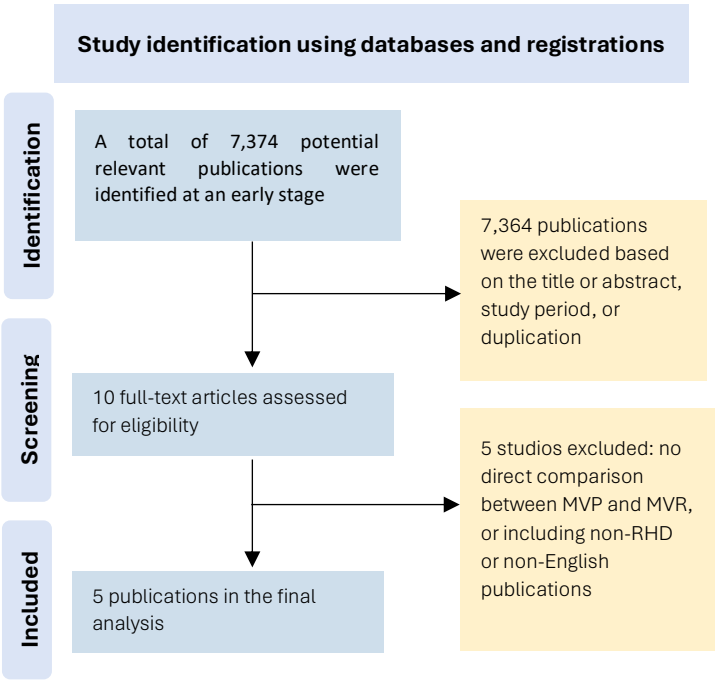

Figure 1: Flow chart of the trial selection process

Table 1: Main characteristics of the included studies.

Study	Country	Study peroid	Mean follow-up years	Study design	NOS scores
Chen	China	2000-2013	5.9 ± 4.2/5.8 ± 4.2	PSM	8
Fu	China	2011-2019	median 4.12	PSM	8
Geldenhuys	South Africa	2000-2010	4.4 ± 3.0	PSM	9
Jiao	China	2011-2017	median 2.85	PSM	8
Russell	Australia	2001-2013	NA	Unmatched	7

MVP, mitral valve repair; MVR, mitral valve replacement; NA, not available; NOS, Newcastle-Ottawa Scale; PSM, propensity score matching

Table 2: Baseline characteristics of patients

Study	Surgery		Mean ages (years)		Male gender (%)		MR (%)		MS (%)		MR+MS (%)		AF (%)	
	MVP	MVR	MVP	MVR	MVP	MVR	MVP	MVR	MVP	MVR	MVP	MVR	MVP	MVR
Chen	467	467	56.8	56.7	46.9	44.1	19.3	18.8	65.1	65.5	15.6	15.6	57.4	58
Fu	529	529	54.5	54.6	27.8	27.8	12.7	10.2	10.4	11.9	76.9	77.9	67.9	69.6
Geldenhuys	69	69	36.9	40.9	23.1	16	39.0	13.0	3.0	7.0	27.0	49.0	29.0	39.0
Jiao	221	700	50.1	55.5	39.8	27.1	32.4	40.7	100	100	32.4	40.7	75.4	
Russell	119	1078	57.3	62	42	28.7	81.5	63.9	25.2	75.3	NA	NA	26.1	48.9

MVP, mitral valve repair; MVR, mitral valve replacement; NA, not available; DM, diabetes mellitus; MR, mitral regurgitation; MS, mitral stenosis; AF, atrial fibrillation

4.2. Early Postoperative Mortality

Five studies involving 3,543 patients (1,292 undergoing MVP and 2,251 undergoing MVR were included in the analysis of early postoperative mortality after propensity score matching[6872]. Although the results showed a trend favoring MVP (OR 0.74; 95% confidence interval [CI], 0.50–1.10; P = 0.14; I^2 = 44%) (Figure 2), the difference between the two groups was not statistically significant. Moderate heterogeneity was noted.

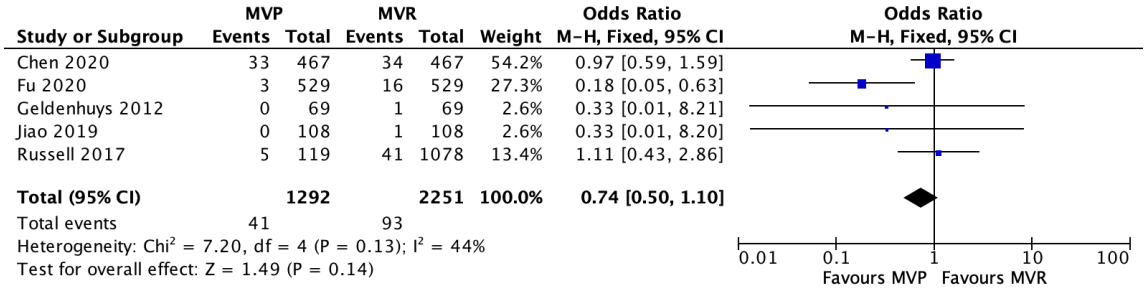

Figure 2: Comparison of 30-day mortality.Mitral valve repair (MVP) versus mitral valve replacement

4.3. Long-Term Survival

Long-term survival data were available for all five studies[68]-[72] and were graphically presented in a forest plot (Figure 3). Significant heterogeneity was observed among the studies. The pooled hazard ratio (HR) was 0.63 (95% CI, 0.35–1.11), suggesting that patients undergoing MVR had a 59% higher long-term risk of mortality.

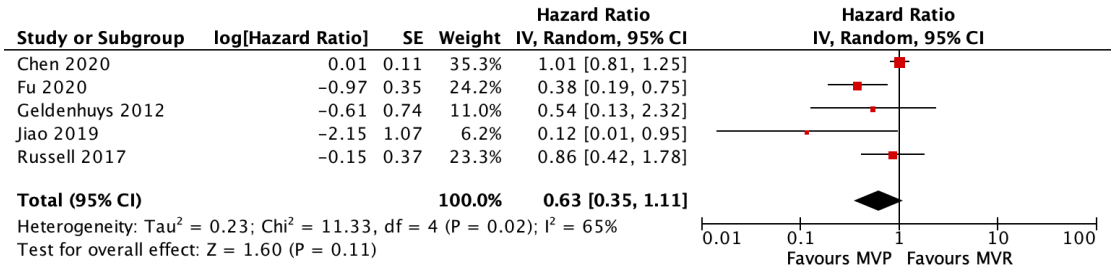

Figure 3: Comparison of long-term survival across studies.Mitral valve repair (MVP) versus mitral valve replacement (MVR). M-H: Mantel-Haenszel; CI: Confidence interval.

4.4. Reoperation Rates

Five studies were included[68]-[72], all of which provided hazard ratios (HRs) and 95% confidence intervals (CIs) either directly or estimated from Kaplan–Meier curves. The analysis demonstrated that the MVP group exhibited a significantly higher reoperation rate compared with the MVR group (HR 3.85; 95% CI, 2.18–6.78; P < 0.00001; I^2 = 0%) (Figure 4).

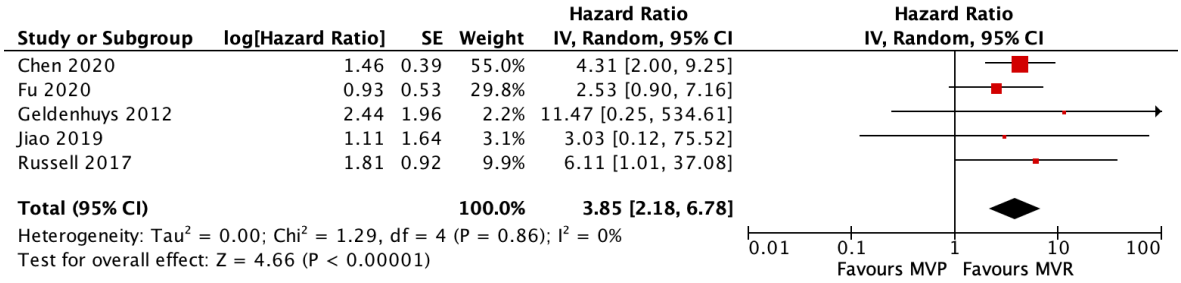

Figure 4: Comparison of reoperation across studies.Mitral valve repair (MVP) versus mitral valve replacement (MVR). M-H: Mantel-Haenszel; CI: Confidence interval.

4.5. Valve-Related Complications

Valve-related adverse events, defined as infective endocarditis, thromboembolic events, and hemorrhagic complications, were assessed using data from four studies[6871]. The hazard ratio (HR) for these events was estimated (Figure 5). Compared with MVR, MVP was associated with a significantly lower risk of postoperative valve-related complications (HR 0.36; 95% CI, 0.21–0.61). No significant heterogeneity was detected among the included studies.

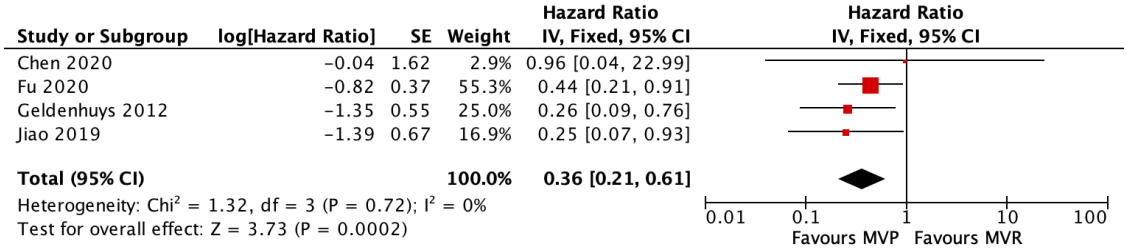

Figure 5: Comparison of valve-related complications across studies. Mitral valve repair (MVP) versus mitral valve replacement (MVR). M-H: Maentel-Haenszel; CI: Confidence interval.

5. Discussion

This review highlights the growing role of mitral valve repair (MVP) as an effective surgical option for patients with rheumatic heart disease (RHD). While mitral valve replacement (MVR) remains the standard approach, increasing evidence supports the potential benefits of MVP, particularly when technically feasible, in both short- and long-term outcomes. Our findings suggest a trend toward lower 30-day mortality and better long-term survival with MVP compared to MVR, consistent with prior studies.

MVP offers several advantages, especially in preserving the native valve and subvalvular structures, which contribute to better postoperative ventricular function and may result in improved long-term survival. Moreover, MVP substantially reduces the incidence of valve-related complications, such as thromboembolic events and infective endocarditis, by eliminating the need for lifelong anticoagulation, a major source of morbidity in patients undergoing mechanical valve replacement. Avoiding long-term anticoagulation therapy represents a critical benefit, as it significantly lowers the risk of bleeding complications, particularly in patients with comorbidities such as renal dysfunction or a history of gastrointestinal bleeding.

However, MVP is associated with a higher risk of reoperation, as noted in our analysis. This risk must be carefully weighed against the benefits of avoiding lifelong anticoagulation therapy. While some patients may eventually require reoperation, the reduction in anticoagulation-related complications, especially in younger patients or those unable to tolerate anticoagulants, should be regarded as a significant advantage of MVP. Therefore, the decision to pursue an MVP should be based on a comprehensive assessment of individual risk factors, including the severity of mitral valve damage, comorbid conditions, and age.

MVP suitability depends on several critical factors, including leaflet mobility, degree of calcification, and subvalvular anatomy. Patients with mild calcification and intact subvalvular structures are more likely to benefit from MVP, as these features contribute to the durability and success of the repair. In contrast, those with extensive leaflet thickening or severe calcification may be better candidates for MVR due to the technical challenges of repair. Advanced imaging techniques, such as three-dimensional echocardiography, play a vital role in the preoperative assessment, helping to identify patients most likely to benefit from MVP.

While long-term, multicenter studies are necessary to further evaluate MVP outcomes, research into adjuvant therapies[7374], such as vaccines, may offer additional benefits by mitigating RHD progression after repair. These therapies could reduce inflammation and fibrosis, thereby improving repair durability and clinical outcomes.

Given the complexities of MVP in the context of RHD, a patient-specific, individualized approach is essential. Surgical expertise, thorough intraoperative assessment, and careful patient selection are key to optimizing outcomes. As surgical techniques continue to evolve, MVP is expected to become an increasingly viable option for patients with RHD, offering enhanced long-term survival and quality of life while minimizing the risks associated with long-term anticoagulation therapy.

Limitation

This review must be interpreted within the context of several important limitations. The majority of the included studies were retrospective in nature, raising concerns regarding inherent selection biases and unmeasured confounding factors. Variability in surgical techniques, perioperative management strategies, and baseline patient characteristics across different centers further complicates direct comparisons between MVP and MVR. Additionally, the decision to pursue repair versus replacement was often based on intraoperative decisions and the individual surgeon's expertise, rather than on standardized preoperative selection criteria, introducing further heterogeneity. Differences in prosthesis type and postoperative management protocols among the MVR cohorts may have also influenced long-term outcomes, particularly with respect to valve-related complications. Moreover, follow-up durations varied considerably among the studies, and were relatively short in several cases, limiting the ability to draw definitive conclusions regarding the durability and very late outcomes of MVP. To more accurately inform surgical decision-making in rheumatic mitral valve disease, larger prospective, multicenter studies with standardized definitions of valve pathology, procedural success, and clinical endpoints are required.

6. Conclusion

MVP appears to offer advantages in early and long-term outcomes for patients with rheumatic heart disease. Although associated with a higher risk of reoperation, it may reduce valve-related complications and eliminate the need for lifelong anticoagulation. Thus, MVP is a reasonable option to consider in appropriately selected patients.

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