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Overview of mitral valve replacement versus mitral valve repair due to ischemic papillary muscle rupture: A meta-analysis inspired by a case report

Barbara Pala et al. Ischemic papillary muscle rupture treatment: Unresolved issue

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Abstract

Background: Papillary muscle rupture (PMR) is an infrequent but catastrophic complication after myocardial infarction (MI). Surgical procedure is considered the optimal treatment, despite high risk. However, the gold standard technique is still a major dilemma. Therefore, a meta-analysis was carried out to assess and provide an overview comparing mitral valve replacement (MVR) and mitral valve repair (MVr) for PMR post-MI.

Methods: A systematic literature search was performed. Data were extracted and verified using a standardized data extraction form. Meta-analysis was realized mainly using RevMan 5.4 software.

Results: From four observational studies 1640 patients were identified; 81% underwent MVR and 19% MVr. Operative mortality results were significantly higher in MVR group than the MVr group. MVR was performed under emergency conditions and patients admitted in cardiogenic shock or who required the use of mechanical cardiac support underwent MVR. MVr had shorter time of hospitalization and similar incidence of postoperative complications than MVR. No significant differences existed between the two procedures regarding cardiopulmonary bypass time.

Conclusions: Mitral valve repair appears to be a viable alternative to MVR for post-MI PMR, given that it has lower operative mortality, shorter time of hospitalization and similar incidence of short-term postoperative complications than MVR. However, it needs to be pointed out that MVR was

associated with the most critical clinical condition following PMR. There is uncertainty regarding the overall survival and improvement of the quality of life between the procedures. Nevertheless, further completed investigation is required.
Key words: ischemic papillary muscle rupture, mitral valve repair, mitral valve replacement, meta-analysis

INTRODUCTION

A case of papillary muscle rupture post-myocardial infarction

A previously healthy 55-year-old man was referred to hospital with chest pain and shortness of breath starting after intensive exertion. The electrocardiogram upon admission revealed sinus tachycardia (120 bpm) with a 3 mm ST depression in leads II, III, aVF, from V3 to V6, and ST elevation in leads I and aVR (Fig. 1A). Additionally, transthoracic echocardiography showed preserved left ventricular ejection fraction without regional wall motion abnormalities, moderate-severe posteriorly directed mitral regurgitation (MR) and an absence of pericardial effusion. Since the clinical scenario suggested acute non-ST-segment elevation myocardial infarction (NSTEMI) complicated by papillary muscle dysfunction, the patient underwent emergency cardiac angiography, which showed small intermediate and marginal branch occlusion; percutaneous coronary intervention (PCI) was not feasible due to their small sizes (Fig. 1B). After the Intensive Care Unit admission, the patient's condition suddenly worsened, showing signs and symptoms of acute heart failure. In order to better evaluate the MR mechanism, transoesophageal echocardiogram was performed, detecting severe acute MR with anterolateral papillary muscle rupture (PMR) (Fig. 1C). The patient experienced cardiogenic shock and respiratory distress requiring sedation, mechanical ventilation and hemodynamic support with vasopressors and intra-aortic balloon counterpulsation (IABP). As the patient's condition worsened, a quick decision about whether to perform surgery and about which surgical techniques to choose — mitral valve replacement (MVR) or mitral valve repair (MVr) — was required.

Given your knowledge of the patient and the points made by the experts, which approach would you choose?...

Ischemic PMR is a life-threatening mechanical complication following acute myocardial infarction (MI) [1, 2].

Papillary muscle rupture, although rare, is responsible for 1–5% of deaths in patients with acute MI [2].

The APEX-AMI trial found a 0.26% incidence of PMR following acute MI; more recently that rate was 0.029%, according to data derived from the National Inpatient Sample in the USA (2005–2014) [3, 4]. Epidemiological data suggest that since the introduction of an up-to-date approach to acute MI, which includes primary PCI, the incidence of mechanical complications after an acute MI, as PMR, has successfully decreased [3, 5].

Almost all cases of PMR occur in the mitral valve, whereas ischemic tricuspid regurgitation caused by PMR is extremely rare [6].

As widely reported in literature, the posterior-medial papillary muscle is the most vulnerable: whereas the antero-lateral papillary muscle has a dual blood supply from the diagonal branches of the left anterior descending artery (LAD) and the obtuse marginal branches of the circumflex artery (Cx), the posteromedial one has a single blood supply from the posterior descending artery, usually deriving from the right coronary artery (RCA) or, less frequently, from Cx [7, 8]. Therefore, the posterior-medial PMR occurs 6–12 times more frequently than the antero-lateral one.

Austen et al. [9], who performed the first valvular replacement in this setting (1965), described the patient's critical condition after PMR with a rapidly deteriorating course. Without adequate diagnosis and treatment, acute heart failure cardiogenic shock and death occurred within a few hours [9].

A high degree of suspicion and early echocardiography are pivotal for a rapid diagnosis.

As medical treatment is associated with very poor survival, surgery remains the cornerstone of treatment [2] and provides the best chance for a successful outcome [10], as recommended in current guidelines [11, 12].

However, because of the rarity of ischemic PMR, few reports have been published on this topic and the choice of MVR versus MVr is controversial [2, 13]. Clinical evaluation and procedures were performed in different centers by different surgeons who might have assessed the clinical conditions differently. No systematic comparison was carried out between these two techniques, making any conclusive analysis of potential inference of the type of surgery difficult to be applicable. Thus, the optimal surgical strategy for an ischemic PMR remained unclear.

Hence, the present study aims to analyze the available studies which report the clinical outcomes of MVR or MVr after ischemic PMR with the ambition of descrambling and comparing these evidences in order to examine if the hazards and complications deemed by surgeons hold true and, if not, hopefully supply a more robust perspective (Central illustration).

METHODS

Search strategy

All published and unpublished randomized clinical trials/observational studies were searched in MEDLINE/PubMed, Embase and Cochrane Library from January 2000 up to November 2020. Previous studies were excluded, since the treatment of acute MI has changed (such as the introduction of primary PCI) and has developed over time and the incidence of mechanical complications, including PMR, has decreased.

Literature searches were performed by using Medical Subject Heading terms and free text terms: “ischemic papillary muscle rupture”, “acute myocardial infarction”, “acute mitral valve regurgitation”, “severe mitral valve regurgitation”, “ischemic mitral insufficiency”, “emergency cardiac surgery”, “mechanical complications after myocardial infarction”, “mitral valve replacement”, “mitral valve surgery”, “mitral valve surgical correction”, “mitral valve surgical treatment”, “mitral valve repair”, “mitral valvuloplasty”, “mitral valve reconstruction”. A systematic literature review was planned according to the PICO format [14]: Population: all men and women who experienced MI and PMR; Intervention: patients underwent MVR; Comparison: patients underwent MVr; Outcomes of interest: operative mortality, urgency of surgery, cardiopulmonary bypass time, use of mechanical support, postoperative course.

This systematic review and meta-analysis was planned and performed in accordance with the Preferred Reporting Items for Systemic Review and Meta-Analysis (PRISMA) statement and Cochrane Handbook for Systematic Reviews of Intervention [15, 16].

Studies were included if the following criteria were met: PMR after MI; comparison between MVR and MVr; availability of data about the present outcomes were considered.

Studies were excluded if presented: no direct comparison of MVR versus MVr; chronic ischemic MR; patient undergoing mitral valve surgery (MVS) for etiologies other than ischemic PMR.

Data were extracted using a standardized data extraction form based on the template of Cochrane good practice data extraction [16].

The following data were extracted from each study: study name, publication date, country, bias, study design, inclusion and exclusion criteria, total patient numbers and sample numbers, mean age, sex and the concomitant diseases including hypertension, diabetes. The following outcome variables were analyzed: operative mortality, the urgency of surgery, cardiogenic shock at admission, the incidence of the use of IAPB, cardiopulmonary bypass time, the incidence of stroke and deep sternal infection, the length of hospital stay. Any discrepancies were settled in group discussion.

Bias risk assessment and quality of evidence

According to Evidence-Based Medicine, a critical analysis of a study aims to evaluate the internal validity, clinical relevance and the applicability of a published study. Methodological quality was assessed with the Newcastle-Ottawa Scale (NOS) which consists of 8 items with 3 subscales and the total maximum score of these 3 subsets is 9 [17]. Studies which scored ≥ 7 in high-quality study were considered, as it is commonly used, since a standard criterion for what represents a high-quality study has not been universally established yet [18].

As recommended by Cochrane Handbook [16], the software GRADE profiler was further used to validate the quality of evidence of the included retrospective studies.

Statistical analysis

Statistical analysis was performed by RevMan software, version 5.4.1 and Comprehensive Meta-Analysis software v3.

When reporting the results of clinical studies, some researchers may choose the five-number summary (including the sample median, the first and third quartiles, and minimum and maximum values) rather than the sample mean and standard deviation, particularly for skewed data. To convert the five-number summary back to the sample mean and standard deviation a method proposed by Shi et al. [19] was used.

Relevant data of clinical outcomes were obtained from each study in order to generate Forest plots. Some studies did not report data categorized by type of surgery.

Dichotomous variables were analyzed using the odds ratios (OR) with 95% confidence intervals (CI), and the Mantel-Haenszel [20] method combines the relevant outcomes. Continuous variables were analyzed using the weighted mean difference (WMD) reported with 95% CI. Pooled estimates were calculated with a DerSimonian-Laird random-effect model approach [21]. This method assumes the treatment effect being estimated follows some random distribution, rather than estimating some common fixed treatment effect as in a fixed-effects meta-analysis.

The pooled effects were determined by the Z-test and p-value < 0.05 was considered to point out statistical significance of all tests.

Heterogeneity among studies was analyzed: Forest plots were visually examined looking for overlap in the CI and the Cochrane chi-squared test and inconsistency (I^2) were used to assess heterogeneity among studies. In accordance with Higgins I^2 values, values below 30–40% were considered as low heterogeneity (most of the variation observed could be plausibly due to random error); I^2 values between 30–75% as moderate heterogeneity; I^2 values between 75–100% as considerable heterogeneity [16]. A chi-squared test-based Q test was also performed and p-value < 0.10 was considered to identify the presence of heterogeneity.

Publication bias was analyzed according to Egger et al. [22]; Egger's test p-value was interpreted suggestive for publication bias at values < 0.10.

Sensitivity analysis was performed to examine whether overall findings are robust enough to potentially influence decision-making: one or more studies were excluded and results were compared from random and fixed models to assess whether such exclusions significantly change the estimate of the effect.

RESULTS

From this systematic research, a total of 3017 references were identified, and duplicates were removed by using EndNote X7. The remaining quotations were screened by the title, excluding articles that did not have any agreement according to participants and interventions required in inclusion criteria (predominantly mitral valve degenerative disease); when title was doubtful, we proceeded to the research in the abstract of the inclusion and exclusion criteria. 84 articles were selected but, following the full-text assessment, 80 of these papers were excluded, leaving 4 studies for inclusion into the present meta-analysis. Figure 2 displays the aforementioned screening process. Methodological quality was assessed with NOS and all the studies were considered to be of high quality.

Four studies provided a total sample of 1640 patients, 1326 (81%) of whom underwent MVR and 314 (19%) underwent MVr.

Baseline characteristics did not differ markedly between MVR patients and the MVr group. According to the present analysis the population was homogeneous regarding gender (OR = 0.55; 95% CI: 0.26–1.15; p = 0.11) and mean age (pooled mean MVR 67.21 ± 10.49; pooled mean MVr 64.8 ± 11.29; OR = 1.84; 95% CI: –1.30–4.98; p = 0.25) with no significant difference between the two groups. Likewise, the incidence of hypertension and diabetes did not show significant differences between the two population groups (respectively OR = 1.09; 95% CI: 0.83–1.45; p = 0.53 and OR = 1.31; 95% CI: 0.95–1.8; p = 0.1).

As widely reported in literature the most affected papillary muscle was the posterior-medial one because it has a single blood supply from the posterior descending artery deriving from RCA or Cx [7, 8]. Indeed, Bouma et al. [23] reported 28 (58%) cases of Cx involvement; 19 (40%) cases of RCA involvement and 1 (2%) case of LAD involvement. Fujita et al. [12] performed coronary angiogram in 89% of 196 patients and the remaining patients underwent surgery without coronary angiogram, likely due to lack of time. They reported 90 (51.7%) cases of Cx involvement; 82 (47.1%) cases of RCA involvement.

Herein, primary outcome was operative mortality (OP), defined as death within 30 days after surgery or in-hospital death. Combining data from 4 studies [12, 13, 23, 24], totaling 1640 patients, the OP in patients undergoing MVR was significantly higher than MVr (OR = 5.47; 95% CI: 3.27–9.13; $p < 0.00001$). This finding featured low heterogeneity ($I^2 = 0\%$, Cochran's Q test p-value = 0.66) (Fig. 3A). Publication bias was not highlighted (Egger's test p-value = 0.55).

The sensitivity analyses showed that the overall results and conclusions were not affected by the different decisions that could be made during the review process; therefore, the results of this outcome can be regarded with a higher degree of certainty.

Two studies [12, 24], totaling 1538 patients, provided data on the percentage of patients admitted to the emergency room in cardiogenic shock (CS) condition (58%). This latter percentage rose up to 59% if we also considered data from Bouma et al. [23], excluded from this analysis because they did not categorize this outcome for MVR vs MVr. CS, defined as systolic blood pressure < 90 mmHg with adequate volume and clinical features or laboratory signs of hypoperfusion, is a high-acuity, low-cardiac-output state resulting in life-threatening end-organ hypoperfusion and hypoxia [25]. The combined result of these studies demonstrated that for patients in CS condition at hospital admission MVR was significantly more frequently performed than MVr (OR = 7.87; 95% CI: 5.76–10.73; $p < 0.00001$). This evidence was with low heterogeneity ($I^2 = 0\%$, Cochran's Q test p-value = 0.51) (Fig. 3B).

In addition, the combined result of these same studies [12, 24], demonstrated that MVR was significantly more frequently performed as emergency surgery than MVr (OR = 6.04; 95% CI: 4.31–8.46; $p < 0.00001$) (Fig. 3C); on the other hand, MVr was significantly more frequently performed as urgent surgery than MVR (OR = 0.41; 95% CI: 0.31–0.53; $p < 0.00001$) (Fig. 3D). This evidence featured low heterogeneity (respectively $I^2 = 0\%$, Cochran's Q test p-value = 0.50; $I^2 = 0\%$, Cochran's Q test p-value = 0.82).

Combining data from three studies [12, 13, 24], 1592 patients, regarding the use of intra-aortic balloon pump (IAPB), a mechanical circulatory device developed to mitigate the adverse outcomes of CS until treating the underlying cause, a significantly higher incidence in patients undergoing MVR than MVr (OR = 5.01; 95% CI: 3.79–6.62; $p < 0.0001$) resulted with low heterogeneity ($I^2 = 0\%$, Cochran's Q test p-value = 0.82) (Fig. 4A).

The combined results of two studies [12, 13], 250 patients, revealed that MVR had a longer time of hospitalization, compared to MVr (OR = 3.9; 95% CI: 1.1–6.69; $p = 0.006$). No heterogeneity emerged ($I^2 = 0\%$, Cochran's Q test p-value = 0.75) (Fig. 4B).

Postoperative data mainly include short-term postoperative complications (stroke and deep sternal infection). The incidence of these latter was compared in two reports [12, 24], totaling 1538 patients. According to the present analysis, no significant difference existed regarding the incidence of stroke (OR = 1.62; 95% CI: 0.71–3.69; p = 0.25) (Fig. 4C), and deep sternal infection between the groups (OR = 0.6; 95% CI: 0.08–4.48; p = 0.62) (Fig. 4D). These findings were with no heterogeneity (respectively I^2 = 18%, Cochran's Q test p-value = 0.27; I^2 = 0%, Cochran's Q test p-value = 0.37).

Pooling data from three studies [12, 13, 24], totaling1592 patients, there seemed to be no statistical significance in cardiopulmonary bypass time between the two groups. This finding was with high heterogeneity (I^2 = 81%, Cochran's Q test p-value = 0.005). An asymmetry of the analysis was evident at the visual inspection of the funnel plot (Fig. 5B). Using the "Trim and Fill" method the influence of the small study on the pooled effect was not relevant when the analysis was repeated omitting this study [26, 27]. A visual inspection of the other funnel plot analysis showed no asymmetry (Fig. 5C).

Bias of included studies

Fujita et al. [12], did not clearly define the clinical diagnosis of MI and CS condition, and did not report how the diagnosis of MR and PMR was performed and exclusion criteria was not clearly defined.

Russo et al. [13], compared MVR and MVr just for a few of our outcomes.

Bouma et al. [23], did not categorize all of the outcomes and patient baseline characteristics into MVR and MVr, resulting in missing and unavailable data.

Kilic et al. [24], did not accurately state the definition of MI and how the diagnosis of ischemic MR and PMR was performed.

These studies contained limitations related to multicenter and retrospective format of data collection.

DISCUSSION

Two surgical techniques in 1640 patients were evaluated, of whom 81% underwent MVR and 19% MVr. During the extensive period of analysis (2000–2020), this difference may be due to the more recent experience in MVr than MVR technique and also to the procedural concerns about necrosis extent of left ventricular wall which could negatively affect MVr results [28].

It is appropriate to point out that baseline patient characteristics are homogeneous, regarding mean age, gender and common comorbidities, achieving relatively reliable results.

The meta-analysis demonstrated that OP in patients undergoing MVR was significantly higher than MVr (Fig. 3A). However, it is important to highlight that the critical condition of patients before MVR, could affect OP outcome. Indeed, according to the present results, MVR was performed in the most critical condition by different surgeons: it was performed much more often than MVr in patients admitted in CS and under emergency conditions (Fig. 3B and 3C, respectively). Similarly, the use of IAPB, as an important bridge to surgery for further hemodynamic support, in patients undergoing MVR was also significantly higher than MVr (Fig. 4A).

In support of this way forward, Kinshon et al. [29], reported that when emergency surgery is performed during the acute phase of MI, MVR is recommended as the first choice because the cardiac muscle around the ruptured papillary muscle is vulnerable, making MVr a difficult and time-consuming procedure. However, according to the authors, MVr might be considered in selected patients who had residual healthy papillary muscle and good quality left ventricular wall tissue around the rupture [29].

Mitral valve repair might be a viable alternative to MVR when also considering the other outcomes that are explored herein: patients who underwent MVR had a longer hospitalization than patients who underwent MVr (Fig. 4B); there was no significant difference in the incidence of short-term post-operative complications (Fig. 4C, D), and no procedure extended surgical time.

The association of coronary artery bypass grafting (CABG) might represent a protective or detrimental factor for patient outcome. Simultaneous CABG was performed in 65% of patients involved in the current meta-analysis, with no differences regarding type of procedure being performed. There is no established consensus to perform concomitant CABG because many patients with PMR have single branch lesions and not extensive MI. This meta-analysis did not explore, due to the scarcity of data, long-term survival which would be probably the most effective tool for defining the effect of concomitant CABG in the two surgical procedures. However, one of the included studies demonstrated improvements in early death rate, particularly in patients who underwent simultaneous CABG [13].

Overall completeness and limitations

GRADE profiler software was used for an overall assessment of the certainty of evidence. The GRADE ratings represent how inconsistency, indirectness, imprecision and publication bias affect confidence in the results of the review. Apart from the high bias risk in confounding factors and patient selection, that are typical of retrospective studies, the current study determined that the evidence provided by these studies is still of an acceptable quality.

Despite the benefits of a pooled analysis, such as higher statistical power, there are some limitations with the present current meta-analysis study.

First and foremost, the retrospective studies included in meta-analysis carried inherent biases such as the selection bias given by their observational nature.

Secondly, some centers might have had funding restrictions which would bias their choice of surgery, along with the surgeon's experience, who might have differently oriented the assessment of surgical choice. However, due to the severity of valve disease with hemodynamic instability, a randomized study would be difficult to carry out.

The perioperative course and management are a delicate and relevant point of discussion, however, the postoperative complications considered in the current analysis, based on data available, was incomplete, particularly regarding the presence of low cardiac output syndrome, or the use of temporary support.

Even data regarding the use of imaging techniques such as echocardiography in the selected study were lacking; intra- or perioperative echocardiographic assessment during both MVr and MVR could help to make a joint, high-impact decision with the surgeon, in a time-sensitive manner and a dynamic clinical situation. Evaluation should include analysis of pre-repair functional anatomy, quantification of valvular dysfunction, identification of predictors of both short and long-term failure of surgical repair [30].

During surgery, as reported by many authors, echocardiography, in particular transesophageal echocardiography, provides real-time information on both morphology and hemodynamics without exposure to radiation or media contrast and is essential for intraoperative monitoring and assistance, for example, in evaluating the sizing of the annuloplasty ring [31].

Another limitation faced was the scarcity of categorization for the various MVr techniques described in literature, such as annuloplasty, suture of the ruptured papillary muscle head or the use of other techniques, such as chordal transfer.

A further limitation pointed out by the present study was the absence of randomized or matched population studies with long-term follow-up, so long-term survival could not be analyzed. The only study which concisely reported this outcome was Russo et al. [13]; they described no differences between MVR and MVr in terms of 5-year survival and an insignificant trend for higher survival, free of congestive heart failure, with MVr.

Another important aspect, which accounts mainly for the surgical strategy, is the role of the preservation of subvalvular apparatus in case of MVR. These patients may indeed experience post-MI ventricular maladaptive remodeling and, therefore, the absence of the mitro-ventricular continuity secondary to complete native valve excision, might affect the post-procedural left ventricular ejection fraction and remodeling.

In general, it has been shown that MVR with preservation of subvalvular apparatus maintains postoperative left ventricular contractile function and improves outcome [32].

In the Bouma et al. [33] study in patients undergoing MVR for post-MI PMR, partial or complete preservation of the subvalvular apparatus, independently predicted and significantly improved overall long-term survival.

This aspect entails a remarkable relevance also and above all in ischemic settings but, in papers considered in the current meta-analysis, no mention was made about this.

The optimal techniques for surgical repair of mitral valve have varied over time and even across continents. Beginning with suture annuloplasty, then commissural fusion with suture, and open leaflet plication, techniques of mitral valve repair have continued to multiply and progress.

The American correction has gained popularity over the past several years as many authors reported [34].

Freedom from reoperation and freedom from recurrent significant mitral regurgitation at 10 years have been reported at 90.1% for American correction than 93.9% of the French correction [35].

However, MVr techniques continue to evolve. In papers selected for our work the difference between various repair techniques was not deeply analyzed, therefore we did not focus on it.

As we mentioned previously, patients with papillary muscle rupture, usually in cardiogenic shock, cannot survive a few days, so the vast majority of them must be treated in emergency conditions and it becomes difficult to do a randomized study comparing valve replacement and valve repair and the different techniques of shelter.

The present study would like to lay the foundations for new accurate studies that can confirm the current evidence that MVr should be considered not only in stable patients, because it could be a valid option in selected patients even in emergency conditions.

CONCLUSIONS

Briefly back to the clinical case: within a few hours, the patient experienced refractory cardiogenic shock, so that an expedited MVR was performed. Post-operative course was uneventful, and patient was discharged in good clinical conditions. MVR was deemed to be the best option, because the complete rupture of papillary muscle was evident and myocardial tissue with acute ongoing ischemia could lead to unpredictable results. The case showed how even an isolated lesion of small coronary branches may cause PMR and a dramatic clinical scenario so that a prompt diagnosis and an early surgical intervention are crucial, especially in patients with hemodynamic instability.

Despite surgeons' choice to further opt for MVR, the current meta-analysis suggests that MVr might be a viable alternative in terms of surgical mortality and length of hospital stay in selected patients. Considering clinical outcomes across the two groups, there were no significant differences in short-term postoperative complications. Only a randomized study comparing the two procedures can define which techniques are superior, but, starting from the available data, this study suggests not considering acute MI as a contraindication, *per se*, to valve repair [13]. However, being conscious that not all patients are suitable candidates for MVr due to critical clinical conditions at hospital admission, infarct size, characteristics of PMR (complete or partial), and many other factors, such as age and preoperative comorbidities, are reasons for further investigation. In conclusion, in more stable and selected patients, MVr may be considered.

Conflict of interest: None declared

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Central illustration. Central Illustration summarizes the whole manuscript in a visual way.

Figure 1. A. Twelve-lead electrocardiogram; **B.** Angiographic image. Right anterior oblique caudal view of the left coronary artery. Arrow indicates site of vessel occlusion; **C.** Transoesophageal echocardiogram. Three-chamber view during systole; arrow indicates ruptured papillary muscle fragment prolapsed in the left atrium.

Figure 2. Preferred Reporting Items for Systemic Review and Meta-Analysis (PRISMA) flow diagram. Display of the screening process; 4 retrospective and nonrandomized studies were selected.

Figure 3. Forest plot; **A.** Operative mortality; **B.** Incidence of cardiogenic shock at admission; **C.** Emergency surgery; **D.** Urgent surgery.

Figure 4. Forest plot; **A.** IAPB use; **B.** Length of hospital stay; **C.** Incidence of stroke; **D.** Deep sternal infection

Figure 5. Funnel plot; **A.** Operative mortality; **B.** Cardiopulmonary bypass time with high heterogeneity; **C.** Assessed using the “Trim and Fill” method.

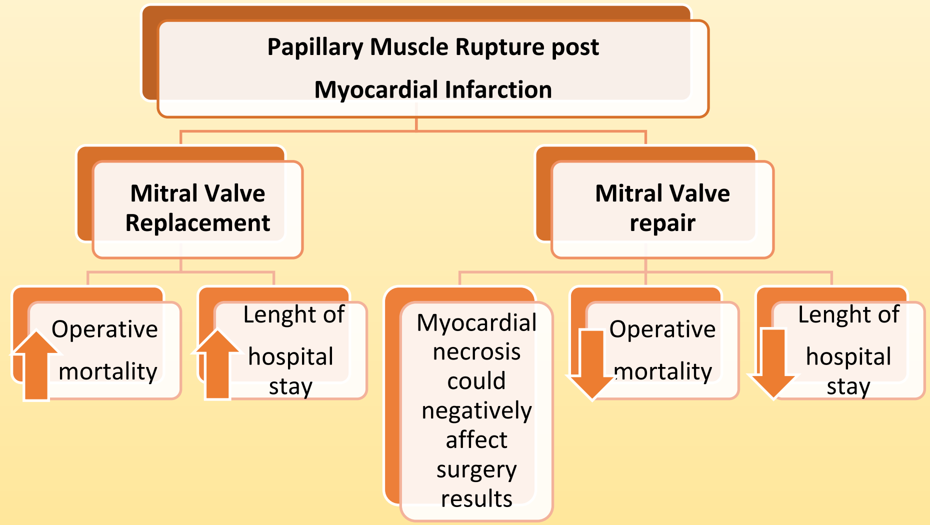
Overview of Mitral Valve Replacement (MVR) versus Mitral Valve repair (MVr) due to ischemic Papillary Muscle Rupture (PMR): a Meta-Analysis inspired by a Case Report

Which is the optimal surgical strategy for PMR post Myocardial Infarction? Our meta-analysis aims to analyze clinical outcomes of MVR or MVr after ischemic PMR.

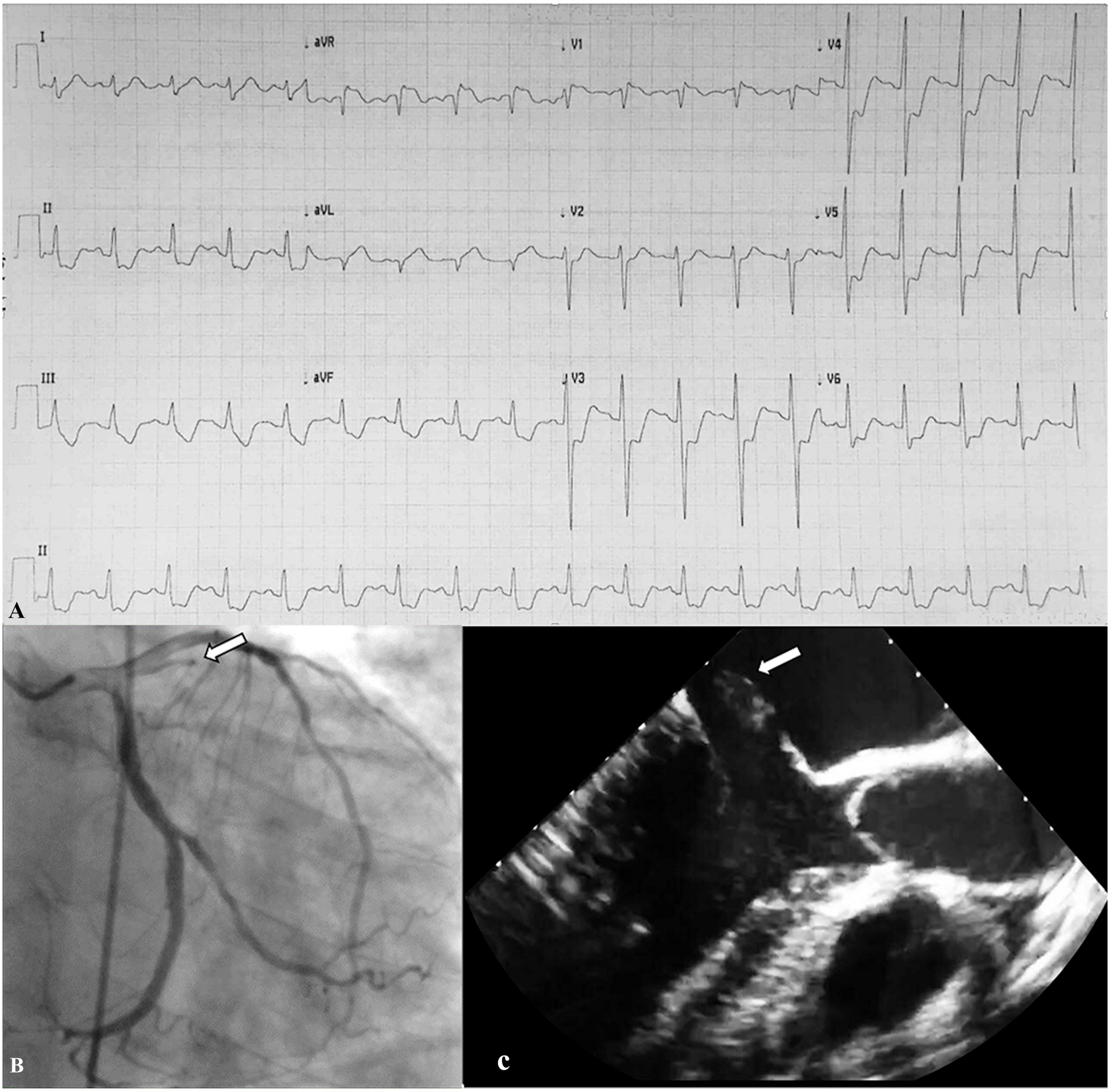
Operative mortality resulted significantly higher in MVR group than MVr one. MVr had shorter time of hospitalization than MVR and similar incidence of postoperative complications.

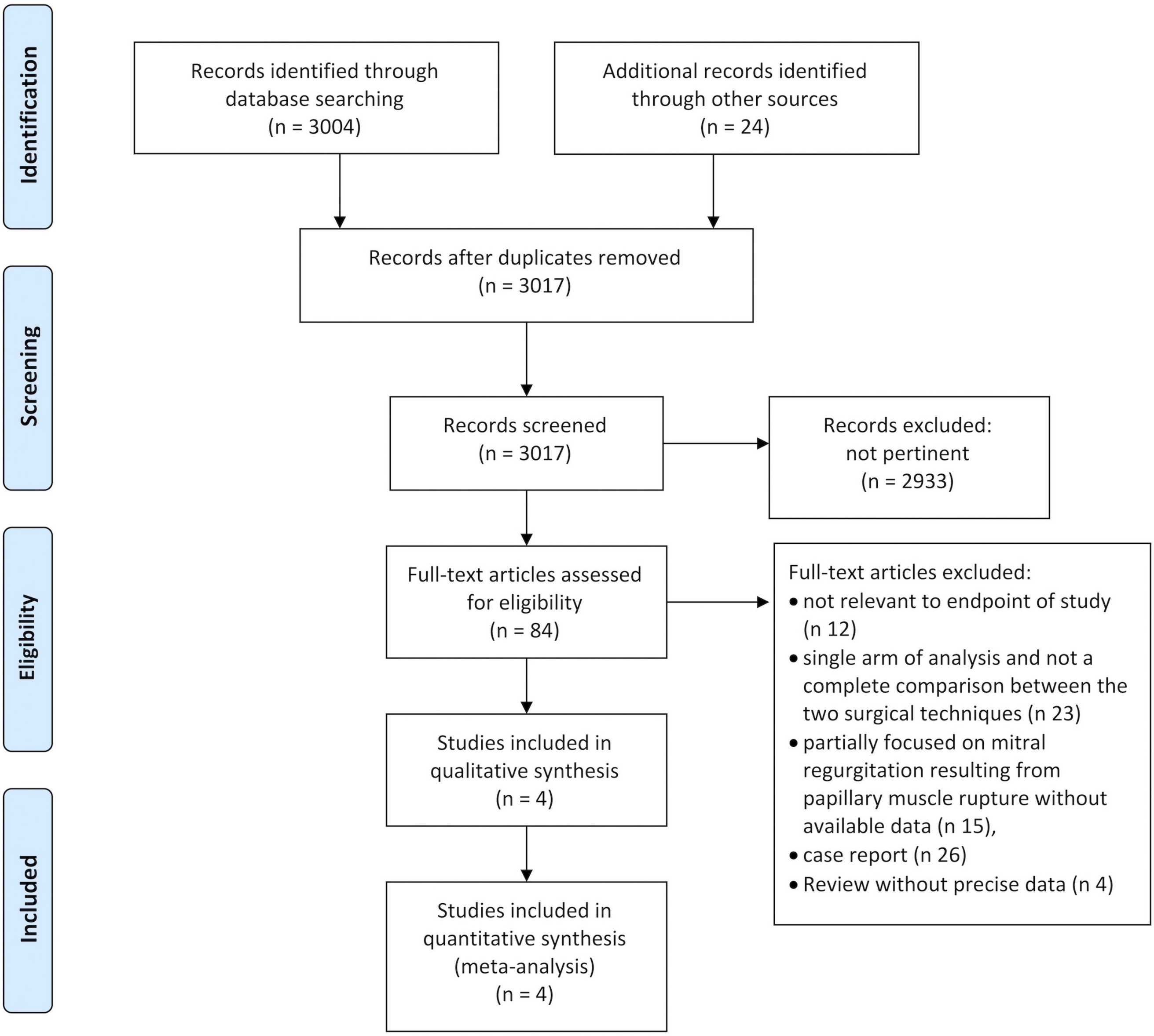
TAKE-HOME MESSAGE

The exact criteria that make patients with PMR post-MI eligible for MVr are not define yet. Our meta-analysis suggests that MVr might be a viable alternative in terms of surgical mortality and length of hospital stay in selected patients.

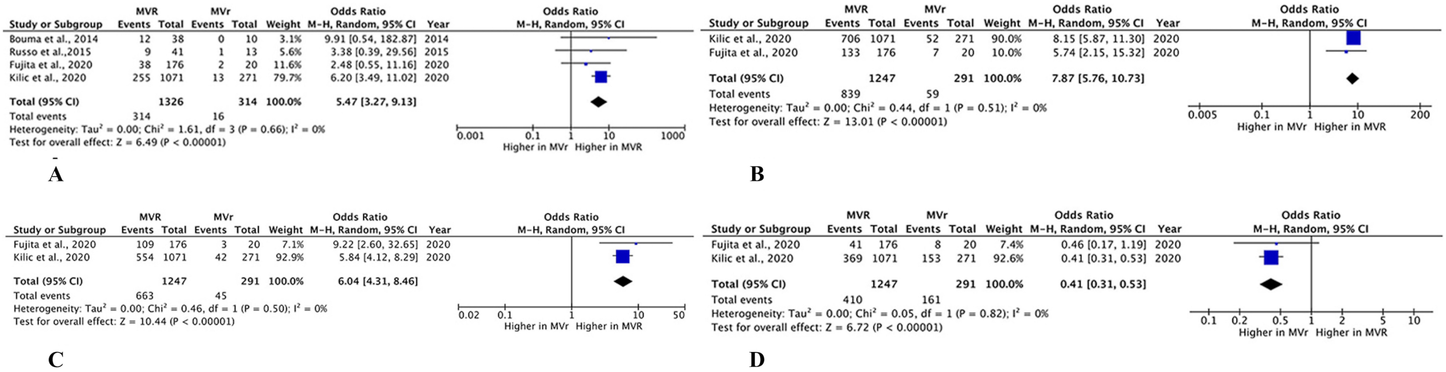


No significant difference in post-operative clinical outcomes: stroke or deep sternal infection

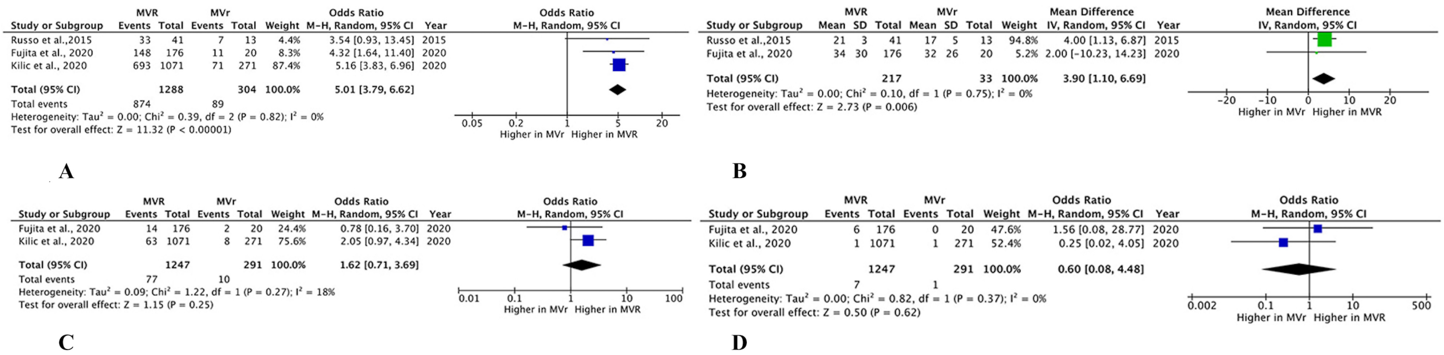

I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II
A
B
c



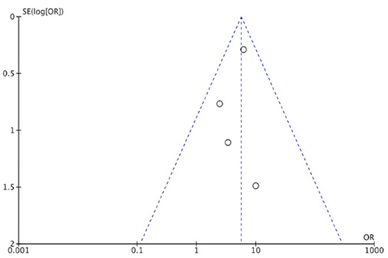
Identification
Screening
Eligibility
Included
Records identified through database searching (n = 3004)
Additional records identified through other sources (n = 24)
Records after duplicates removed (n = 3017)
Records screened (n = 3017)
Records excluded: not pertinent (n = 2933)
Full-text articles assessed for eligibility (n = 84)
Full-text articles excluded:
• not relevant to endpoint of study (n 12)
• single arm of analysis and not a complete comparison between the two surgical techniques (n 23)
• partially focused on mitral regurgitation resulting from papillary muscle rupture without available data (n 15),
• case report (n 26)
• Review without precise data (n 4)
Studies included in qualitative synthesis (n = 4)
Studies included in quantitative synthesis (meta-analysis) (n = 4)



MVR
MVr
Odds Ratio
Study or Subgroup Events Total Events Total Weight M-H, Random, 95% CI Year
Bouma et al., 2014 12 38 0 10 3.1% 9.91 [0.54, 182.87] 2014
Russo et al.,2015 9 41 1 13 5.6% 3.38 [0.39, 29.56] 2015
Fujita et al., 2020 38 176 2 20 11.6% 2.48 [0.55, 11.16] 2020
Kilic et al., 2020 255 1071 13 271 79.7% 6.20 [3.49, 11.02] 2020
Total (95% CI) 1326 314 100.0% 5.47 [3.27, 9.13]
Total events 314 16
Heterogeneity: Tau² = 0.00; Chi² = 1.61, df = 3 (P = 0.66); I² = 0%
Test for overall effect: Z = 6.49 (P < 0.00001)
Odds Ratio
M-H, Random, 95% CI
0.001 0.1 1 10 1000
Higher in MVr Higher in MVR
A
MVR
MVr
Odds Ratio
Study or Subgroup Events Total Events Total Weight M-H, Random, 95% CI Year
Kilic et al., 2020 706 1071 52 271 90.0% 8.15 [5.87, 11.30] 2020
Fujita et al., 2020 133 176 7 20 10.0% 5.74 [2.15, 15.32] 2020
Total (95% CI) 1247 291 100.0% 7.87 [5.76, 10.73]
Total events 839 59
Heterogeneity: Tau² = 0.00; Chi² = 0.44, df = 1 (P = 0.51); I² = 0%
Test for overall effect: Z = 13.01 (P < 0.00001)
Odds Ratio
M-H, Random, 95% CI
0.005 0.1 1 10 200
Higher in MVr Higher in MVR
B
MVR
MVr
Odds Ratio
Study or Subgroup Events Total Events Total Weight M-H, Random, 95% CI Year
Fujita et al., 2020 109 176 3 20 7.1% 9.22 [2.60, 32.65] 2020
Kilic et al., 2020 554 1071 42 271 92.9% 5.84 [4.12, 8.29] 2020
Total (95% CI) 1247 291 100.0% 6.04 [4.31, 8.46]
Total events 663 45
Heterogeneity: Tau² = 0.00; Chi² = 0.46, df = 1 (P = 0.50); I² = 0%
Test for overall effect: Z = 10.44 (P < 0.00001)
Odds Ratio
M-H, Random, 95% CI
0.02 0.1 1 10 50
Higher in MVr Higher in MVR
C
MVR
MVr
Odds Ratio
Study or Subgroup Events Total Events Total Weight M-H, Random, 95% CI Year
Fujita et al., 2020 41 176 8 20 7.4% 0.46 [0.17, 1.19] 2020
Kilic et al., 2020 369 1071 153 271 92.6% 0.41 [0.31, 0.53] 2020
Total (95% CI) 1247 291 100.0% 0.41 [0.31, 0.53]
Total events 410 161
Heterogeneity: Tau² = 0.00; Chi² = 0.05, df = 1 (P = 0.82); I² = 0%
Test for overall effect: Z = 6.72 (P < 0.00001)
Odds Ratio
M-H, Random, 95% CI
0.1 0.2 0.5 1 2 5 10
Higher in MVr Higher in MVR
D



MVR
MVr
Odds Ratio
Study or Subgroup Events Total Events Total Weight M-H, Random, 95% CI Year
Russo et al.,2015 33 41 7 13 4.4% 3.54 [0.93, 13.45] 2015
Fujita et al., 2020 148 176 11 20 8.3% 4.32 [1.64, 11.40] 2020
Kilic et al., 2020 693 1071 71 271 87.4% 5.16 [3.83, 6.96] 2020
Total (95% CI) 1288 304 100.0% 5.01 [3.79, 6.62]
Total events 874 89
Heterogeneity: Tau² = 0.00; Chi² = 0.39, df = 2 (P = 0.82); I² = 0%
Test for overall effect: Z = 11.32 (P < 0.00001)
Odds Ratio
M-H, Random, 95% CI
0.05 0.2 1 5 20
Higher in MVr Higher in MVR
A
MVR
MVr
Mean Difference
Study or Subgroup Mean SD Total Mean SD Total Weight IV, Random, 95% CI Year
Russo et al.,2015 21 3 41 17 5 13 94.8% 4.00 [1.13, 6.87] 2015
Fujita et al., 2020 34 30 176 32 26 20 5.2% 2.00 [-10.23, 14.23] 2020
Total (95% CI) 217 33 100.0% 3.90 [1.10, 6.69]
Heterogeneity: Tau² = 0.00; Chi² = 0.10, df = 1 (P = 0.75); I² = 0%
Test for overall effect: Z = 2.73 (P = 0.006)
Mean Difference
IV, Random, 95% CI
-20 -10 0 10 20
Higher in MVr Higher in MVR
B
MVR
MVr
Odds Ratio
Study or Subgroup Events Total Events Total Weight M-H, Random, 95% CI Year
Fujita et al., 2020 14 176 2 20 24.4% 0.78 [0.16, 3.70] 2020
Kilic et al., 2020 63 1071 8 271 75.6% 2.05 [0.97, 4.34] 2020
Total (95% CI) 1247 291 100.0% 1.62 [0.71, 3.69]
Total events 77 10
Heterogeneity: Tau² = 0.09; Chi² = 1.22, df = 1 (P = 0.27); I² = 18%
Test for overall effect: Z = 1.15 (P = 0.25)
Odds Ratio
M-H, Random, 95% CI
0.01 0.1 1 10 100
Higher in MVr Higher in MVR
C
MVR
MVr
Odds Ratio
Study or Subgroup Events Total Events Total Weight M-H, Random, 95% CI Year
Fujita et al., 2020 6 176 0 20 47.6% 1.56 [0.08, 28.77] 2020
Kilic et al., 2020 1 1071 1 271 52.4% 0.25 [0.02, 4.05] 2020
Total (95% CI) 1247 291 100.0% 0.60 [0.08, 4.48]
Total events 7 1
Heterogeneity: Tau² = 0.00; Chi² = 0.82, df = 1 (P = 0.37); I² = 0%
Test for overall effect: Z = 0.50 (P = 0.62)
Odds Ratio
M-H, Random, 95% CI
0.002 0.1 1 10 500
Higher in MVr Higher in MVR
D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1000

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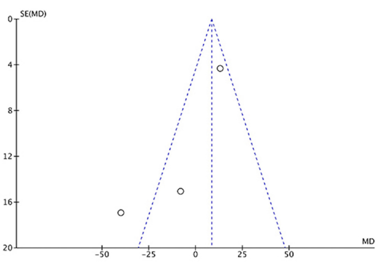
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20
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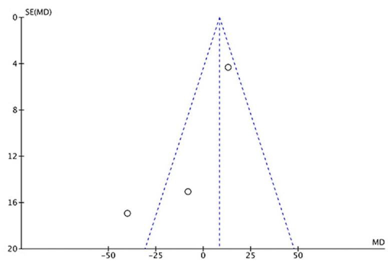
25
50

B


SE(MD)
MD
0
4
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12
16
20
-50
-25
0
25
50

C