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Rigid ring vs. flexible band for tricuspid valve repair in patients with tricuspid valve regurgitation: A systematic review and meta-analysis

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A R T I C L E I N F O

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A B S T R A C T

Background & objectives: Rigid ring and Flexible band are techniques used to repair tricuspid valve regurgitation. The comparison between both techniques' effectiveness is controversial in the literature. We conducted this systematic review and meta-analysis to compare the safety and efficacy of rigid ring versus flexible band for tricuspid valve repair in patients with tricuspid valve regurgitation.

Methods: We conducted a PRISMA-compliant systematic review and meta-analysis. A systematic search was performed in major databases, including PubMed, Scopus, Web of Science, and Cochrane CENTRAL to identify relevant published studies. Data were extracted and analyzed using Stata (version 17 for Mac) and Revman (version 5.4 for Windows).

Results: Twelve studies were included in this meta-analysis. Total number of patients was 4259. The rigid ring wasn't superior to the flexible band in terms of postoperative tricuspid regurgitation RR 0.74, 95 % CI (0.43–1.27) (P = 0.29). However, the results were not homogeneous. After employing sensitivity analysis, the significance of the pooled effect estimate didn't change, showing no significant difference between the two annuloplasty RR 0.72, 95%CI (0.45–1.15). On the other hand, the rigid ring was associated with a higher bypass time than the flexible band (RR 4.85, P = 0.00). There were no differences between the two groups in terms of hospital stay, ICU stays, prolonged ventilation, mechanical ventilation time, annuloplasty size, stroke, concomitant mitral valve surgery, concomitant aortic valve surgery, atrial fibrillation, pacemaker implantation, low cardiac output, in-hospital death, or late death (all P > 0.05).

Conclusion: Our study findings suggested no difference between rigid ring compared to flexible band regarding the rates of postoperative tricuspid regurgitation; however, rigid ring may encompass a higher bypass time. Therefore, further research is required to ensure our findings.

1. Introduction

Tricuspid regurgitation (TR) is a valvular heart condition affecting 65–85 % of the population globally [1,2]. Based on the underlying mechanism, we can distinguish three types of TR, primary/or organic TR (due to the direct involvement of the tricuspid valve), secondary/or functional TR (resulting from right-sided heart remodeling) [3,4], and more recently, isolated TR (atrial fibrillation being the dominant cause)

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is now being recognized as a distinct entity and is explained as TR without left-sided heart lesions [4]. The secondary TR accounts for the most frequent mechanism of TR. Women are at a higher risk of developing TR compared to men [5].

Different etiologies contribute to the pathophysiology of TR, such as ischemic cardiomyopathies, endocarditis, systemic diseases, and tumors, but the most frequent cause is the dilation of the right ventricle leading to leaflet dysfunction and malcoaptation of the tricuspid valve [6–8]. Interestingly, two heart conditions play a pivotal role in right cardiac remodeling, left-sided valvular and myocardial diseases [9,10] by increasing pressure and volume overload in cardiac chambers resulting in tricuspid structure damage [11,12].

Signs and symptoms of TR varied across the stages of the disease. Most patients experienced the classical symptoms of right-sided heart failure, such as ascites, hepatomegaly, and peripheral edema [13]. Along with growing insights into the development and advances made in 3-dimensional imaging modalities, echocardiography is the gold standard for assessing the mechanism, morphology, and severity of TR in order to evaluate the intercourse of disease progression [14,15].

With the emerging evidence regarding the deleterious outcomes and high mortality risk of untreated TR, there is an eminent need for establishing the optimal and appropriate surgical treatment. Tricuspid valve annuloplasty (TVA) is the preferred approach for surgical treatment of tricuspid regurgitation, and it consists of suture annuloplasty and prosthetic tricuspid annuloplasty [16,17].

In light of this, several studies have demonstrated the ability of prostheses for tricuspid valve repair to offer better long-term outcomes when compared with suture annuloplasty [18,19]. The two common types of prosthetic tricuspid annuloplasty are flexible bands and rigid rings which are widely adopted to treat TR [20,21]. Flexible bands can be well-adapted to cyclical cardiac movement, whereas it cannot persist for a long period. On the other hand, the rigid ring is not well-adjusted to the anatomical characteristics of the tricuspid valve but it maintains longer [22].

To date, the optimal tricuspid valve annuloplasty prosthesis is still a subject of ongoing research [23], thus the superiority of one annuloplasty device over the other is still debated.

Therefore, our study objective is to compare the safety and efficacy of rigid ring versus flexible band annuloplasty on short-term and long-term control of tricuspid regurgitation, as well as in preventing its recurrence.

2. Methods

We performed this systematic review and meta-analysis in strict accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) statement recommendations [24]. Additionally, all steps have been done according to the Cochrane Handbook of Systematic Reviews and Meta-analysis of Interventions [25].

2.1. Information sources and search strategy

We performed a comprehensive search of four electronic databases; PubMed, Scopus, Web of Science, and Cochrane CENTRAL, employing the following keywords: (Rigid ring OR rigid-ring OR flexible band OR flexible-band OR annuloplasty OR valvoplast* OR Cardiac Valve Annuloplasty OR Valvular Annuloplasty OR Valve Annuloplasty OR Cardiac Valve Annular Repair OR Cardiac Valve Annular Reduction OR Cardiac Valve Annular Shortening) AND (tricuspid regurg* OR Tricuspid Incompetence OR Tricuspid Insufficiency OR Tricuspid Valve Insufficiency OR Tricuspid Valve Regurg* OR Tricuspid Valve Incompetence) Further, the references of the included studies were manually searched for any substantial relevant records.

No restrictions over publication date, time period, language, sample size, country, socioeconomic status, or population characteristics among the published literature were used. The same reviewers performed the searches independently, and all identified articles were retrieved. Duplications were removed using Endnote software. study metadata and abstracts were uploaded to the Rayyan platform for screening.

We conducted an updated search prior to finalizing the study for further scrutiny according to our inclusion and exclusion criteria to include any new suitable studies.

2.2. Eligibility criteria

All included studies had to meet the following eligibility criteria: (1) Population: Patients with tricuspid valve regurgitation, (2) Intervention: Rigid ring, (3) Comparator: Flexible band, (4) Outcomes: Any reported outcome was considered, (5) Study design: randomized controlled trials (RCTs) and Observational studies.

We excluded the following: Review articles, letters, commentaries, case reports, case series, in vitro and animal studies, studies whose data were unreliable for extraction and analysis, articles for which the full text was not available, conference abstracts/posters, books, thesis, and editorials.

2.3. Screening and study selection

We performed the screening process of retrieved citations using Rayyan software platform. All studies that show information about rigid ring and flexible band for tricuspid regurgitation repair were screened for relevant information. Two reviewers completed the preliminary screening of the title and abstract of the articles in two steps: (1) title and abstract screening to determine the relevance to this meta-analysis, (2) full-text screening for the final eligibility to meta-analysis. An arbitration in conjunction with a third reviewer has been made to resolve and adjudicate any disagreement in inclusion decisions.

2.4. Data extraction process and data items

Data were collected and revised independently by five review authors and extracted into a uniform data extraction Excel sheet. The extracted data included (1) Characteristics of the included studies, (2) Characteristics of the population of included studies, (3) Risk of bias domains, and (4) Outcome measures. Any disagreement between the review authors was resolved by consensus or consultation.

2.5. Assessing the risk of bias

The quality and the potential risk of bias of the included studies were evaluated by two independent authors, we used the New-castle of Ottawa scale (NOS) for evaluating the cohort studies. The conflict of the quality was solved by a third independent author.

2.6. Synthesis methods

All data were analyzed using Review Manager (version 5.4) software for windows (Review Manager, version 5.4.1, The Cochrane Collaboration, Oxford, United Kingdom) and Stata software (version 17 for macOS) for meta-analysis. Mean difference (MD) with 95 % confidence interval (CI) was used to pool continuous variables and risk ratio (RR) with 95 % CI for the categorical variables using the DerSimonian Liard meta-analysis model (random-effects model). The relative risk (RR), and 95 % confidence interval (CI) were calculated. Statistical heterogeneity between studies was assessed by I-squared (I^2) statistics and Chi-square, and χ^2 p-value of <0.1 indicates significant heterogeneity, as well as I-square values ≥ 50 % were indicative of high heterogeneity.

2.7. Sensitivity analysis and publication bias assessment

To test the robustness of the evidence and to manage the heterogeneity between studies, we conducted a certainty assessment through sensitivity analysis. We ran sensitivity analysis in multiple scenarios for every outcome in the meta-analysis, excluding one study in each scenario to ensure the overall effect size was not dependent on any single study.

The Publication bias was assessed using Egger test and Funnel plot, Funnel plots were generated to visually inspect the distribution of risk difference against their standard errors, in addition to visual inspection, Egger's test was conducted to quantify the degree of funnel plot asymmetry.

3. Results

3.1. Baseline and study characteristics

Following the screening of the databases retrieved articles, twelve studies [26–37] accomplished the inclusion criteria [Fig. 1]. The summary of the included studies and the baseline characteristics are shown in [Table 1], [Supplementary Table. 1], respectively.

3.2. Risk of bias assessment

Twelve studies were evaluated using NOS, most of the included studies were Record-based retrospective cohort studies. The NOS overall scores ranged from five to nine, indicating either good or fair quality with the majority of the studies bending of good quality which indicates a low risk of bias among the included studies as shown in [Supplementary Table. 2].

3.3. Outcomes

Post-operative Tricuspid Regurgitation. Nine articles [26–28,30,32,33,35–37] reported the occurrence of postoperative tricuspid regurgitation. The pooled effect estimate revealed no difference between the rigid ring and flexible band regarding post-operative TR (RR = 0.74, 95 % CI 0.43–1.27, P = 0.29). Among them, there was significant heterogeneity (P = 0.05; I^2 = 49 %) [Fig. 2]. Leave-one-out sensitivity analyses were applied and showed that two studies [32,37] were the most contributors to the heterogeneity (P = 0.72; I^2 = 0 %), however, their omission didn't distort the significance of the effect estimate (RR = 0.72, 95 % CI 0.45–1.15) [Supplementary Fig. 1].

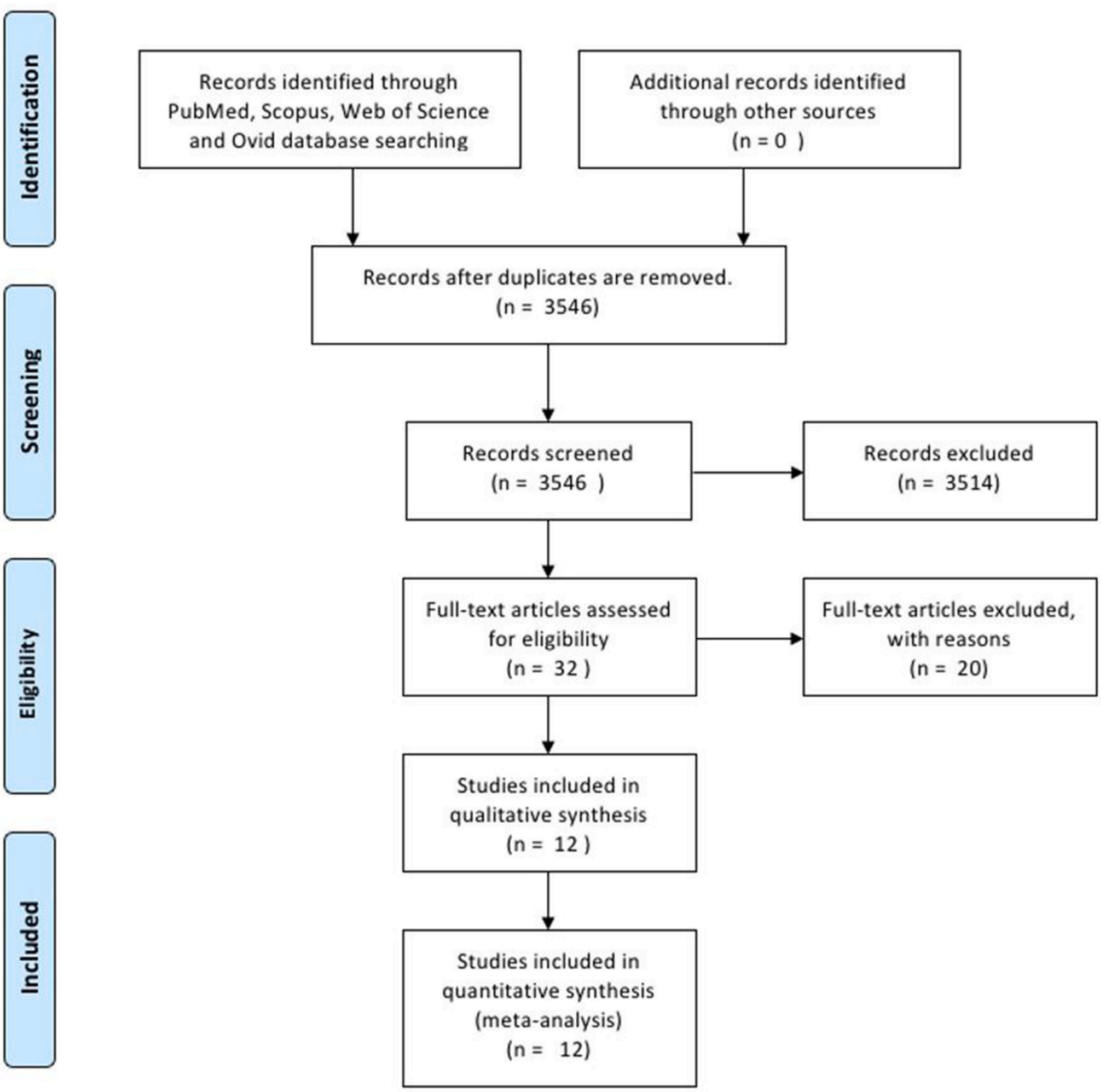

Fig. 1. A PRISMA flow chart summarizes the steps of the study and the screening process.

Table 1
Summary of the included studies.

Author	Year	Country	Study period	Follow up		Sample size of Flexible band	Type of flexible band	Sample size of Rigid ring	Type of rigid ring	Aim of the study
				band	ring					
Adas et al.	2019	Egypt	2011–2017	26 ± 12.6 M		84	strip of Dacron tube graft	39	Carpentier Edwards incomplete rigid rings (Baxter Healthcare Corp., Edward Division, Santa Ana, CA)	Evaluate different annuloplasty modalities to repair functional tricuspid regurgitation.
Gatti et al.	2016	Italy	1999–2014	3.2 ± 4.2 Y		345	Medtronic-Duran, Koehler mrs, CarboMedics Annulo Flex®	117	Carpentier–Edwards Classic, Edwards MC3, Carpentier–Edwards Physio	To Assess Flexible band versus rigid ring annuloplasty for functional tricuspid regurgitation
Ito et al.	2017	Japan	2006–2015	34.0 ± 12.8 M	65.6 ± 21.6 M	57	None	41	None	To determine risk predictors for recurrent tricuspid regurgitation (TR) following tricuspid valve annuloplasty during mitral valve surgery.
Izutani et al.	2010	Japan	2005–2007	34.6 ± 9.0 M	21. ±7.0 M	35	Cosgrove-Edwards	82	MC3	To compare between Cosgrove-Edwards flexible band and the MC3 rigid ring for repair of functional tricuspid regurgitation to determine the efficacy and mid-term durability of tricuspid annuloplasty.
Algarni et al.	2020	Saudi Arabia	2009–2017	–		–	SMN50 band, Duran band, Cosgrove-Edwards band	–	MC3 rigid ring	to compare the effect of rigid versus flexible TVA prostheses on long-term outcomes after repair of functional tricuspid regurgitation (FTR).
Lafci et al.	2019	Turkey	January 2010 and December 2015	–		93	none	76	none	to compare three different tricuspids annuloplasty techniques using suture, ring, and band.
Lee et al.	2017	South Korea	2001 through December 2012	–		370	Duran AnCore	211	Edwards MC3 rings.	To compare between Medtronic Duran AnCore versus Edwards MC3 rings for tricuspid annuloplasty
Lin et al.	2014	China	2006–2011	–		98	–	59	–	to compare effectiveness of different tricuspid annuloplasty (TVP), and reveal the risk factors of recurrence
Nasso et al.	2021	Italy	2008–2016	94.1 ± 24.5 M		109	autologous pericardial strip	115	prosthetic ring	to compare the outcomes of prosthetic ring versus autologous pericardial strip for the treatment of functional tricuspid regurgitation during left-sided valve surgery by minimally invasive approach
Ovcharov et al.	2021	Russian Federation	–	–		154	–	154	–	to compare results of using a flexible band ring versus a rigid ring for functional tricuspid regurgitation in patients undergoing mitral valve surgery
Pfannm€uller et al.	2010	Germany	2002–2009	21.0 ± 19.0 M		415	flexible Cosgrove-Edwards band	405	rigid Carpentier-Edwards Classic annuloplasty ring	To provide Surgical management of tricuspid valve

(*continued on next page*)

Table 1 (*continued*)

Author	Year	Country	Study period	Follow up		Sample size of Flexible band	Type of flexible band	Sample size of Rigid ring	Type of rigid ring	Aim of the study
				band	ring					
Wang et al.	2016	China	2009–2013	–		46	Cosgrove-Edwards band	60	the rigid Edwards MC3 ring	regurgitation mainly consists of tricuspid valve annuloplasty to compare the efficacy and mid-term durability of tricuspid ring annuloplasty for FTR secondary to rheumatic mitral valve disease using flexible Cosgrove-Edwards band and the rigid Edwards MC3 ring.

Abbreviations M: Months; Y: Year. Another well visualized table version is present in the supplementary material (Table 1).

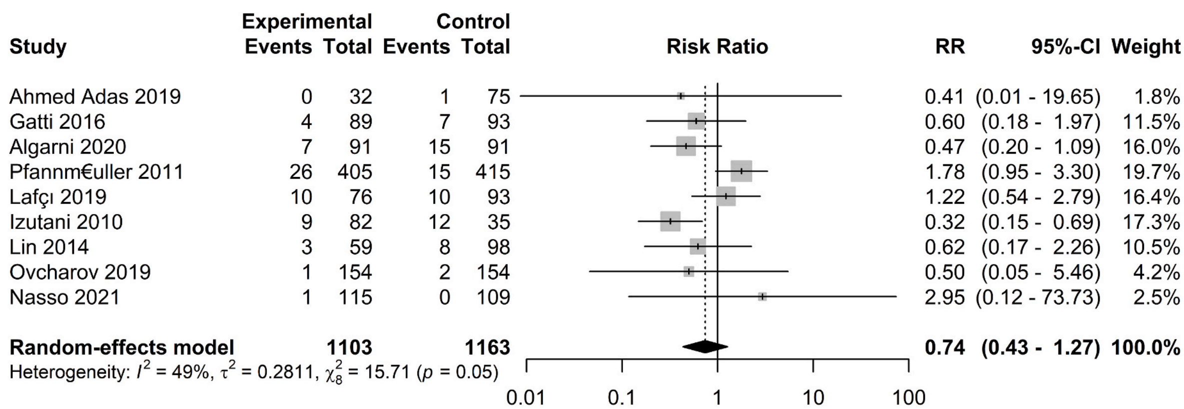

Fig. 2. Forest Plot comparing the post-operative TR between all the included studies.

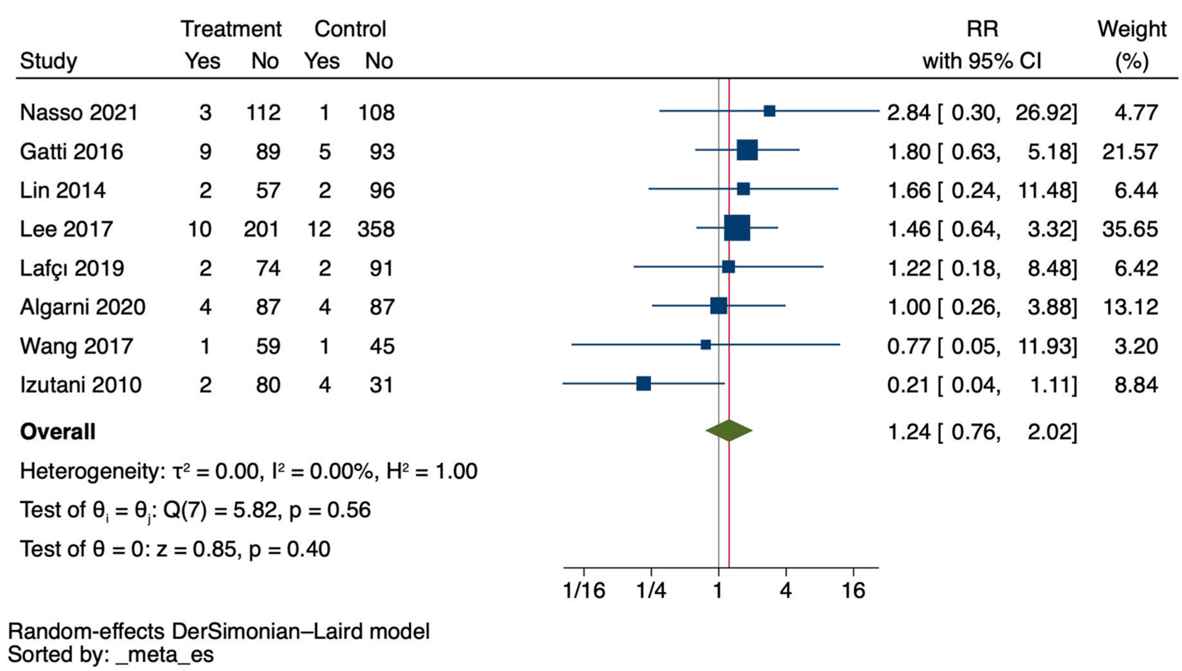

Fig. 3. Forest Plot comparing the post-operative in-hospital mortality between the included studies.

3.4. Complications

In-Hospital Mortality. In-hospital mortality outcome was reported in eight articles [27,29,30,32–36]. There was no significant difference shown between the flexible band and rigid ring in terms of in-hospital death (RR = 1.24, 95 % CI 0.76–2.02, P = 0.40), with insignificant heterogeneity among the articles (P = 0.56; I^2 = 0.00 %) [Fig. 3].

Late Mortality. Four articles reported the incidence of late mortality [29,32,33,36]. The pooled effect estimate revealed no difference between the rigid ring and flexible band in terms of late death (RR = 1.27, 95 % CI 0.55–2.92, P = 0.57). There was no heterogeneity (P = 0.88; I^2 = 0.00 %) [Fig. 4].

Stroke. Four articles reported the incidence of stroke [28,30,34,37]. In terms of stroke incidence, the pooled effect estimate showed no significant difference between the rigid ring and flexible band (RR = 0.99, 95 % CI 0.48–2.03, P = 0.98). Across the articles no significant heterogeneity was found (P = 0.60; I^2 = 0.00 %) [Supplementary Fig. 2].

Atrial fibrillation. The incidence of atrial fibrillation was reported in nine articles [27,28,30–34,36,37]. According to the pooled effect estimate, there was no significant difference between the rigid ring and flexible band in terms of stroke incidence (RR = 0.96, 95 % CI 0.86–1.07, P = 0.47), no discernible heterogeneity was observed among the articles (P = 0.11; I^2 = 39.18 %) [Supplementary Fig. 3].

Pacemaker implantation. Pacemaker implantation was reported in five articles [27,28,30,34,35]. There was no significant difference shown between the flexible band and rigid ring regarding Pacemaker implantation (RR = 1.74, 95 % CI 0.92–3.28, P = 0.09), and no significant heterogeneity was observed (P = 0.87; I^2 = 0.00 %) [Supplementary Fig. 4].

Low cardiac output syndrome. Four articles reported the incidence of low cardiac output syndrome [30,34,35,37]. Pooled effect estimate revealed no significant difference between the stiff ring and flexible band in terms of low cardiac output syndrome (RR = 1.14, 95 % CI 0.80–1.63, P = 0.47), with no observed significant heterogeneity (P = 0.41; I^2 = 0.00 %) [Supplementary Fig. 5].

3.5. Perioperative timings

Bypass time. Bypass time was assessed in twelve articles [26–37]. In comparison to flexible band annuloplasty, rigid ring annuloplasty was associated with a significantly longer time for bypass duration (MD = 4.85, 95 % CI 2.10–7.59, P = 0.00), with considerable heterogeneity among the articles (P = 0.04; I^2 = 46.08 %) [Fig. 5]. leave-one-out sensitivity analyses indicated that Lee et al. was the major causes of heterogeneity (P = 0.29; I^2 = 16 %), and the exclusion of it didn't affect the effect estimate (MD = 3.50, 95 % CI 1.54–5.47) [Supplementary Fig. 6].

Cross-clamp time. Cross-clamp time reported in ten articles [26–28, 30,31,33–37]. Pooled effect estimate showed no significant difference between flexible band and rigid ring (MD = 0.74, 95 % CI -2.27 – 3.75, P = 0.63), and substantial heterogeneity was observed between the articles (P = 0.00; I^2 = 63.30 %) [Supplementary Fig. 7]. Two studies [27, 34] were shown to have contributed the most to the observed heterogeneity through the use of Leave-one-out sensitivity analyses (P = 0.61; I^2 = 0.00 %), without a distortion of the effect estimate by their exclusion (MD = 0.01, 95 % CI -1.51 – 1.52) [Supplementary Fig. 8].

Operative duration. Duration of the operation was assessed in five articles [29–32,37]. There was no indicated significant difference between flexible band and rigid ring (MD = 14.11, 95 % CI -2.26 – 30.48, P = 0.09), but there was a significant heterogeneity observed across the articles (P = 0.01; I^2 = 71.02 %) [Supplementary Fig. 9]. With leave-one sensitivity analyses, indicated that Lee et al. was the major causes of heterogeneity (P = 0.14; I^2 = 45 %), and the exclusion of it didn't affect the effect estimate (MD = 7.43, 95 % CI -4.41 – 19.27) [Supplementary Fig. 10].

4. Discussion

4.1. Summary of the findings

On the basis of a careful systematic review and meta-analysis, our findings revealed a trend of lower post-operative TR in the rigid ring group compared to flexible band group that did not reach statistical significance (RR = 0.74, 95 % CI 0.43–1.27, P = 0.29). Furthermore, sensitivity analysis revealed no significant difference between the groups (RR = 0.72, 95 % CI 0.45–1.15). In contrast, our pooled data indicated that rigid ring annuloplasty was associated with a significantly longer time for bypass duration compared to flexible band (MD = 4.85, 95 % CI 2.10–7.59, P = 0.00), with considerable heterogeneity among the articles. Interestingly, leave-one-out sensitivity analyses upon excluding Lee et al. didn't affect the effect estimate (MD = 3.50, 95 % CI 1.54–5.47). Additionally, the perioperative timing, particularly in regard to the cross-clamp time and operative duration, did not differ significantly between both groups. Besides, we did not observe significant differences in postoperative complications including in-hospital mortality, late mortality, stroke, atrial fibrillation, pacemaker implantation, and low cardiac output syndrome.

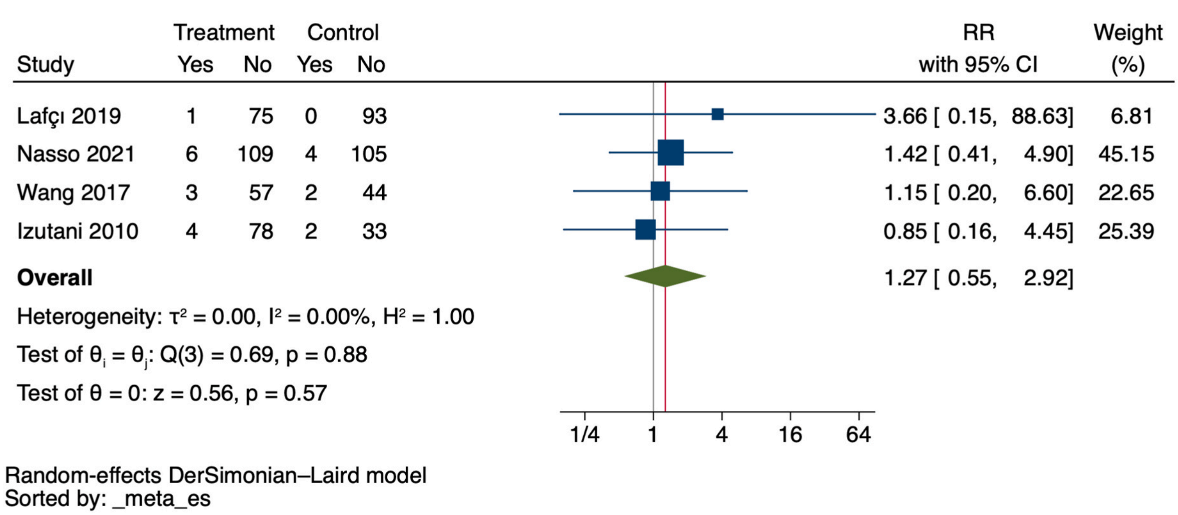

Fig. 4. Forest Plot comparing the prevalence of late mortality between the included studies.

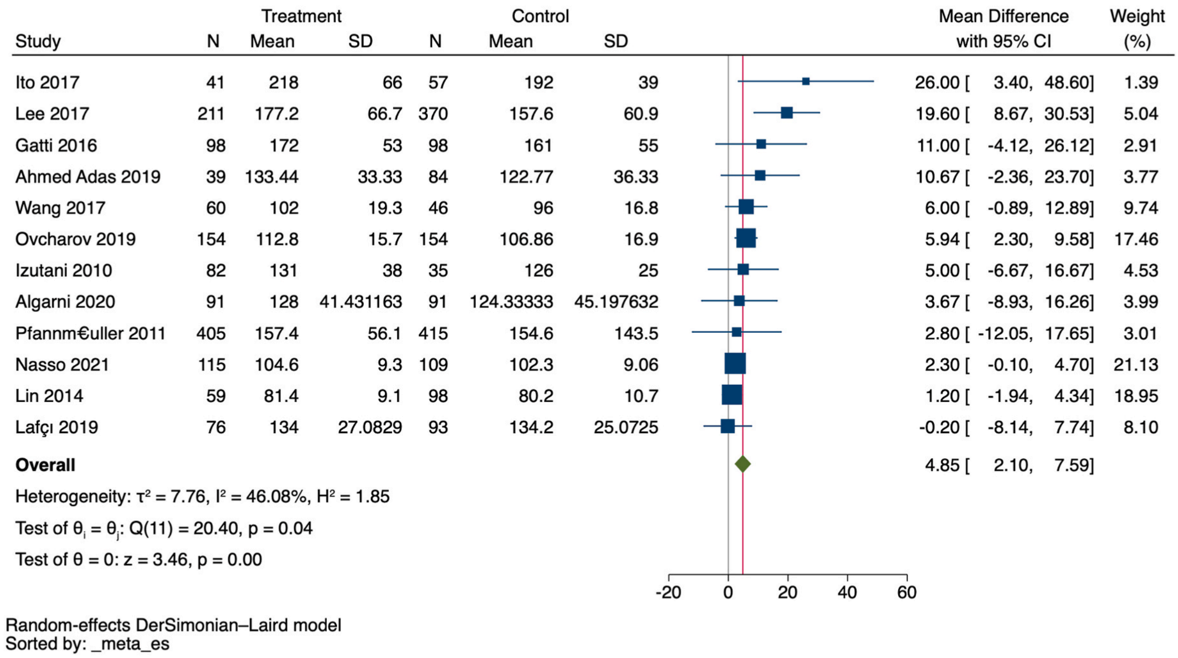

Fig. 5. Forest Plot comparing the Bypass time between the included studies.

4.2. Explanation of the findings

TR is managed primarily with valve reconstruction, proving its safety profile and lower operative risk than valve replacement [38]. In this context, different methods have been proposed for tricuspid valve repair according to the anatomic level of surgery [39], including standard rigid rings, and flexible bands [40]. These two techniques offer a simpler design and implantation system with reduced risk of cardiac tissue injuries accompanied by an adequate TR control [7,41,42]. Despite the potential advantages of these two surgical approaches to repair TR, there have been no definitive conclusion of superior outcomes with bands versus rings. Therefore, we performed this meta-analysis to evaluate the effectiveness of these two techniques for TR management. The longer bypass time observed for rigid rings warrants careful consideration and interpretation. One possible explanation for this finding is the inherent differences in the surgical technique and handling of rigid rings compared to other types of annuloplasty devices. Rigid rings are typically composed of materials such as titanium or stainless steel, which may require additional steps during implantation, potentially contributing to prolonged bypass times. Furthermore, the use of rigid rings may necessitate more meticulous suturing techniques to ensure proper placement and anchoring, which could also contribute to increased bypass times. Additionally, the rigid nature of these devices may require more precise adjustments during surgery, which could further extend the operative duration.

4.3. Agreements and disagreements with previous studies

Our results are consistent with the study findings conducted by Prokophiev et al. showing that there is no between-group difference in early mortality and survival [28]. Still, hospital mortality and perioperative complications seem unaffected by the type of surgical device used as demonstrated by Gatti et al. which is in accordance with our findings [30]. This consistency of findings reinforces our study results. Although, the raised questions regarding the prevention of post-operative TR, our study results revealed no difference between rigid ring group and flexible band group. These results were supported by a study conducted by Ito et al. [31]. However, one meta-analysis was performed by Veen et al. seems to contradict our findings [43]. A retrospective study conducted by Izutani and colleagues suggests that the rigid ring was more effective than the flexible band in offering a better post-operative TR control, nevertheless, these findings were biased due to the selection of a smaller rings size, and this could influence the results as speculated by the authors [32]. Some differences were identified in the baseline characteristics of the two groups. The incidence rates of atrial fibrillation are more frequent in patients undergoing flexible bands. Thus, the increased rates of TR rates can be partly attributable to atrial fibrillation in the flexible band group. A diseased mitral valve (stenosis or regurgitation) can cause annular dilation and leaflet tethering resulting in tricuspid malcoaptation. Consequently, concomitant mitral surgery was more frequent in flexible band than rigid ring, which may reflect the incidence of atrial enlargement and atrial fibrillation in flexible band group. Regarding the discrepancy in outcomes between our study and Wang et al.'s meta-analysis, it's essential to consider potential factors such as differences in study populations, methodologies, and follow-up durations. Variability in patient characteristics, surgical techniques, and post-operative care protocols across studies may contribute to divergent findings. Furthermore, the inclusion of more recent studies in our analysis may reflect advancements in surgical practices and device technology, which could influence outcomes [44]. Regarding the discrepancies observed in the study by Lee et al. differences in study designs, methodologies, and patient populations among included observational studies and RCTs could indeed contribute to variations in results. Variability in inclusion criteria, patient characteristics, and operative techniques across studies may introduce heterogeneity and influence the comparative effectiveness of rigid ring versus flexible band annuloplasty for TR management [34].

4.4. Strength points and limitations

Our meta-analysis has the largest sample size compared to the previous studies and it covers all the studies available, providing the most updated evidence regarding the safety and efficacy of rigid ring versus flexible band for tricuspid valve repair in patients with TR. Our study is the only one that measures the per-operative timings such as bypass and cross-clamp times. We performed a comprehensive search and reviewed the reference list of included studies and the previous meta-analysis to ensure that we did not miss any relevant studies. However, in our study, we combined both observational studies and RCTs, an approach that we believe is inaccurate and yields biased results. Variations in inclusion criteria, patient characteristics, and operative techniques may also contribute to apparent heterogeneity. By incorporating both study designs, we aimed to capture a more complete picture of the research question. To address the limitations associated with this mixed-method approach, particularly regarding variations in inclusion criteria, patient characteristics, and operative techniques, we employed several strategies. Firstly, we carefully delineated inclusion and exclusion criteria to ensure consistency across studies. This involved thorough screening of studies based on predefined criteria to minimize heterogeneity in patient populations and methodologies. we highlight our efforts in managing diversity within the sample, including meticulous outlining of inclusion/exclusion criteria, conducting sensitivity analyses, and implementing rigorous quality control measures. These strategies enhance the study's validity and generalizability, enriching our understanding of the findings. Despite performing sensitivity analysis, significant heterogeneity was observed in almost all outcome measures, which restricts the clinical implications of our findings. Future large-scale RCTs with longer follow-up periods are needed in order to ascertain our findings.

5. Conclusion

In summary, both rigid ring and flexible band seem to be equally effective in the treatment of TR offering an acceptable outcome. Rates of postoperative TR are comparable in both techniques; however, perioperative durations specifically bypass time can be slightly longer in rigid ring devices. Therefore, Large RCTs are warranted to confirm our findings.

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Non.

Data sharing statement

Not Applicable.

Ethical approval

Not Applicable.

Patient informed consent

Not Applicable.

Methodology

The quality and the potential risk of bias of the included studies were evaluated by two independent authors, we used the New-castle of ottawa scale (NOS) for evaluating the cohort studies. The conflict of the quality was solved by a third independent author.

Results

Twelve studies were evaluated using NOS, most of the included studies were Record-based retrospective cohort studies. The NOS overall scores ranged from five to nine, indicating either good or fair quality with the majority of the studies bending of good quality which indicates a low risk of bias among the included studies.

CRediT authorship contribution statement

Shadi Alaa Abdelaal: Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. **Mahmoud Tarek Hefnawy:** Writing – review & editing, Writing – original draft, Validation, Methodology, Conceptualization. **Enas Ewais:** Writing – review & editing, Visualization, Formal analysis, Data curation. **Naydeen Mostafa:** Writing – review & editing, Visualization, Formal analysis, Data curation. **Ahmed Mohamed Abozaid:** Writing – review & editing, Validation, Formal analysis, Data curation. **Adel Mouffokes:** Writing – review & editing, Writing – original draft, Validation, Software, Methodology. **Amnir Moustapha:** Writing – review & editing, Validation, Methodology. **Mohamed Mohamed:** Validation, Investigation, Formal analysis. **Hazem S. Ghaith:** Writing – review & editing, Validation, Methodology. **Alaa Ramadan:** Writing – review & editing, Validation, Formal analysis. **Nathan Ezie Kengo:** Writing – review & editing, Writing – original draft, Validation. **Ahmed Negida:** Writing – review & editing, Validation, Supervision.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijcrp.2024.200296.

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