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Can Valve-Sparing Aortic Root Replacement Outperform The Bentall Procedure in Acute Type A Aortic Dissection? A Decade-Long Meta-Analysis Update

Florentina Dewi Pramesuari¹, Antonius Sarwono Sandi Agus²

¹ Research and Development, RAA Soewondo General District Hospital, Pati, Central Java, Indonesia

² Department of Cardiothoracic and Vascular Surgery, Telogorejo Hospital, Semarang, Indonesia

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Abstrak:

Pendahuluan: Penggantian akar aorta (aortic root replacement/ARR) merupakan prosedur penting dalam tata laksana diseksi aorta tipe A akut (AAAD) dengan keterlibatan akar aorta. Prosedur Bentall telah lama menjadi teknik standar yang paling banyak digunakan, sedangkan *valve-sparing aortic root replacement* (VSRR) menguntungkan dengan menggunakan katup aorta native. Namun, prosedur ini secara teknis lebih kompleks dan durasi operasi lebih panjang. Studi ini bertujuan menilai efektivitas komparatif antara VSRR dan prosedur Bentall pada pasien dengan AAAD. **Metode:** Dilakukan tinjauan sistematis dan meta-analisis menggunakan basis data Cochrane, PubMed, dan ScienceDirect terhadap publikasi tahun 2014–2024. Luaran yang dievaluasi meliputi acute kidney injury (AKI), stroke, perdarahan gastrointestinal, atrial fibrilasi (AF), mortalitas 30 hari, lama perawatan di ICU, serta angka reoperasi. Analisis dilakukan dengan model efek acak atau tetap sesuai heterogenitas, dan hasil dilaporkan sebagai odds ratio (OR) atau mean difference (MD) dengan interval kepercayaan 95%.

Hasil: Sebanyak 12 studi dengan total 3237 pasien (1610 VSRR dan 1627 Bentall) dianalisis. VSRR terbukti menurunkan risiko AKI (OR 0,75; 95%CI 0,60–0,91), memperpendek lama perawatan ICU (MD -2,92 hari; 95%CI -4,00 hingga -1,84), menurunkan mortalitas 30 hari (OR 0,43; 95%CI 0,20–0,95), serta menurunkan kejadian AF (OR 0,40; 95%CI 0,22–0,71). Tidak terdapat perbedaan bermakna pada perdarahan gastrointestinal, stroke, lama rawat inap, maupun mortalitas intrahospital. VSRR juga mengurangi risiko reoperasi terkait katup (OR 0,59; 95%CI 0,39–0,91).

Kesimpulan: VSRR menunjukkan hasil klinis yang menjanjikan pada AAAD, khususnya dalam menurunkan AKI, durasi perawatan ICU, mortalitas 30 hari, AF, dan kebutuhan reoperasi. VSRR dapat menjadi opsi yang layak pada pasien terpilih, terutama di pusat berpengalaman dengan jumlah kasus tinggi.

Kata Kunci: *Aneurisma akar aorta; Bentall; diseksi aorta; strategi bedah; valve-sparing*

Abstract:

Introduction: Aortic root replacement (ARR) is crucial in managing acute type A aortic dissection with aortic root involvement. While Bentall procedure is widely utilized, valve-sparing aortic root replacement (VSRR) offers the advantage of native valve preservation, albeit with technical challenges and longer operative time. This study compares VSRR and Bentall outcomes in AAAD patients. This study aims to evaluate the comparative effectiveness of VSRR versus the Bentall procedure in AAAD. **Methods:** A systematic review and meta-analysis was conducted using Cochrane, PubMed, and ScienceDirect databases for studies published between 2014 and 2024. Outcomes assessed included acute kidney injury (AKI), stroke, gastrointestinal bleeding, atrial fibrillation (AF), 30-day mortality, ICU stay, and reoperation rates. Data were pooled with random-effects or fixed-effect models based on heterogeneity, reporting odds ratios or mean differences with 95% confidence intervals. **Result:** Twelve studies involving 3237 patients (1610 VSRR, 1627 Bentall) were analyzed. VSRR significantly reduced the risk of AKI (OR 0.75; 95%CI 0.60-0.91), reduced ICU stay (MD -2.92 days; 95%CI -4.00 to -1.84), reduce the odds of 30-days mortality (OR 0.43, 95%CI 0.20-0.95), and AF (OR 0.40, 95%CI 0.22-0.71) compared to Bentall. No significant differences were found in gastrointestinal bleeding, stroke, hospital stay, or in-hospital mortality. VSRR also reduced valve-related reoperation risk (OR 0.59; 95%CI 0.39-0.91). **Conclusion:** VSRR shows promising outcomes in AAAD, particularly in reducing AKI, ICU stay, 30-day mortality, AF, and reoperation risk. VSRR may be a viable option in carefully selected patients, particularly at experienced, high-volume centers.

Keywords: aortic dissection; aortic root aneurysm; Bentall; surgical strategy; valve-sparing

1. Introduction

In the context of acute type A aortic dissection (AAAD), aortic root replacement (ARR) is frequently warranted when patients present with root enlargement, extensive tissue disruption, or intimal tearing confined to the root region. Historically, the Bentall operation utilising a composite valved conduit composed of a vascular graft and prosthetic valve has been considered the benchmark intervention (1). Nonetheless, mechanical prostheses inherently impose lifelong dependence on anticoagulation, alongside risks of thromboembolic events, altered hemodynamics, and progressive aortic root dilatation, which may ultimately culminate in valve dysfunction, a recognized late complication of this technique (2). While the use of bioprostheses may reduce these risks, the potential for prosthetic degeneration necessitating re-intervention represents a significant drawback (3).

Over the past decade, valve-sparing aortic root replacement (VSRR) has emerged as an increasingly favored operative option. By maintaining the integrity of the patient's native aortic valve, this technique has shown distinct advantages, especially among younger individuals with morphologically preserved cusps, yielding superior early postoperative recovery and a reduction in late cardiovascular mortality (4). VSRR operations, including the reimplantation technique by David and the remodelling technique by Yacoub (5,6). Despite its potential advantages, VSRR is a more technically challenging and time-intensive procedure than the Bentall operation, limiting its routine application in AAAD cases. The primary objective of valve-sparing root surgery is to achieve long-term aortic valve function without necessitating further surgical intervention.

Numerous studies have investigated the early and late outcomes, as well as the complications, associated with both Bentall and VSRR procedures. Systematic reviews and meta-analyses have been conducted to synthesize these findings. However, significant variability in reported postoperative complication rates across studies has hindered the integration of consistent, evidence-based recommendations into clinical practice. Given that the optimal approach to aortic root surgery remains undefined, we undertook a comprehensive synthesis of studies published over the past decade (2014–2024) to compare the outcomes of valve-sparing root surgery and Bentall procedures in patients with AAAD.

2. Materials and Methods

Prior to commencement, this review was prospectively enrolled in the International Prospective Register of Systematic Reviews (PROSPERO; registration ID CRD42024612722) under a prespecified protocol. The methodology adhered rigorously to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework (7).

2.1 Literature search

To capture all relevant literature, a systematic search was undertaken in Cochrane, PubMed, and ScienceDirect, focusing on studies comparing valve-sparing root replacement (VSRR) and the Bentall procedure in AAAD. The search terms employed included “((Aortic dissection) AND (Bentall or composite graft or valved conduit or CVG)) AND (Valve-sparing or aortic valve preservation or aortic valve repair or aortic valve-sparing or VSRR or David procedure)” to maximize the yield of relevant studies. Eligible titles and abstracts were shortlisted for qualitative assessment, followed by detailed full-text evaluation. Studies included were published between 2014 and 2025, written in English, and provided accessible full-texts.

2.2 Eligibility Criteria

The following criteria had to be met in order for a study to be included: having a population of participants acute type A aortic dissection; comparing outcomes of two interventions, valve sparing (David procedure) and Bentall procedure. The following were the exclusion criteria: (1) not in English; (2) lack of data or results that weren't

relevant, studies solely involving aortic aneurysm patients were excluded because we specifically analyzing the settings of acute type A aortic dissection; (3) no access to the full text. All primary comparative investigations including randomized controlled trials (RCTs), prospective or retrospective cohort studies, and quasi-experimental designs—were eligible for inclusion, provided they satisfied the criteria and reported statistically comparable outcomes. Studies that were not original research, such as letters, comments, editorials, protocols, or reviews, were excluded.

2.3 Statistical analysis

Quantitative synthesis was conducted with Review Manager (RevMan) software, version 5.4. Screening of titles, abstracts, and full texts was carried out independently by two reviewers using a two-tiered process, with discrepancies reconciled through consensus discussions. For effect estimation, odds ratios (ORs) and mean differences (MDs) with 95% confidence intervals (CIs) were calculated using either a fixed-effect or a random-effects model, depending on heterogeneity. Between-study variability was evaluated using Cochran’s Q and the I² index, which quantifies the proportion of total variance due to heterogeneity. Results were illustrated using a forest plots to clarify the pooled effects and heterogeneity.

2.4 Quality assessment

The quality of each article, as well as that of the body of evidence of this paper, was evaluated according to the Cochrane Risk of Bias tools (8).

3. Results

3.1 Study selection and the basic information

In total, 12 studies were included. There were 11 observational studies and 1 randomized controlled trial (RCT) comprising 3237 patients (VSRR 49.7% and Bentall group 50.3%). A total of 1610 patients were treated with the VSRR, and 1627 with the Bentall procedure. The study flow in the PRISMA diagram is shown in **Figure 1** below.

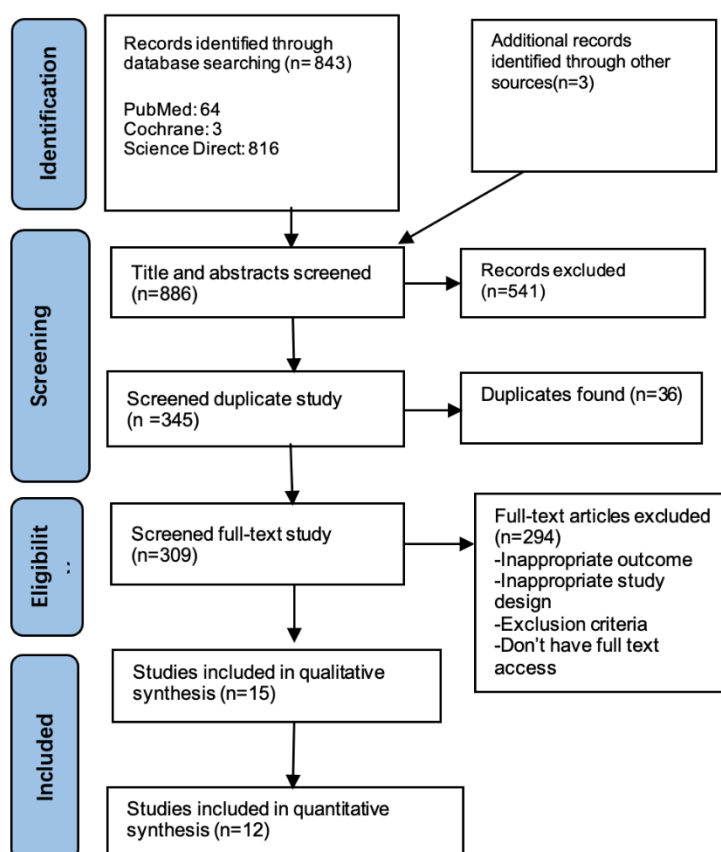


Figure 1. PRISMA flow diagram

The appraisal of methodological quality, assessed through standardized Risk of Bias instruments, is illustrated in **Figures 2 and 3**. Overall, two studies were rated as low risk, six were judged to raise some concerns, and four were considered at high risk of bias. The predominant reliance on observational study designs was the principal source of bias across the included literature.

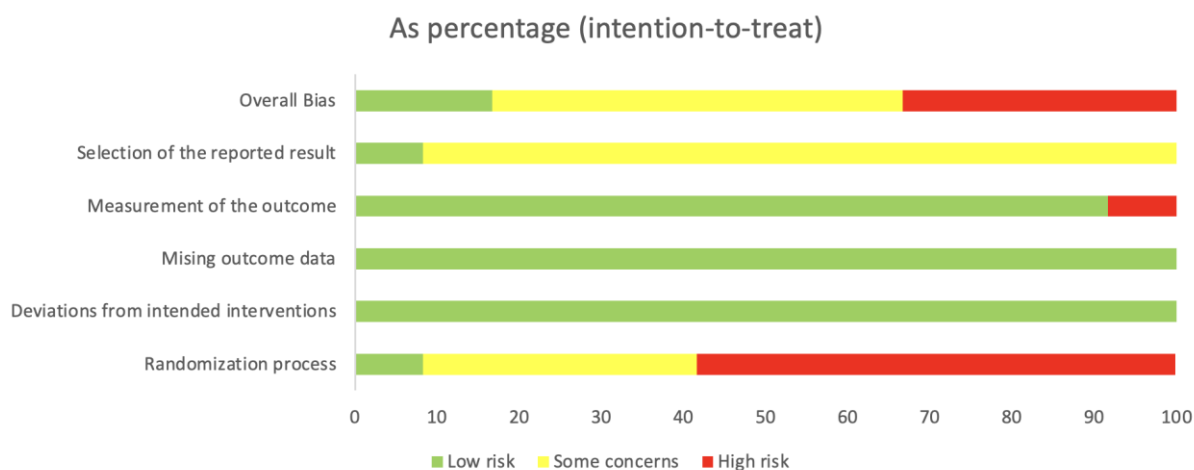


Figure 2. Risk of bias graph

Study ID	Experimental	Comparator	D1	D2	D3	D4	D5	Overall	
Jun Li	VSRR	Bentall	-	+	+	+	!	-	+ Low risk ! Some concerns - High risk
Joshua M R	VSRR	Bentall	-	+	+	+	!	-	
Markian M Bojko	VSRR	Bentall	-	+	+	+	!	!	
Xiaoyong Li	VSRR	Bentall	!	+	+	+	!	!	
Heemon Lee	VSRR	Bentall	-	+	+	+	!	-	D1 Randomisation process
Mahmoud	VSRR	Bentall	!	+	+	+	!	!	D2 Deviations from the intended interventions
Erik Beckman	VSRR	Benatl	-	+	+	-	!	-	D3 Missing outcome data
Jue Yang	VSRR	Bentall	!	+	+	+	!	!	D4 Measurement of the outcome
Qingsong Wu	VSRR	Bentall	!	+	+	+	!	+	D5 Selection of the reported result
Ryohei Ushioda	VSRR	Bentall	-	+	+	+	!	!	
Bo Yang	VSRR	Bentall	-	+	+	+	!	!	
Bin Hu	VSRR	Bentall	+	+	+	+	+	+	

Figure 3. Risk of bias summary

All surgical interventions were executed via median sternotomy. Cardiopulmonary bypass was routinely initiated via cannulation of the femoral, right axillary, or right subclavian artery. Myocardial quiescence was achieved using cold blood cardioplegia delivered directly into the coronary ostia following cross-clamping, with retrograde cardioplegia through the coronary sinus administered to augment myocardial preservation. Intraoperatively, root geometry, sinus dissection extent, and cusp morphology were carefully evaluated to determine the feasibility of root reconstruction. Root preparation was undertaken during systemic cooling to the target hypothermic temperature. Once distal aortic and left carotid anastomoses were secured, root replacement was carried out, using either the David reimplantation technique or the Bentall operation, depending on patient-specific anatomy. Hypothermic circulatory arrest under cerebral oximetry guidance was employed, with unilateral

selective perfusion through the right axillary artery as the primary strategy and additional antegrade flow via the left carotid artery when cerebral desaturation occurred. The surgical approach frequently included implantation of a frozen elephant trunk, succeeded by total arch reconstruction using a four-branched vascular graft (9,10).

In most studies, the selection of the procedural approach was determined by the operating surgeon based on patient-specific factors assessed through transesophageal echocardiography, intraoperative findings, and established clinical indications. The David reimplantation technique was chosen in cases involving connective tissue disorders, pre-existing sinus dilation, or multiple severely torn sinuses with otherwise intact and functional aortic cusps. Conversely, the Bentall procedure was indicated for patients with an aortic sinus diameter exceeding 45 mm, connective tissue disorders, intimal tears involving the aortic root, primary pathologies of the aortic valve, Neri C-type coronary ostial involvement, or cases with extensive sinus disruption (more than two sinuses) or detachment of multiple commissures. In the absence of these contraindications, efforts were made to perform aortic root repair whenever feasible, with a focus on simplifying the surgical intervention and preserving the native aortic valve.

Patients had rheumatic or senile degenerative changes in the aortic valves, iatrogenic dissection, patients with renal failure before surgery were excluded from the study. The study's final observation outcomes were as follows: gastrointestinal bleeding, postoperative stroke, AKI, mortality, ICU stay, atrial fibrillation (AF), and reoperation rates. The follow up time varied between studies included, early follow up was 1-3 months after surgery and midterm follow up was 6 months-2 years. This meta-analysis incorporated data from studies with both early and midterm follow-up intervals. While valve-sparing root replacement (VSRR) encompasses several surgical variants, including the David reimplantation, Yacoub remodeling, and Florida sleeve approaches, this review concentrated exclusively on the David and Yacoub techniques. Study sample total size ranged from 39 to 1075 patients. **Table 1** displays the main characteristics of all included studies. Across both cohorts, male patients represented the majority. Procedurally, valve-sparing operations were associated with longer cardiopulmonary bypass and aortic cross-clamp durations compared to Bentall procedures.

Table 1. Characteristics of selected studies

Author (year)	Patients, VSRR/ Bentall	Study design	Age (years)	Sex, male, n (%)	LVEF, %	Hypertensio n, n (%)	Diabetes, n (%)
Jun Li, 201 (10)	55/93	Observational	40 (31-52) / 44 (30-55.5)	40 (72.7) / 63 (67.7)	63.5 (60-67) / 61.5 (56.3-65)	16 (29.1) / 33 (35.5)	2 (3.6) / 1 (1.1)
J M Rosenblum, 2019(11)	59/77	Observational	43.5 ±11.4 / 50.4±13	50 (84.7)/60 (77.9)	51.6 ±9.2 / 53.1 ± 11.6	53 (89.8) /64 (83.1)	3 (5.1) / 7 (9.1)
M M Bojko, 2020 (12)	585/131	Observational	61 (51-71)/ 54 (44-66.5)	364 (62.2) / 103 (77.8)	65 (55-70) / 60 (50-65)	483 (82.6) / 94 (71.8)	71 (12.1) / 15 (11.5)
Xiaoyong Li, 2024 (9)	447/628	Observational	62 (54-67) / 55 (42-60)	310 (69.4)/404 (64.3)	Not stated	400 (89.3)/ 562.7 (89.6)	22 (4.9) / 40.82 (6.5)
Heemoon Lee, 2015 (13)	18/34	Observational	37±11/ 48 ±11	20 (58.8)/10 (55.6)	Not stated	8 (44.4) /10 (29.4)	0 (0)/ 2 (5.9)
Mahmoud Elghannam, 2020 (14)	11/36	Observational	55.36 ± 11.0 / 60.05 ± 9.9	8 (72.7%) /25 (69.4%)	51±9.0 / 54±9.1	Not stated	Not stated
Erik Beckmann, 2015 (15)	47/72	Observational	52 (46-61) / 67 (57-73)	32 (69%) /45 (62%)	Not stated	Not stated	Not stated
Jue Yang, 2022 (16)	192/316	Observational	52.4 ± 12.8 / 53.9 ± 13.1	122/ 207	64.0 ± 3.1 / 63.5 ± 4.2	171 (89.1)/ 279 (88.3)	5 (2.6%) / 12 (3.8%)

Qingsong Wu, 2021 (17)	117/96	Observational	51 (47, 55) / 51 (45, 55)	77 (65.8) / 68 (70.8)	65 (60.1, 67.6) / 64.2 (60.7, 67.1)	97 (82.9) / 80 (83.3)	4 (3.4) / 2 (2.1)
Ryohei Ushioda, 2022 (18)	17/21	Observational	51.4±8.6 / 65.7±12.1	14 (82.3%) / 17 (80.9%)	Not stated	6 (35.3%) / 5 (23.8%)	1 (5.9%) / 0 (0%)
Bo Yang, 2018 (19)	40/95	Observational	45 (37–51) / 61 (52–70)	77 (81) / 32 (80)	55 (50–60) / 55 (55–60)	18 (45) / 63 (66)	1 (3) / 8 (8)
Bin Hu, 2018 (20)	22/28	RCT	44.1±6.7 / 41.4±7.5	16 / 20	58.4±8.6 / 57.5±8.3	15 (68.2) / 20 (71.4)	Not stated

3.2 Results of the indicator analyses

3.2.1 GI bleeding

Figure 4 illustrates forest plot of the VSRR vs Bentall group in gastrointestinal bleeding. Four studies assessed gastrointestinal bleeding in the VSRR versus Bentall cohorts (Figure 4). Statistical testing demonstrated no heterogeneity ($P = 0.73, I^2 = 0\%$), allowing the use of a fixed-effects model for pooled analysis. The findings indicate that there was no significant difference between the VSRR and Bentall groups (OR 0.51, 95% CI 0.24 to 1.08, $P = 0.08$).

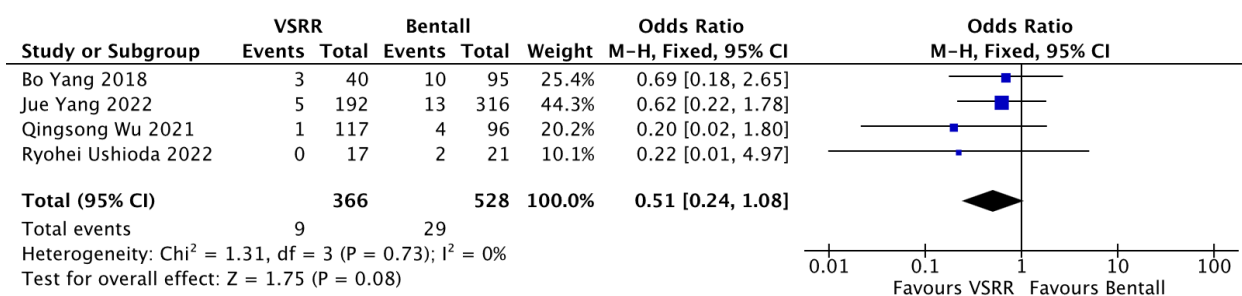


Figure 4. Forest plot of the VSRR group vs Bentall group in GI Bleeding

3.2.2. Post operative stroke

Figure 5 illustrates forest plot of the VSRR vs Bentall group in postoperative stroke. Postoperative stroke was reported in ten studies (Figure 5). The pooled analysis demonstrated no significant difference (OR 0.95, 95% CI 0.68–1.34; $P=0.78$), with low heterogeneity ($P=0.14, I^2=34\%$).

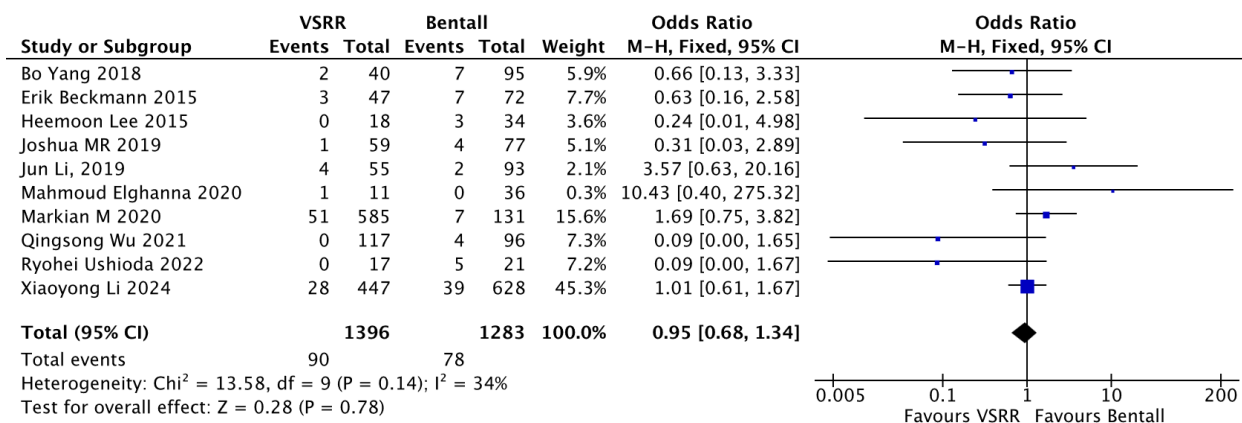


Figure 5. Forest plot of the VSRR group vs Bentall group in Postoperative stroke

3.2.3 Post operative AKI

Figure 6 illustrates forest plot of the VSRR vs Bentall group in postoperative AKI. Figure 5 illustrates forest plot of the VSRR vs Bentall group in postoperative AKI. Eleven studies assessed the incidence of acute kidney injury (AKI)

(Figure 6). No heterogeneity was detected ($P=0.69$, $I^2=0\%$), and fixed-effects modeling showed a statistically significant reduction in AKI events in the VSRR cohort compared to Bentall (OR 0.75, 95% CI 0.60–0.92; $P=0.006$).

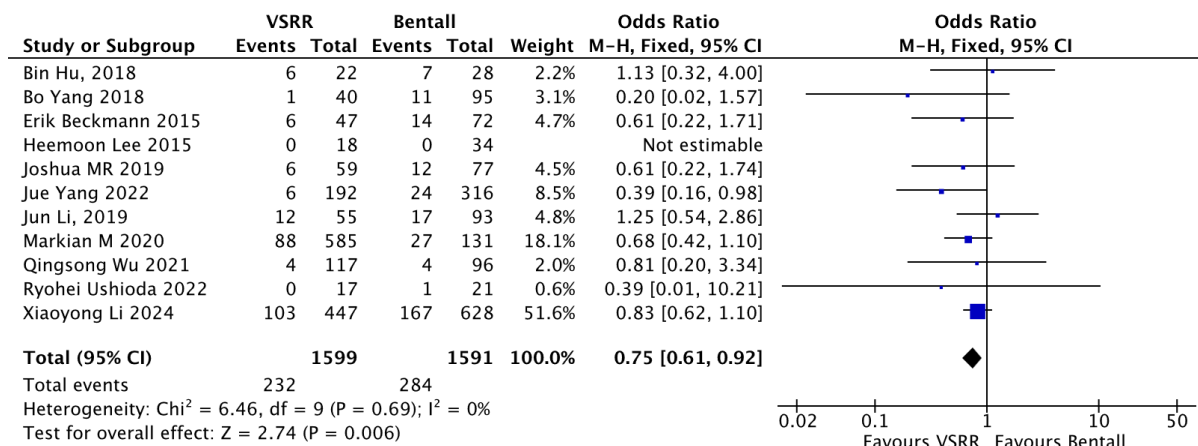


Figure 6. Forest plot of the VSRR group vs Bentall group – Post operative AKI

3.2.4 ICU stay

Figure 7 illustrates forest plot of the VSRR vs Bentall group in ICU stay. The number of studies included involving length of ICU stay of the VSRR group and the Bentall group were eight (Figure 7). Heterogeneity results suggested that there was heterogeneity in the statistical data of each study ($P<0.00001$, $I^2=99\%$), and a meta-analysis was performed using a random analysis model. The findings indicate that the VSRR and Bentall groups differed significantly (MD -2.92, 95% CI -4.00 to -1.84, $P < 0.00001$). VSRR reduced the the ICU stay compared to the Bentall group by 2.92 days.

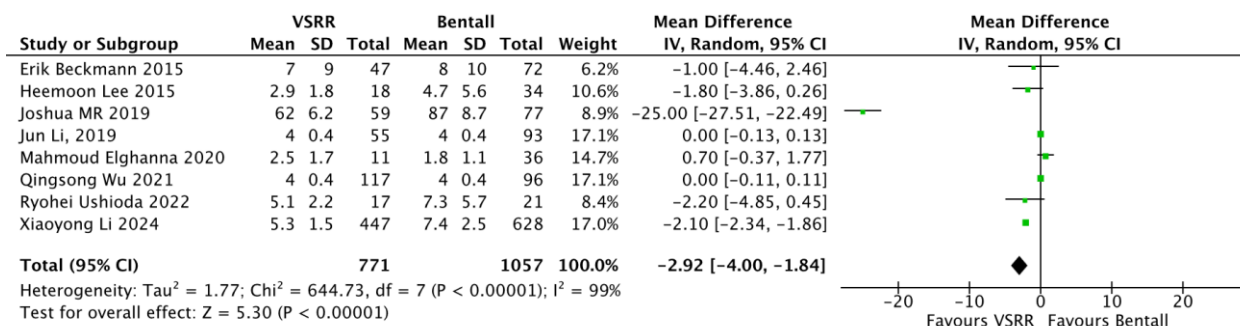


Figure 7. Forest plot of the VSRR group vs Bentall group – ICU stay

3.2.5 Hospital length of stay

Figure 8 illustrates forest plot of the VSRR vs Bentall group in Hospital stay. Nine studies reported hospital length of stay (Figure 8). Considerable heterogeneity was observed ($P<0.00001$, $I^2=98\%$), necessitating a random-effects model. No statistically meaningful difference was demonstrated between VSRR and Bentall (MD-1.35, 95% CI -2.91 to 0.21; $P=0.09$).

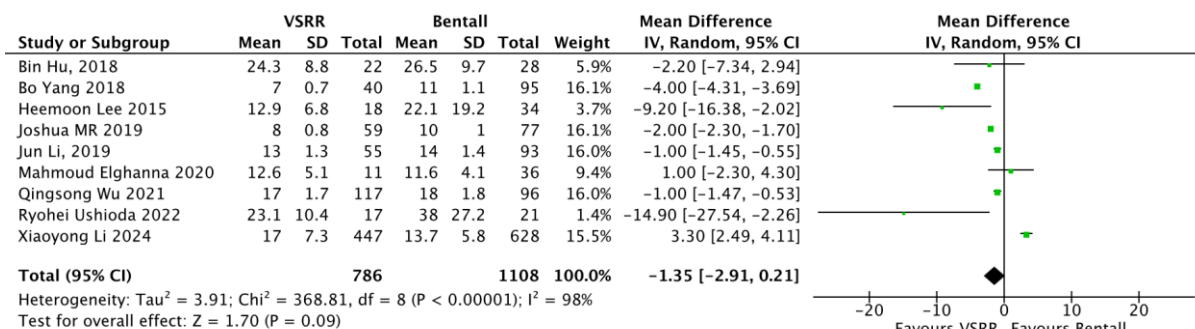


Figure 8. Forest plot of the VSRR group vs Bentall group – Hospital length of stay

3.2.6 In-Hospital mortality

Figure 9 illustrates forest plot of the VSRR vs Bentall group in-Hospital mortality. In-hospital mortality was assessed in four studies (Figure 9). Pooled results indicated no significant difference (OR 0.55, 95% CI 0.28–1.11; P=0.09), with no heterogeneity detected (P=0.57, I²=0%).

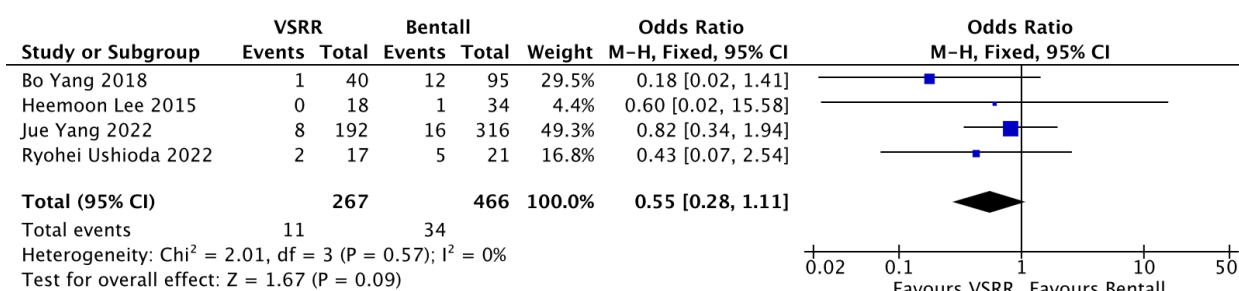


Figure 9. Forest plot of the VSRR group vs Bentall group – In hospital mortality

3.2.7 30-days mortality

Figure 10 illustrates forest plot of the VSRR vs Bentall in group 30-days mortality. Ten studies reported 30-day mortality outcomes (Figure 10). Substantial heterogeneity was noted (P < 0.00001, I² = 80%), requiring a random-effects approach. Results demonstrated a significant survival advantage with VSRR compared with Bentall (OR 0.43; 95% CI 0.20–0.95; P = 0.04). The pooled results suggest that the VSRR group had significantly reduced the odds ratio of 30-day mortality compared to the Bentall procedure group. However, the high heterogeneity suggests that the findings should be interpreted with caution.

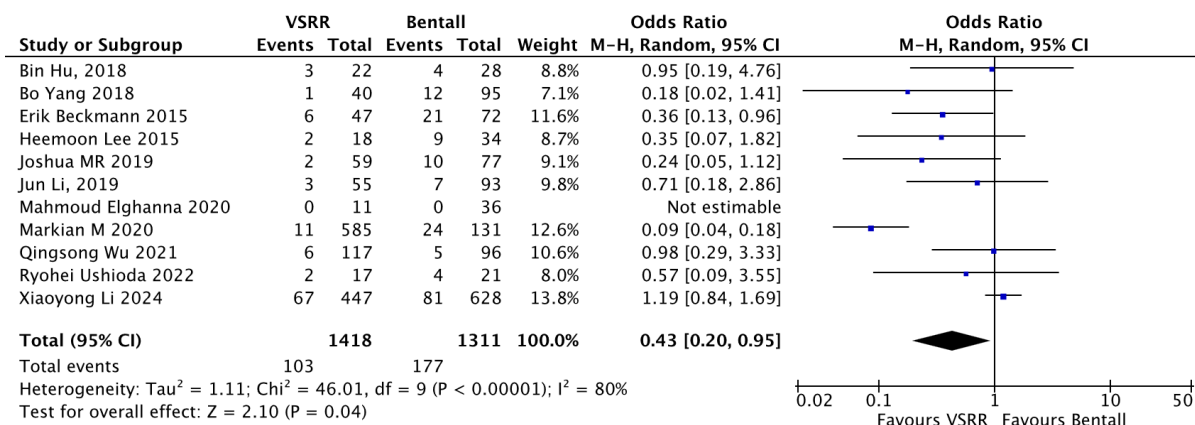


Figure 10. Forest plot of the VSRR group vs Bentall group – 30-day mortality

3.2.8 Atrial Fibrillation

Figure 11 illustrates forest plot of the VSRR vs Bentall group regarding atrial fibrillation. Two studies reported postoperative atrial fibrillation. No heterogeneity was identified (P = 0.85, I² = 0%), thus a fixed-effects model was

used. The pooled analysis showed significantly fewer atrial fibrillation events following VSRR (OR 0.40; 95% CI 0.22–0.71; P = 0.002).

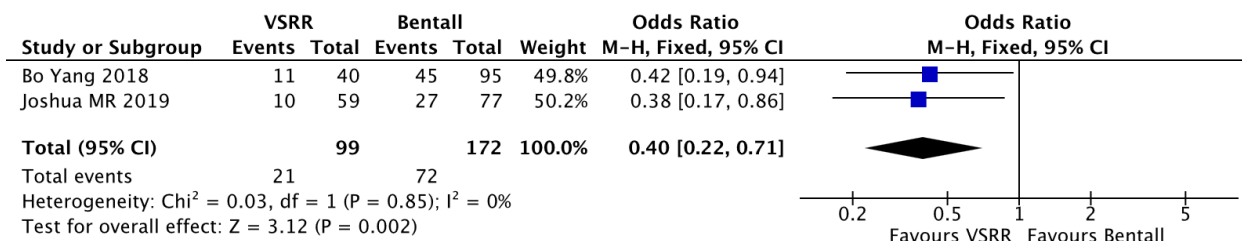


Figure 11. Forest plot of the VSRR group vs Bentall group – Atrial fibrillation

3.2.9 Reoperation (bleeding cause)

Reoperation for bleeding was documented in three studies (Figure 12). Pooled analysis under a fixed-effects model revealed no significant intergroup difference (OR 0.98, 95% CI 0.71–1.36; P=0.93), with low heterogeneity (P=0.25, I²=28%).

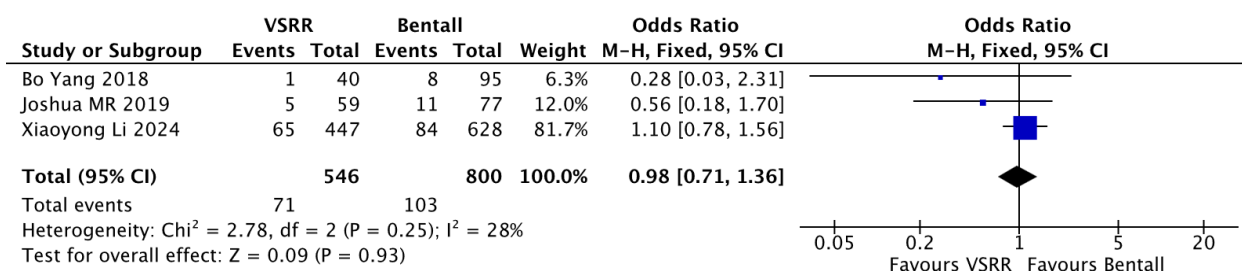


Figure 12. Forest plot of the VSRR group vs Bentall group – Reoperation (bleeding cause)

3.2.10 Reoperation (valve-related cause)

The number of studies involving reoperation events caused by valve-related of the VSRR group and the Bentall group were eight (Figure 13). The heterogeneity results indicated that there was no heterogeneity in each studies (P= 0.67, I² = 0%), which were carried out with a fixed effects model. The overall pooled OR from these studies is 0.59 (95% CI: 0.39 to 0.91), with a p-value of 0.02, suggesting that VSRR is associated with reduced in-hospital incidence for reoperation for valve-related cause compared to the Bentall procedure.

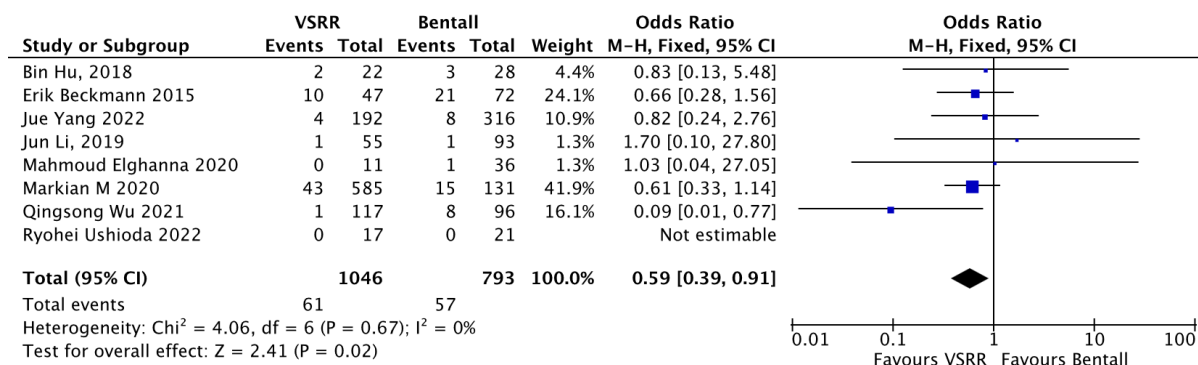


Figure 12. Forest plot of the VSRR group vs Bentall group – Reoperation (valve-related cause)

4. Discussion

This systematic review synthesized a decade of evidence on type A aortic dissection, with particular emphasis on surgical outcomes. One of the most frequent sequelae of conservative management is progressive dilatation of

the aortic root, often culminating in valvular insufficiency. To mitigate such complications, replacement of the root with a composite valved conduit has been associated with lower rates of reintervention at the root level.

In younger individuals with longer life expectancy, the Bentall procedure carries important limitations when compared to valve-sparing approaches. These disadvantages largely stem from the prosthetic valve itself, as mechanical devices necessitate lifelong anticoagulation and are burdened with a substantial incidence of late thromboembolism, stroke, and infective endocarditis.

To circumvent the drawbacks of prosthetic valves and the lifelong anticoagulation they necessitate, valve-sparing root replacement (VSRR) techniques were introduced. In the remodeling method described by Yacoub, the diseased aorta is excised down to the cusp insertions at the sinuses of Valsalva while preserving the native valve. The sinuses are reconstructed using a scalloped Dacron graft, sutured to the residual aortic tissue above the cusp insertions. The graft's proximal hemostatic line is anchored at the annulus, while a secondary suture line along the resected edge is used to resuspend the valve within the graft. In both Yacoub and David procedures, coronary buttons are subsequently reimplanted into the graft (21).

Whether the native aortic valve should be preserved in acute type A dissection remains controversial, as current data on mortality and valve-related morbidity after VSRR are limited. Our pooled analysis comparing VSRR with the Bentall operation demonstrates heterogeneous findings, with each approach conferring unique benefits. For endpoints such as gastrointestinal bleeding, postoperative stroke, duration of hospitalization, and in-hospital mortality, no significant intergroup differences were observed, suggesting broadly comparable safety profiles in these domains.

However, the results indicate that VSRR has certain advantages, particularly in reducing the risk of postoperative AKI and postoperative AF. The significant reduction in AKI risk (OR 0.75, $P = 0.006$) may highlight the less invasive nature of VSRR and its ability to preserve renal function better. Additionally, the lower incidence of atrial fibrillation (OR 0.40, $P = 0.002$) in the VSRR group could indicate its beneficial impact on cardiac electrical stability post-surgery.

Interestingly, the VSRR group also demonstrated shorter ICU stay (OR -2.92, $P < 0.00001$), reducing the odds of mortality after 30 days postoperative by 0.43 (OR 0.43 95% CI 0.20-0.95, $p=0.04$), and fewer reoperations for valve-related issues (OR 0.58, $P = 0.01$) compared to the Bentall group, further supporting its advantage in certain postoperative metrics. Nevertheless, heterogeneity was noted in studies involving ICU stay, 30-day mortality, and hospital length of stay, suggesting variability in these outcomes across different studies, which should be considered when interpreting these results.

VSRR and the Bentall procedure represent two distinct approaches to addressing aortic root disease, with the primary difference being whether the native aortic valve is preserved. It is widely acknowledged that VSRR is technically more challenging than the Bentall procedure. The 2022 American College of Cardiology/American Heart Association (ACC/AHA) guidelines endorse valve-sparing root replacement as an acceptable alternative in candidates requiring root replacement, provided the native valve is anatomically repairable and the procedure is undertaken by a skilled surgeon within a dedicated aortic team. Furthermore, a comprehensive evaluation of the patient's aortic valve morphology and functionality, along with a thorough assessment of the overall systemic condition, is critical to ensure optimal outcomes when performing VSRR (22).

Although these results lend support to VSRR in the AAAD population, several caveats remain. In particular, Bentall cohorts tended to include older patients than those undergoing VSRR, a demographic imbalance that may confound direct comparisons between the two strategies. A blanket statement favoring VSRR over the Bentall operation cannot be justified. Rather, the evidence supports that VSRR offers excellent outcomes in carefully chosen candidates, particularly those with preserved, non-calcified, and anatomically normal valve cusps; younger, active individuals; patients with minimal comorbidities; those with contraindications to anticoagulation; and patients with a long life expectancy. Although patients undergoing VSRR experienced longer durations of aortic cross-clamping and circulatory arrest compared to those undergoing the Bentall operation, the 30-day mortality rate was observed to be lower in the VSRR group. These findings highlight the importance of patient selection and individualized surgical planning to optimize outcomes for each approach.

Valve-related reinterventions were observed less frequently following VSRR compared with the Bentall procedure. This observation is corroborated by a separate investigation (23), which documented a 96% freedom from reoperation at two decades, closely paralleling the outcomes of our pooled analysis. Nonetheless, it should be

acknowledged that the comparatively older age and elevated mortality within the Bentall cohorts may have confounded the apparent reduction in valve-related reoperations in that group.

This valve-sparing technique demonstrates excellent long-term outcomes, underscoring its potential to be more widely adopted within the cardiac surgical community. This approach, while traditionally utilized as an elective procedure, shows significant promise in acute scenarios, including type A aortic dissection, and warrants broader consideration as a viable alternative in both elective and emergent settings.

Limitations

Several limitations warrant consideration. Many of the included studies suffered from selection bias, as the operative choice between Bentall and David techniques often relied on surgeon discretion—raising the possibility that some Bentall recipients might have been equally suitable for VSRR. Moreover, the overall methodological rigor of the available studies was modest, with a paucity of high-level evidence. Most included studies are observational and only one RCT was available, so selection and center effects may influence these findings. Differences in institutional experience and surgeon proficiency with VSRR likely introduced further variability into outcomes. Notwithstanding these caveats, the aggregated findings indicate that VSRR represents an attractive option in appropriately selected patients. Future prospective, high-quality investigations are essential to validate these advantages and to establish more robust, evidence-driven recommendations for wider clinical implementation.

5. Conclusions

When performed in high-volume centers with adequate expertise, VSRR for AAAD has demonstrated excellent perioperative and long-term results relative to the Bentall operation. Consequently, it may be particularly advisable in younger, active individuals, not only in elective cases but also within acute surgical contexts. At present, VSRR should be considered an alternative to Bentall in carefully chosen cases rather than a universally preferable strategy. Further high-quality randomized and multicenter studies are needed to determine comparative effectiveness.

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