Features and short-term outcomes of real-world transcatheter tricuspid valve repair *vs.* replacement in Asia-Pacific

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Background: Transcatheter therapies for tricuspid regurgitation (TR), including tricuspid transcatheter edge-to-edge repair (T-TEER) and transcatheter tricuspid valve replacement (TTVR), have shown promising safety and efficacy in clinical trials. However, real-world data in the Asia-Pacific (APAC) region remain limited. This descriptive study evaluates the clinical characteristics, procedural details, and 30-day outcomes of T-TEER and TTVR in patients with severe TR in the APAC region.

Methods: A retrospective analysis was conducted on 174 patients with severe symptomatic TR treated between 2017 and 2025 at four centers in Hong Kong, Taiwan, and Thailand. Patients underwent T-TEER or TTVR (heterotopic or orthotopic). The primary outcome was TR reduction to ≤ moderate at 30 days. Secondary outcomes included procedural complications, adverse events, reinterventions, and symptom improvement.

Results: Of the total cohort, 136 patients underwent T-TEER and 38 underwent TTVR. The TTVR group had more severe TR [median effective regurgitant orifice (ERO) area: 0.85 *vs.* 0.57 cm^2, P=0.001], a larger coaptation gap (median: 9.7 *vs.* 4.7 mm, P<0.001), and more posteroseptal TR origin (P<0.001). Combined mitral valve intervention was more common in the T-TEER group (50/136 *vs.* 1/38, P<0.001). At 30 days, TR reduction to ≤ moderate was achieved more frequently with TTVR (100.0%) compared with T-TEER (74.0%, P=0.001). Both groups showed significant symptomatic improvement, with 93.7% and 96.2% achieving New York Heart Association (NYHA) class I/II, respectively. TTVR was associated with higher inpatient major adverse events (15.8% *vs.* 2.2%, P=0.003), longer hospital stays (median: 15 *vs.* 5 days, P<0.001), and a greater decline in platelet count (–77,500/μL *vs.* –23,000/μL, P<0.001).

Conclusions: In the APAC region, TTVR is primarily reserved for patients with unfavorable anatomy for T-TEER. Both interventions improve TR and symptoms, but TTVR carries higher procedural risks and longer hospitalization. This comparison was exploratory and hypothesis-generating. These findings emphasize regional practice patterns and the need for long-term comparative studies to optimize treatment strategies.

Keywords: Tricuspid regurgitation (TR); tricuspid transcatheter edge-to-edge repair (T-TEER); transcatheter tricuspid valve replacement (TTVR)

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Introduction

Tricuspid regurgitation (TR) represents a significant global health burden and is associated with considerable morbidity and mortality (1). Transcatheter interventions are transforming the paradigm of TR treatment. Both tricuspid transcatheter edge-to-edge repair (T-TEER) and transcatheter tricuspid valve replacement (TTVR) have demonstrated clinical efficacy and safety, leading to their increasing adoption worldwide (2,3). The Trial to Evaluate Cardiovascular Outcomes in Patients Treated with the Tricuspid Valve Repair System Pivotal (TRILUMINATE Pivotal) trial confirmed the safety and efficacy of a dedicated T-TEER device (2), with extended 3-year follow-up showing sustained TR reduction to ≤ moderate in 79% of patients (4). Similarly, the EVOQUE Transcatheter Tricuspid Valve Replacement: Pivotal Clinical Investigation of Safety and Clinical Efficacy Using a Novel Device (TRISCEND II) trial reported a sustained TR reduction to ≤ mild in 95.2% of patients, along with improvements in quality of life and symptomatic relief at 1 year (3).

In the Asia-Pacific (APAC) region, the adoption of T-TEER and TTVR has been limited by healthcare policies, device availability, and reimbursement challenges (5). However, initial real-world experiences with T-TEER in Asia have been promising, demonstrating a device success rate of 74.0% with TR ≤ moderate at 30 days and a high safety profile, with a 30-day major adverse event rate of 1.9% (6). The TTVR option in APAC remains limited (5,7), with devices such as the orthotopic Lux Valve Plus (Jenscare, Ningbo, China), Cardiovalve (Cardiovalve Ltd., Or Yehuda, Israel), and the heterotopic TricValve (Product and Features, Vienna, Austria). Currently, the Lux Valve Plus TTVR is the only available orthotopic TTVR device and is increasingly used under compassionate use programs in several APAC countries for patients who are anatomically ineligible for T-TEER (8-10).

Despite these advancements, data on the features and outcomes of T-TEER and TTVR in this region remain limited. This study aims to describe the real-world clinical and anatomical profiles, procedural characteristics, and clinical outcomes associated with these two interventions in the APAC region.

Methods

This was a retrospective analysis of patients with severe symptomatic TR who underwent T-TEER or TTVR between 2017 and 2025 at four centers in Hong Kong, Taiwan, and Thailand. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the local ethics committees.

T-TEER and heterotopic TTVR using the TricValve device were performed under commercial indications, while orthotopic TTVR was performed under compassionate use. Generally, T-TEER was selected as the first-line treatment, with TTVR options considered alternatives if the patient's anatomy was unsuitable for T-TEER, as determined by the local Heart Team. Patients underwent computed tomography assessment to determine eligibility for orthotopic TTVR; when anatomical criteria were not met, heterotopic TTVR was considered as an alternative option. Reimbursement policies for different devices varied and changed over time at each participating site. T-TEER and orthotopic TTVR were performed under general anesthesia with transesophageal echocardiogram (TEE), with or without intracardiac echocardiogram (ICE) guidance (8). In contrast, heterotopic TTVR was performed under either general or local anesthesia, with or without TEE guidance.

Patient demographics, symptom burden, baseline laboratory data (obtained one day prior procedure), and medication records were reviewed. Procedural data collected included procedure duration, device type and position, and procedural complications. Inpatient events, length of hospital stay (defined as days of hospitalization after the procedure), trough hemoglobin, and platelet count during the hospitalization period were documented. Echocardiographic assessments at baseline and at 30 days post-intervention were reviewed locally at each center and reported for TR severity and mechanism, coaptation gap, concomitant mitral regurgitation (MR) severity, left ventricular ejection fraction, and right ventricular systolic pressure, following the Tricuspid Valve Academic Research Consortium (TVARC) Definitions for Tricuspid Regurgitation and Trial Endpoints (9). Clinical outcomes analyzed included 30-day major adverse events and

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symptomatic improvement, assessed by New York Heart Association (NYHA) class.

Definitions and study endpoints

TR severity was classified into five grades: mild (1+), moderate (2+), severe (3+), massive (4+), and torrential (5+) (10). TR etiology was categorized as organic TR, functional TR, or cardiac implantable electronic device (CIED)-related TR. The primary endpoint of the study was the reduction of TR to ≤ moderate at 30 days. Due to mechanistic differences, patients who received heterotopic TTVR were excluded from postoperative TR assessment. Secondary endpoints included inpatient major adverse events (defined by the TVARC), need for tricuspid valve reintervention, heart failure hospitalization, and all-cause mortality at 30 days, and symptomatic improvement at 30 days as assessed by NYHA functional class.

Statistical analysis

Parametric data are presented as mean ± standard deviation (SD), while nonparametric data are expressed as median and interquartile range (IQR). A Shapiro-Wilk test was used to test for normality. Differences between groups with continuous data were analyzed using Student's *t*-test for parametric data or Mann-Whitney U test for non-parametric data. Categorical data are presented as counts and percentages, with group comparisons performed using Chi-squared or Fisher's exact tests for low counts. McNemar's test was employed to compare baseline and follow-up data for TR severity and NYHA classes. A two-sided P value of <0.05 was considered statistically significant. All analyses were conducted using R version 4.4.2 and Python version 3.10 with the scipy and stats packages.

Results

Baseline characteristics

Between 2017 and 2025, a total of 174 patients with severe symptomatic TR underwent T-TEER or TTVR across four APAC centers. Of these, 136 patients were treated with T-TEER and 38 with TTVR. The median age of the entire cohort was 77.0 years (IQR, 71–84 years), and 44.8% were male (n=78) (*Table 1*). Both the T-TEER and TTVR groups demonstrated similar comorbidity profiles. The TRI-SCORE for the whole cohort was high {median [IQR]: 4.0 [3–6]}, with comparable scores in the T-TEER and TTVR subgroups {median [IQR]: 4.0 [3–6] *vs.* 4.5 [2–6], P=0.706}. Notably, the majority of patients had atrial fibrillation (overall: 86%, T-TEER: 85.9%, TTVR: 86.5%, P>0.99). The proportions of patients with prior cardiac surgery (overall: 28.2%, T-TEER: 25.7%, TTVR: 36.8%, P=0.254) and CIEDs (overall: 18.4%, T-TEER: 16.9%, TTVR: 23.7%, P=0.474, respectively) were similar between the two groups.

Heart failure symptoms were significant, with NYHA class II symptoms in 58.6% (n=102) of patients, and class III–IV symptoms in 40.8% (n=71), with a similar distribution between the two groups. Notably, the TTVR group had a significantly higher baseline hemoglobin level than the T-TEER group {median [IQR]: 12.4 [12–14] *vs.* 11.3 [10–13] g/dL, P=0.026}. Patterns of heart failure medication and diuretic prescription were similar between the groups, except for sodium-glucose co-transporter 2 inhibitors, which were more commonly prescribed in the TTVR group (44.7% *vs.* 26.8%, P=0.050). Most patients were on oral anticoagulants at baseline (overall: 77.6%, T-TEER: 75.0%, TTVR: 86.8%, P=0.184). Baseline demographics of heterotopic *vs.* orthotopic TTVR were illustrated in Table S1.

Baseline echocardiographic features

Baseline MR severity differed significantly between the two groups, with severe MR present in 34.6% of the T-TEER group and none in the TTVR group (*Table 2*). Although categorical TR grades were similar between the groups (*Table 2*), patients in the TTVR group demonstrated a larger effective regurgitant orifice (ERO) area for TR {median [IQR]: 0.85 [0.6–1.2] *vs.* 0.57 [0.5–0.7] cm^2, P=0.001}, and a larger maximal coaptation gap {median [IQR]: 9.7 [6–14] *vs.* 4.7 [3–6] mm, P<0.001} compared to the T-TEER group. Additionally, the mechanism of TR differed significantly between the groups (P<0.001; *Table 2*), with more functional TR and less organic TR observed in the T-TEER group compared to the TTVR group. The location of TR also varied significantly, with a higher proportion of posteroseptal TR treated in the TTVR group (*Table 2*). T-TEER patients also exhibited a larger left atrial volume {median [IQR]: 103.0 [71–147] *vs.* 76.3 [55–102] mL, P=0.011}. Otherwise, the median left ventricular ejection fraction, tricuspid annulus dimensions, and right atrial volume were similar between the two groups.

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Table 1 Baseline demographics

Parameters	Whole cohort (n=174)	T-TEER group (n=136)	TTVR group (n=38)	P value
Demographics				
Age (years)	77.0 [71–84]	77.0 [72–83]	76.5 [70–84]	0.825
Male	78 (44.8)	64 (47.1)	14 (36.8)	0.350
Body weight (kg)	58.0 [50–67]	57.0 [49–68]	59.1 [53–67]	0.434
BMI (kg/m^2)	23.0±3.8	22.9 [20–25]	23.7 [21–26]	0.410
Smoker	17 (9.8)	12 (8.8)	5 (13.2)	0.627
Baseline NYHA				0.761
Class I	1 (0.6)	1 (0.7)	0	
Class II	102 (58.6)	77 (56.6)	25 (65.8)	
Class III	62 (35.6)	51 (37.5)	11 (28.9)	
Class IV	9 (5.2)	7 (5.1)	2 (5.3)	
Comorbidities				
Hypertension	87 (50.0)	70 (51.5)	17 (44.7)	0.582
Hyperlipidemia	48 (27.6)	38 (27.9)	10 (26.3)	>0.99
Diabetes	37 (21.3)	30 (22.1)	7 (18.4)	0.795
Atrial fibrillation	149 (85.6)	116 (85.3)	33 (86.8)	>0.99
Coronary artery disease	44 (25.3)	36 (26.5)	8 (21.1)	0.640
Prior PCI	32 (18.4)	26 (19.1)	6 (15.8)	0.817
Prior myocardial infarction	8 (4.6)	8 (5.9)	0	0.275
Prior stroke	19 (10.9)	13 (9.6)	6 (15.8)	0.427
COPD	9 (5.2)	8 (5.9)	1 (2.6)	0.700
Asthma	2 (1.1)	2 (1.5)	0	>0.99
Prior cardiac surgery	49 (28.2)	35 (25.7)	14 (36.8)	0.254
Peripheral artery disease	4 (2.3)	4 (2.9)	0	0.647
Prior CIED	32 (18.4)	23 (16.9)	9 (23.7)	0.474
EuroSCORE II	3.7 [2–6]	4.0 [2–7]	3.6 [2–5]	0.270
TRI-SCORE	4.0 [3–6]	4.0 [3–6]	4.5 [2–6]	0.706
Laboratory results				
Hemoglobin (g/dL)	11.6 [10–13]	11.3 [10–13]	12.4 [12–14]	0.026
Platelet (count/μL)	159,000 [127,000–196,000]	161,000 [128,000–190,500]	149,000 [124,250–208,250]	0.797
Creatinine (mg/L)	1.07 [0.9–1.4]	1.05 [0.8–1.4]	1.11 [0.9–1.3]	0.744
Albumin (g/L)	36.5 [34–40]	36.5 [34–40]	36.5 [32–40]	0.597
Bilirubin (mg/dL)	1.00 [0.7–1.5]	0.99 [0.7–1.5]	1.11 [0.8–1.3]	0.495
NTproBNP (pg/mL)	1,706 [706–2,701]	1,713.5 [800–2,980]	1,338 [623–2,330]	0.177

Table 1 (*continued*)

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Table 1 (*continued*)

Parameters	Whole cohort (n=174)	T-TEER group (n=136)	TTVR group (n=38)	P value
Medications				
Beta-blocker	122 (70.1)	96 (70.6)	26 (68.4)	0.133
ACEi/ARB/ARNI	68 (39.1)	52 (38.2)	16 (42.1)	0.807
Aldosterone antagonist	115 (66.1)	93 (68.4)	22 (57.9)	0.311
Furosemide	133 (76.4)	104 (76.5)	29 (76.3)	>0.99
Thiazide diuretics	25 (14.4)	20 (14.7)	5 (13.2)	>0.99
SGLT2i	53 (30.5)	36 (26.75)	17 (44.7)	0.050
Aspirin	17 (9.8)	15 (11.0)	2 (5.3)	0.454
Other antiplatelet	13 (7.5)	11 (8.1)	2 (5.2)	0.813
OAC	135 (77.6)	102 (75.0)	33 (86.8)	0.184

Data are presented as median [IQR], number (%), or mean ± SD. ACEi, angiotensin-converting enzyme inhibitors; ARB, angiotensin receptor blockers; ARNI, angiotensin receptor-neprilysin inhibitor; BMI, body mass index; CIED, cardiac implantable electronic device; COPD, chronic obstructive pulmonary disease; IQR, interquartile range; NTproBNP, N-terminal pro B-type natriuretic peptide; NYHA, New York Heart Association; OAC, oral anticoagulant; PCI, percutaneous coronary intervention; SD, standard deviation; SGLT2i, sodium-glucose cotransporter-2 inhibitor; T-TEER, tricuspid transcatheter edge-to-edge repair; TTVR, transcatheter tricuspid valve replacement.

Procedural characteristics

In the T-TEER group, MitraClip was used in 17.6% (n=24) and TriClip was used in 82.4% (n=112) of cases, while in the TTVR group, the devices used were Lux Valve Plus (71.1%, n=27), TricValve (26.3%, n=10), and CardioValve (2.6%, n=1). The procedural times were comparable between the T-TEER and TTVR groups {median [IQR]: 132.0 [99–195] *vs.* 115.0 [99–154] min, P=0.294} (*Table 3*). However, combined procedures were more frequently performed in the T-TEER group (43.4% *vs.* 13.2%, P=0.001). Among these, mitral TEER was the most common. Additionally, the majority (75.0%) of T-TEER patients received a figure-of-eight suture for hemostasis, whereas most (86.8%) of the TTVR patients received ProGlide devices alone or in combination with a figure-of-eight suture (P<0.001).

Inpatient and 30-day outcomes

All 38 TTVR patients were included in the safety analysis, whereas heterotopic TTVR patients were excluded from the analysis of TR grade at 30 days. The TTVR group experienced significantly more inpatient composite major adverse events (15.8% *vs.* 2.2%, P=0.003), primarily driven by a higher rate of vascular complications (10.5% *vs.* 1.5%, P=0.028) (*Table 4*). Additionally, the length of hospital stay post-procedure was significantly longer in the TTVR group {median [IQR]: 15 [9–30] *vs.* 5 [3–7] days, P<0.001}. Furthermore, patients in the TTVR group showed a more pronounced decline in hemoglobin and platelet count after the procedure {median change in hemoglobin [IQR]: −2.45 [−4.4 to 1.8] *vs.* −0.7 [−1.5 to 0] g/dL, P=0.12; median change in platelets [IQR]: −77,500/μL [−115,500/μL to −65,000/μL] *vs.* −23,000/μL [−46,000/μL to 0/μL], P<0.001}. Notably, in both groups, no new pacemaker implantations were required during inpatient stay or at 30 days. Inpatient outcomes of heterotopic *vs.* orthotopic TTVR are illustrated in Table S2. Furthermore, sensitivity analyses on inpatient outcomes of T-TEER *vs.* orthotopic TTVR, and standalone T-TEER *vs.* standalone orthotopic TTVR (without mitral valve interventions) were performed, which showed similar patterns (Tables S3,S4).

At 30 days, four patients in the T-TEER group and seven patients in the TTVR group had missing clinical follow-up or echocardiographic data. Accordingly, 30-day outcomes were evaluated in the remaining patients, while 30-day TR severity analyses were evaluated based on patients who underwent orthotopic TTVR. Among these patients, significant TR improvements were observed in both groups (*Figure 1*); however, more patients in the TTVR group achieved TR ≤ moderate compared to the T-TEER group [26/26 (100.0%) *vs.* 94/127 (74.0%), P=0.001]. No tricuspid

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Table 2 Baseline echocardiographic data

Echocardiographic parameters	Whole cohort (n=174)	T-TEER group (n=136)	TTVR group (n=38)	P value
LVEF (%)	57.0 [51–63]	57.0 [51–64]	55.0 [52–60]	0.311
LA volume (mL/cm^2)	99.5 [66–138]	103.0 [71–147]	76.3 [55–102]	0.011
MR severity				<0.001
Severe	47 (27.0)	47 (34.6)	0	
Moderate	27 (15.5)	18 (13.2)	9 (23.7)	
Mild	66 (37.9)	50 (36.8)	16 (42.1)	
Trace/none	26 (14.9)	16 (11.8)	9 (26.3)	
TR mechanism				<0.001
Functional	119 (68.4)	104 (76.5)	15 (39.5)	
CIED	32 (18.4)	24 (17.6)	8 (21.0)	
Organic	15 (8.6)	7 (5.1)	8 (21.0)	
Unclassified	8 (4.5)	1 (0.7)	7 (17.5)	
TR ERO (cm^2)	0.59 [0.5–0.8]	0.57 [0.5–0.7]	0.85 [0.6–1.2]	0.001
TR severity				0.448
Torrential	64 (36.8)	48 (35.3)	16 (42.1)	
Massive	34 (19.5)	30 (22.1)	4 (10.5)	
Severe	72 (41.4)	57 (41.9)	15 (39.5)	
Moderate	1 (0.6)	1 (0.7)	0	
TV maximal coaptation gap (mm)	5.0 [3–9]	4.7 [3–6]	9.7 [6–14]	<0.001
Location of TR				0.017
Throughout	100 (63.7)	83 (61.9)	17 (73.9)	
Anteroseptal	40 (25.5)	39 (29.1)	1 (4.3)	
Posteroseptal	17 (10.8)	12 (9.0)	5 (21.7)	
TAPSE (mm)	18.0±4.7	17.8±4.8	19.0±4.1	0.152
RVSP (mmHg)	45.0 [36–54]	46.0 [39–54]	36.0 [30–41]	<0.001
Tricuspid annulus dimension (mm)	40.0 [36–44]	41.0 [37–44]	40.0 [36–45]	0.786
RA volume (mL/cm^2)	154.7±67	161.2±67.5	107.5±51.8	0.110

Data are presented as median [IQR], number (%), or mean ± SD. CIED, cardiac implantable electronic device; ERO, effective regurgitant orifice; IQR, interquartile range; LA, left atrium; LVEF, left ventricular ejection fraction; MR, mitral regurgitation; RA, right atrium; RVSP, right ventricular systolic pressure; SD, standard deviation; T-TEER, tricuspid transcatheter edge-to-edge repair; TAPSE, tricuspid annular plane systolic excursion; TR, tricuspid regurgitation; TTVR, transcatheter tricuspid valve replacement; TV, tricuspid valve.

valve reinterventions were performed in either group, but one mortality was noted in the TTVR group (2.6%). Recurrent heart failure hospitalizations were uncommon (T-TEER: 5.1% *vs.* TTVR: 5.3%, P=0.645) (*Table 5*). Additionally, both groups showed significant improvement in heart failure symptoms (*Figure 2*), with the majority remaining at NYHA class I/II at 30 days. NYHA class III/IV symptoms were present in only 3.8% (n=5) of T-TEER patients and 6.3% (n=2) of TTVR patients at 30 days.

Additionally, a multivariable logistic regression was

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Table 3 Procedure features and outcomes

Procedure parameters	Whole cohort (n=174)	T-TEER group (n=136)	TTVR group (n=38)	P value
Device used				<0.001
TriClip/MitraClip	136 (78.2)	136 (100.0)	0	
MitraClip	24 (13.8)	24 (17.6)		
TriClip	112 (64.4)	112 (82.4)		
TricValve	10 (5.7)	0	10 (26.3)	
Lux Valve Plus	27 (15.5)	0	27 (71.1)	
CardioValve	1 (0.6)	0	1 (2.6)	
Procedure time (min)	128.0 [99–195]	132.0 [99–195]	115.0 [99–154]	0.294
Vascular closure method				<0.001
Figure-of-eight	107 (61.5)	102 (75.0)	5 (13.2)	
Proglide	49 (28.2)	34 (25.0)	15 (39.5)	
Combined	18 (10.3)	0	18 (47.4)	
Additional procedure[†]	64 (36.8)	59 (43.3)	5 (13.2)	<0.001
M-TEER	51	50	1	
PFO/ASD occlusion	8	8	0	
TAVI	1	1	0	
LAAO	11	11	0	
PCI	2	1	1	
PADN	1	0	1	
PTMC	2	1	1	
Aortic PVL closure	1	1	0	

Data are presented as number (%), median [IQR], or number. [†], numbers indicate the count of procedures (not patients). Total numbers exceeded 64 as some patients underwent multiple concomitant interventions. 2D, two-dimensional; 3D, three-dimensional; 4D, four-dimensional; ASD, atrial septal defect; ICE, intracardiac echocardiogram; IQR, interquartile range; LAAO, left atrial appendage occlusion; M-TEER, mitral transcatheter edge-to-edge repair; PADN, pulmonary artery denervation; PCI, percutaneous coronary intervention; PFO, patent foramen ovale; PTMC, percutaneous transcatheter mitral commissurotomy; PVL, paravalvular leak; T-TEER, tricuspid transcatheter edge-to-edge repair; TAVI, transcatheter aortic valve implantation; TTVR, transcatheter tricuspid valve replacement.

conducted using treatment, coaptation gap, ERO, and MR severity as the predictors for TR ≤ moderate at 30 days and inpatient major adverse events, respectively (Table S5).

Discussion

This study highlights several important findings regarding real-world transcatheter tricuspid valve interventions in the APAC region. First, TTVR was used in patients with larger ERO areas and larger coaptation gaps. Second, combined procedures were more common in the T-TEER group. Third, both T-TEER and TTVR significantly improved TR and heart failure symptoms, with TTVR achieving a higher rate of TR ≤ moderate at 30 days (100.0% *vs.* 74.0%) (*Figure 3*). Fourth, TTVR was associated with a higher rate of inpatient major adverse events, longer hospital stays, and a more pronounced decrease in hemoglobin and platelet counts following the procedure (*Figure 3*).

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Table 4 In-patient outcomes

Outcome measures	T-TEER group (n=136)	TTVR group (n=38)	P value
Composite of major adverse events	3 (2.2)	6 (15.8)	0.003
Mortality	0	0	NA
Myocardial infarction	0	0	NA
Stroke	0	0	NA
Device embolization	0	0	NA
New onset renal failure requiring dialysis	0	0	NA
Life-threatening bleeding	1 (0.7)[†]	0	>0.99
Cardiac tamponade	0	2 (5.3)[‡]	0.067
Conversion to open heart	0	2 (5.3)[§]	0.067
Major vascular complication	2 (1.5)	4 (10.5)	0.028
New pacemaker needed	0	0	NA
LOS post-procedure (days)	5.0 [3–7]	15.0 [9–30]	<0.001
Trough hemoglobin (g/dL)	10.4±2.0	9.7±2.1	0.120
Change in hemoglobin (g/dL)	–0.70 [–1.5 to 0]	–2.45 [–4.4 to –1.8]	<0.001
Trough platelet (count/μL)	133,291±47,257	77,867±37,195	<0.001
Change in platelet (count/μL)	–23,000 [–46,000 to 0]	–77,500 [–115,500 to –65,000]	<0.001
Post-operative oral anticoagulant	102±75.0	38±100	<0.001

Data are presented as number (%), median [IQR], or mean ± SD. [†], gastrointestinal bleeding with esophageal perforation. [‡], one required pericardial drainage and the other required open heart repair. [§], both cases were heterotopic valve implantation, one with cardiac tamponade and inferior vena cava injury and another with device migration, both cases survived after open heart repair. IQR, interquartile range; LOS, length of stay; NA, not available; SD, standard deviation; T-TEER, tricuspid transcatheter edge-to-edge repair; TTVR, transcatheter tricuspid valve replacement.

Patient selection

Due to differences in device availability, evidence, and regulatory approval across the region, orthotopic and heterotopic TTVR remained as second-line therapies to T-TEER for patients with TR who were anatomically unfavorable or unfeasible for T-TEER. Consequently, patients undergoing TTVR in our series presented with a higher median ERO area and a significantly larger maximal coaptation gap (median: 9.7 *vs.* 4.7 mm, P<0.001), as well as a higher proportion of posteroseptal TR origin compared to the T-TEER group. Nevertheless, similar baseline demographics, EuroSCORE II, and TRI-SCORE between the two groups suggest that TR interventions were predominantly performed in a high surgical risk patient cohort in the region. Interestingly, severe MR was more prevalent in the T-TEER group and was associated with a higher rate of combined mitral TEER procedures. Additionally, in the T-TEER group, a greater proportion of functional TR (76.5% *vs.* 39.5%) was treated, along with a larger baseline left atrial volume. This likely reflects regional preferences for combined procedures and the high prevalence of atrial functional MR and TR (5,6,11). Unfortunately, detailed anatomical parameters such as leaflet morphology and right ventricular dimensions were not available for patient selection assessment. Moreover, other factors influencing treatment choice—such as patient preference, affordability of compassionate use devices, and fitness for oral anticoagulants—were also not documented.

Procedural complications and outcomes

Combined interventions, particularly those combining

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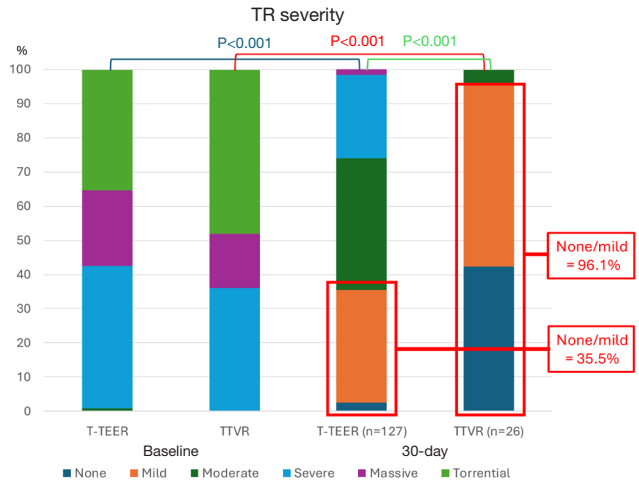

Figure 1 Baseline *vs.* 30-day TR in T-TEER and TTVR patients. Significant improvement in the 30-day TR severity from baseline was observed for both the T-TEER and TTVR groups. However, the TTVR group had a more substantial TR reduction (100% *vs.* 74.0% ≤ moderate TR). Note that heterotopic TTVR patients were excluded for evaluation of TR severity due to mechanistic differences. T-TEER, tricuspid transcatheter edge-to-edge repair; TR, tricuspid regurgitation; TTVR, transcatheter tricuspid valve replacement.

T-TEER with mitral TEER, were frequently performed in the T-TEER group, consistent with previous reports (6,12) and data from the TriValve registry, where 52% of patients underwent combined tricuspid and mitral procedures (13,14). In contrast, most TTVR procedures were performed as isolated interventions, likely due to differences in underlying disease mechanisms and procedural ergonomics, as most orthotopic TTVR cases employed a transjugular approach.

In our study, 74.0% of T-TEER patients achieved TR ≤ moderate at 30 days, comparable to findings from the TRILUMINATE and bRIGHT registries (15,16). It should be highlighted that combined mitral TEER and T-TEER were performed in 36% of patients in this group, while treatment of MR can also alter right-sided hemodynamics and contribute to a reduction in TR severity. All orthotopic TTVR cases also achieved TR ≤ moderate at 30 days, consistent with international experience (3,17), despite more severe baseline TR with larger coaptation gaps. Prior analyses indicate that torrential TR at baseline predicts significant residual TR at 30 days post-T-TEER (6,13). This suggests that orthotopic TTVR may be a viable option for patients with torrential baseline TR. Despite

Table 5 Thirty-day outcomes

Outcome measures	T-TEER (n=132)	TTVR (n=31)	P value
TV re-intervention	0	0	NA
Heart failure hospitalizations	7 (5.1)	2 (5.3)	0.645
Death	0	1 (2.6)	NA
30-day NYHA class			0.806
Class I	42 (31.8)	10 (31.3)	
Class II	85 (64.4)	20 (62.5)	
Class III	4 (3.0)	2 (6.3)	
Class IV	1 (0.8)	0	
30-day TR severity	n=127[†]	n=26[†‡]	<0.001
Massive	2 (1.6)	0	
Severe	31 (24.4)	0	
Moderate	49 (38.6)	1 (3.8)	
Mild	42 (33.1)	14 (53.8)	
None	3 (2.3)	11 (42.3)	

Data are presented as number or number (%). [†], have echo data. [‡], removed heterotopic TTVR patients for TR severity analysis. NA, not available; NYHA, New York Heart Association; T-TEER, tricuspid transcatheter edge-to-edge repair; TR, tricuspid regurgitation; TTVR, transcatheter tricuspid valve replacement; TV, tricuspid valve.

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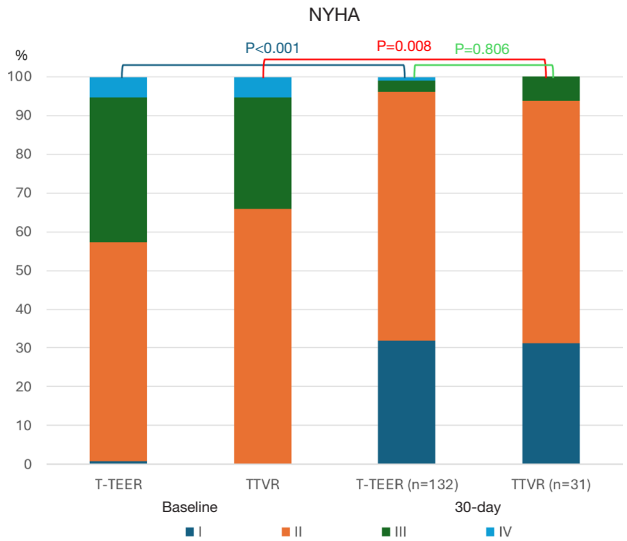

Figure 2 Baseline *vs.* 30-day NYHA class in T-TEER and TTVR patients. Significant improvements in heart failure symptoms (NYHA) from baseline to 30-day were observed for both the T-TEER and TTVR groups. There was no significant difference between the two groups in the 30-day heart failure symptoms. NYHA, New York Heart Association; T-TEER, tricuspid transcatheter edge-to-edge repair; TTVR, transcatheter tricuspid valve replacement.

differences in the degree of TR reduction, both groups experienced significant symptom improvement; however, as post-operative medication data were incomplete, the extent to which symptom relief was attributable to therapy *vs.* medication adjustments could not be determined.

Although TTVR can offer superior anatomical correction of TR in T-TEER ineligible patients, it carries a higher risk of inpatient major adverse events (15.8% *vs.* 2.2%, P=0.003), especially vascular complications. This aligns with previous TTVR studies and appears device-independent (3,18,19). In particular, the current study reflects the combined experience of several devices (primarily the Lux Valve Plus and TricValve) in high-risk, anatomically complex patients, rather than a device-class effect in general. The higher rate of vascular complications may be due to a combination of factors, including the large-bore size of the delivery sheath at 33-Fr, differences in vascular access sites, the effect of post-procedure thrombocytopenia. Moreover, all patients in the TTVR group, compared to 75% in the T-TEER group, received oral anticoagulant postoperatively, which might also contribute to bleeding complications. The significant drop in platelet counts post-TTVR observed may be related to device-specific platelet consumption and activation. This was previously described, but the exact pathophysiology remains unclear, and its clinical implications warrant further investigation (20). Presumably, the occurrence of vascular complications, hemoglobin and platelet drop in TTVR patients led to a prolonged hospital stay (15 *vs.* 5 days, P<0.001). An additional hypothesis for prolonged length of stay (LOS) is the occurrence of acute right heart failure following TTVR. Abrupt reduction of TR may lead to a sudden preload reduction and afterload mismatch, resulting in right ventricular dysfunction. Longer hospital stay may be required to allow for right ventricular adaptation and recovery (21). The early experience with TTVR also contributed to the LOS, as physicians were more conservative in discharging patients post-TTVR. Notably, none of the TTVR patients required a pacemaker at 30 days, likely reflecting device-specific factors (17,22).

There is a learning curve associated with TR reduction in T-TEER, which appears less prominent for TTVR (3,6). Whether increased clinical experience will reduce the adverse event rate in the TTVR group remains uncertain. Additionally, head-to-head comparisons of T-TEER and TTVR in patients eligible for both therapies are lacking. Long-term data on the durability of TR reduction, clinical outcomes, and right ventricular remodeling are also needed.

Limitation

The study has several limitations. First, the sample size was small, with only 174 patients from four centers in APAC. However, this is the largest series reported in the region and provides valuable insights into regional practices and outcomes of T-TEER and TTVR. Second, a few patients (four patients in the T-TEER group, seven patients in the TTVR group) had missing clinical follow-up or echocardiographic data at 30-day, which may introduce potential bias to our results. Third, the echocardiographic assessments were not performed by a central core lab, but all centers are recognized as experts in tricuspid interventions and followed standard international guidelines during the TR assessment. Fourth, due to confounding by indication and lack of adjusted analyses for the comparison of outcomes between T-TEER and TTVR, the study should not be interpreted as a head-to-head comparison between the two modalities. Rather, our findings reflect local clinical practice patterns and real-world outcomes associated with

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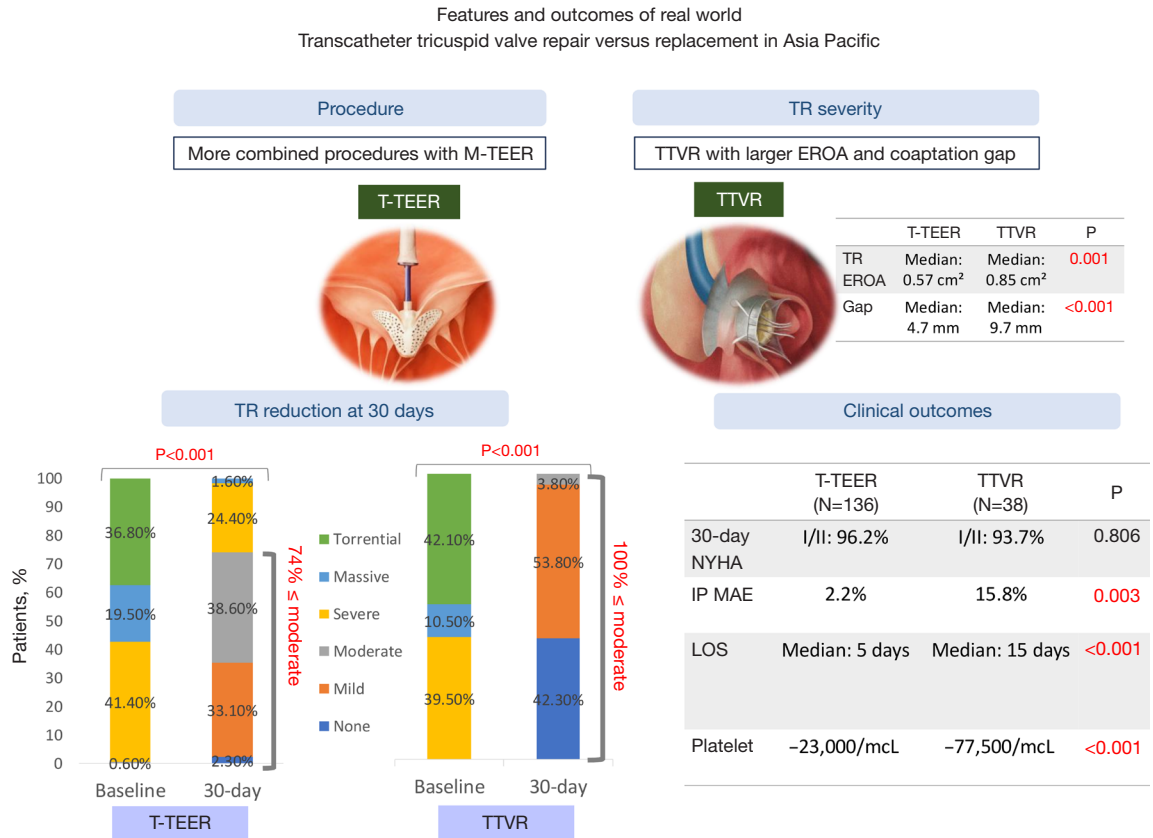

Figure 3 Features and outcomes of real-world transcatheter tricuspid valve repair *vs.* replacement in APAC. A total of 136 T-TEER and 38 TTVR were included. The TTVR group had more severe TR measured by EROA and a larger coaptation gap. At 30 days, TR reduction to ≤ moderate was achieved more frequently with TTVR compared to T-TEER. Both groups showed significant symptomatic improvement by the NYHA classification. However, TTVR was associated with higher IP MAE, longer hospital LOS post-procedure, and a greater decline in platelet count. APAC, Asia-Pacific; EROA, effective regurgitant orifice area; IP MAE, inpatient major adverse events; LOS, length of stay; M-TEER, mitral transcatheter edge-to-edge repair; NYHA, New York Heart Association; T-TEER, tricuspid transcatheter edge-to-edge repair; TR, tricuspid regurgitation; TTVR, transcatheter tricuspid valve replacement.

these two transcatheter approaches for management of TR. Further comparative studies are required to directly evaluate the effectiveness of both therapies in comparable patient populations. Additionally, most TTVR procedures used the Lux Valve Plus device, followed by TricValve, based on each center's experience. In contrast, the Evoque device is more common in Europe and the United States. So, these findings may not apply directly to Western populations. Nonetheless, the study offers important regional data on transcatheter tricuspid interventions. Fifth, device availability changed over the study period, but the impact of this on outcomes was not analyzed. Finally, it should be noted that this study primarily focuses on short-term (30-day) outcomes. Device durability, long-term clinical outcome, and effect on right ventricular remodeling warrant evaluation in studies with extended follow-up periods. The comparative analysis of this descriptive study was exploratory in nature, and results should be considered hypothesis-generating and need confirmation in a larger-scale study.

Conclusions

In the APAC region, TTVR is primarily reserved for patients with unfavorable anatomy for T-TEER. Both interventions improve TR and symptoms, but TTVR carries higher procedural risks and longer hospitalization. The comparison was exploratory and hypothesis-generating.

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These findings emphasize regional practice patterns and the need for long-term comparative studies to optimize treatment strategies.

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Footnote

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Conflicts of Interest: K.M. is a physician proctor for Abbott Structural Heart. Dr. T.N. is a physician proctor (TEE proctoring) for Abbott Structural Heart and Boston Scientific. A.P.W.L. is a speaker and consultant for Abbott Structural, Philips, Huihe, and Siemens. G.H.L.T. has received speaking honoraria from and served as a physician proctor, consultant, advisory board member, TAVR publications committee member, RESTORE study steering committee member, APOLLO trial screening committee member, and IMPACT MR steering committee member for Medtronic; has received speaking honoraria from and served as a physician proctor, consultant, advisory board member, and TRILUMINATE trial anatomic eligibility and publications committee member for Abbott Structural Heart; has served as an advisory board member for Boston Scientific and JenaValve; has served as a consultant and physician screening committee member for Shockwave Medical; has served as a consultant for NeoChord, Peija Medical, and Shenqi Medical Technology; and has received speaking honoraria from Siemens Healthineers. A.S.H.S. is a physician proctor for Abbott Structural Heart. K.C.Y.S. is a physician proctor for Abbott Structural Heart, Boston Scientific, Edwards, and Medtronic; and serves as a consultant for Venus Medtech and Jenscare. The other authors have no conflicts of interest to declare.

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