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ORIGINAL RESEARCH

Implementing Formal Mitral Heart Team Improves Multidisciplinary Evaluation Rate and Survival of Patients With Severe Primary Mitral Regurgitation

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BACKGROUND: Multidisciplinary heart team (HT) evaluation is recommended for patients with severe primary mitral regurgitation to optimize treatment decisions. However, its impact on patient outcomes remains unknown. We evaluated the impact of implementing mitral HT on patient survival.

METHODS AND RESULTS: We conducted a retrospective cohort study of patients with new diagnoses of severe primary mitral regurgitation in a large healthcare network echocardiogram database between 2016 and 2020. We compared the incidence of multidisciplinary evaluation by structural cardiology and cardiac surgery services and 2-year survival before and after mitral HT implementation. The 1:1 propensity-score matching between pre- and post-mitral HT used Society of Thoracic Surgeons Predicted Risk of Mortality for mitral repair, age, sex, race, heart failure symptoms, inpatient setting, history of MI, and dementia as covariates. Logistic regression identified variables associated with the likelihood of undergoing multidisciplinary evaluation. Among 70 510 echocardiograms performed, 391 patients had severe primary mitral regurgitation (median age, 77 years; 46% women). Multidisciplinary evaluation increased from 29% to 89% (P<0.001), and intervention increased from 24% to 75% following mitral HT implementation (P<0.001). Among 180 propensity-score matched patients, mortality was lower post-mitral HT at 2 years (19% versus 32%, P=0.04). The multivariable model showed that mitral HT implementation and heart failure symptoms were associated with higher odds of undergoing multidisciplinary evaluation (OR [odds ratio], 18.7 and 2.72, respectively), whereas female sex and older age were associated with lower odds (OR, 0.39 and 0.93, respectively).

CONCLUSIONS: Implementation of mitral HT was associated with drastic improvement in multidisciplinary evaluation for patients with severe primary mitral regurgitation. This coincided with higher proportions of patients undergoing mechanical correction of MR and improved overall patient survival.

Key Words: heart team ■ mitral regurgitation ■ mitral valve ■ mitral valve repair

The multidisciplinary heart team (HT) evaluation is a Class 1 recommendation by both American and European cardiovascular societies for patients with severe primary mitral regurgitation (MR).[1,2] Formally implementing a mitral HT is thought to optimize the patient selection, procedural planning, management approaches, and potentially outcomes for individual patients through multidisciplinary decision-making among structural cardiology, cardiac surgery, structural echocardiogram teams, and coordinators.[3,4]

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CLINICAL PERSPECTIVE

What Is New?

- This study evaluated the impact of implementing a formal mitral heart team on survival for patients presenting with primary severe mitral regurgitation.

What Are the Clinical Implications?

- The rate of referral to a multidisciplinary heart team and the proportion of patients undergoing intervention increased substantially following the implementation of a formal mitral heart team.
- Patients had improved overall survival following the implementation of a formal mitral heart team.

Nonstandard Abbreviations and Acronyms

HT	heart team
MR	mitral regurgitation
PROM	predicted risk of mortality
STS	Society of Thoracic Surgeons
TEER	transcatheter edge-to-edge repair

Although the potential benefit of multidisciplinary mitral HT is intuitive, the impact of a formal mitral HT on patient outcomes remains unknown.

The multidisciplinary HT model has been widely used in other medical fields, including oncology, transplantation, and cardiovascular disease.[5–11] Patients with coronary artery disease and aortic stenosis in particular have benefited from a multidisciplinary HT approach.[5,9,12,13] With the evolving evidence supporting transcatheter edge-to-edge repair (TEER) and transcatheter mitral valve replacement as a complementary approach to mitral valve surgery, the impact of a dedicated mitral HT on the outcome of patients with mitral valve disease warrants further understanding. Center-level variation in the successful surgical repair rate in degenerative MR[14–17] also makes the mitral HT discussion more important in uniquely tailoring the decision-making process to the local practice. The Mitral Valve Repair Reference Center Award is designated by the American Heart Association based on outcomes,[1] and it is important to understand the impact of a mitral HT in centers where an excellent mitral repair option is readily available. Additionally, it is important to understand the factors associated with the likelihood of patients undergoing multidisciplinary evaluation, which remain unknown among patients with severe primary MR.

Using a healthcare network-wide echocardiogram database, we aimed to evaluate whether patient characteristics and mid-term survival among patients with newly detected primary severe MR changed in association with the implementation of a formal mitral heart team. We also sought to identify patient factors associated with the likelihood of undergoing multidisciplinary evaluation.

METHODS

The data that support the findings of this study are available from the corresponding author upon reasonable request. This study was conducted after the approval of our institutional ethics committee (2000028791). No informed consent was required.

Patient Population

We conducted a retrospective cohort study at Yale-New Haven Health, a large healthcare network in the United States, encompassing 10 inpatient sites in academic and community settings and 440 outpatient clinics at satellite locations throughout Connecticut and Rhode Island. The system-wide electronic medical record database was queried to identify patients age ≥18 years who received complete (as opposed to focused exam) transthoracic echocardiogram for any indication between January 1, 2016 to December 31, 2020, either during inpatient or outpatient encounters. These included echocardiograms obtained from 32 sites. Yale-New Haven Hospital, the flagship hospital of the health system, has received American Heart Association Mitral Valve Repair Reference Center Award designation in 2021 based on mitral repair outcomes in 2020.

We restricted the cohort to severe MR of primary etiology using the following criteria: mitral leaflet being described using the words “prolapsed,” “prolapse,” “degenerative”, or “myxomatous” and included only patients for whom this was the first identification of severe MR among all echocardiograms performed during the study period. Mitral stenosis of any severity or endocarditis of any valve was excluded. Patients with prior valve operations were also excluded. We focused on severe primary MR to homogenize the patient group to those with higher likelihood of needing mitral valve intervention or operation.

Variable Definitions

The exposure variable was formal multidisciplinary mitral HT evaluation, which was implemented in January 2019. The mitral HT at our institution consisted of three cardiac surgeons, two structural cardiologists,

and one structural imaging specialist who held mitral HT conference every other week.

Demographics, admission details, follow-up care, and echocardiogram measurements were extracted from medical records. Admission details included the reason for admission and documented heart failure symptoms, and follow-up included incidence and reason for readmission. Echocardiogram measurements included the presence and severity of mitral annular calcification, left ventricular end-diastolic diameter, left ventricular ejection fraction (LVEF), and left atrial volume. The Society of Thoracic Surgeons (STS) Predicted Risk of Mortality (PROM) for mitral valve repair and replacement were calculated for each patient.[18] Patient mortality was adjudicated by the combination of Connecticut Vital Statistics Database linkage, which captures all Connecticut State residents' mortality occurring in and out of the state, supplemented with individual patient chart review.

Outcome Measures

The primary end point during follow-up was 2-year all-cause mortality. We restricted the follow-up up to 2 years since the index echocardiogram to ensure all patients had the potential for a complete follow-up.

Statistical Analysis

Bivariate analyses compared patient characteristics, operative details, postoperative outcomes, and STS PROM between patients before and after formal implementation of mitral heart team evaluation. Wilcoxon rank-sum tests were used for continuous variables, and the median and interquartile range were reported. X^2 tests were used for categorical variables, which were summarized by percentages. The Fisher exact test was used if cell counts were ≤5. Unadjusted survival was estimated using Kaplan–Meier plot.

To estimate the impact of formal mitral heart team evaluation on survival, 1:1 propensity-score matching was performed between patients before and after the advent of formal mitral heart team using a logistic regression model with the STS PROM for mitral valve repair, age, sex, race, heart failure symptoms, inpatient setting, history of myocardial infarction, and dementia as the covariates. We used the nearest neighbor method and a caliper size of 0.06; 180 patients were matched between the 2 groups without replacement. The quality of matching was evaluated using propensity-score density and a Love plot. Wilcoxon signed rank tests were used for continuous variables, and McNemar tests were used for categorical variables. A Cox proportional hazard model and a mixed effect model were fitted to any remaining unbalanced covariates after propensity-score matching. A logistic regression model was fitted to the overall pre-match cohort to identify variables associated with the likelihood of being evaluated by a multidisciplinary team, defined as the involvement of both cardiology and cardiac surgery teams during workup towards potential interventions. Logistic regression parameters were chosen to reflect those with $P<0.1$ on bivariate analysis, including patient age, sex, LVEF, STS PROM score for mitral valve repair, documentation of heart failure symptoms at the time of initial echo, documentation of formal HT evaluation, inpatient setting, history of dementia, and history of myocardial infarction. Rheumatoid arthritis was excluded because of clinical judgment. No patients were missing the above variables and thus no patients were excluded from either the logistic regression or the propensity-score matching analysis. A Cox proportional hazards model was fitted using the same set of covariates as the propensity-score matching as a further sensitivity analysis. Statistical significance was defined as $P<0.05$. Analyses were performed in R version 4.2.2 (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Patient Characteristics

There were 70 510 unique patients who underwent echocardiograms during the study period, of which 391 had severe primary MR. The analysis was conducted on 391 patients with severe primary MR (Figure 1). Among the 391 patients with severe primary MR, the median age was 77 years (interquartile range [IQR], 65–85), and 180 (46%) were women. The echocardiograms were obtained predominately in an

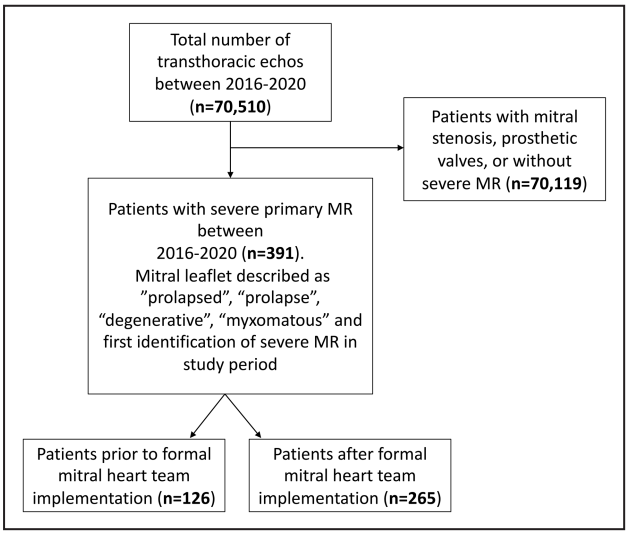

Figure 1. Study flowchart.
This flowchart displays the inclusion criteria for our study and the distribution of patients before and after the implementation of formal mitral heart team. MR indicates mitral regurgitation.

inpatient setting (63%). Patients who did not experience an event had a median of 730 (IQR, 729–730) follow-up days, indicating near-complete follow-up for this 2-year study. The rate of multidisciplinary evaluation increased from 29% to 89% following implementation of formal mitral HT (P<0.001; Figure 2). Compared with patients with severe primary MR before and after the implementation of mitral HT, the patients tended to be younger (median age of 76 years [IQR, 64–83] versus median age of 79 years [IQR, 68–89]), were more commonly men (61% versus 40%), and more frequently had an echocardiogram done in an outpatient setting (46% versus 21%) after the implementation of mitral HT (Table 1).

Before mitral HT implementation, 24% of patients with severe primary MR underwent intervention (n=26 surgery, n=4 TEER), which increased to 75% following mitral HT implementation (n=166 surgery, n=32 TEER). The median days-to-intervention since the index echocardiogram did not significantly change before and after mitral HT implementation (median of 37 days versus median of 51 days, P>0.9). Additionally, the time to surgery did not seem to be associated with repairability of the valve (Tables S1–S4). Following mitral HT implementation, an increased proportion of patients had heart failure symptoms around the time of the initial echocardiogram (83% versus 56%). The LVEF was comparable between both groups before and after implementation of mitral HT, respectively. The median STS predicted 30-day mortality for mitral valve repair was lower following implementation of mitral HT (1.9% [IQR, 0.8%–4.6%] versus 2.9% [IQR, 1.1%–9.3%]; Table 1). To understand the patient triaging, we analyzed the risk profile of patients who did and did not receive multidisciplinary evaluation. The STS predicted risk of 30-day mortality was higher for both evaluated (1.7% versus 1.5%) and unevaluated (4.7% versus 4.0%) patients, after mitral HT implementation (Table 2; Figure 3).

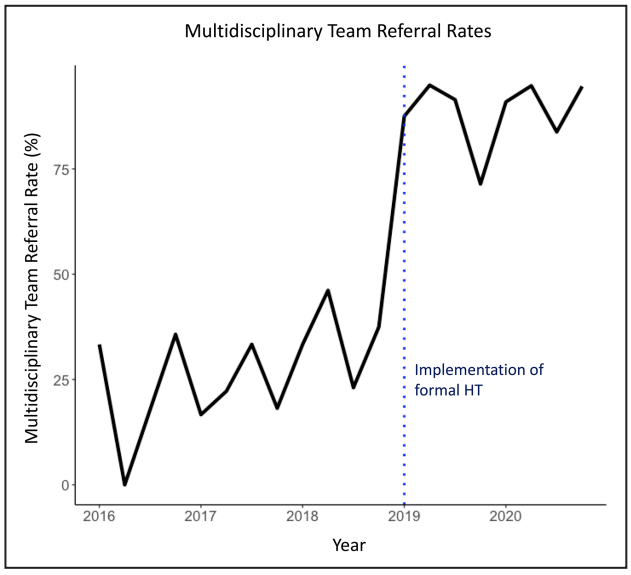

Figure 2. Yearly referral rates.
The rate of referral to a multidisciplinary heart team between the years 2016–2020. The dashed blue line indicates the implementation of a formal mitral heart team in 2019. HT indicates heart team.

Overall Survival

Mortality was lower after the implementation of mitral HT: before implementation, all-cause mortality at 90 days, 1 year, and 2 years was 22%, 29%, and 37%, which decreased to 8.7%, 13%, and 18%, respectively, following mitral HT implementation (P value by log-rank test <0.001; Figures S1–S4).

Propensity-Score Matching

There were 180 patients matched: 90 before and 90 after mitral HT implementation (Table 3). The propensity score variance ratio was 1.06, and the standard mean difference was 0.036, indicating an acceptable match (Figure S2; Table 3). The distribution of propensity scores showed good overlap after matching (Figure S2). A Cox proportional hazards model and mixed effects model were fitted to any remaining unbalanced covariates after propensity-score matching; the hazard ratios associated with peripheral vascular disease were 1.39 and 1.39 (95% CI, 0.75–2.55, P=0.3 and 95% CI, 0.82–2.33, P=0.2), respectively (Table 4; Table S2). Among the matched patients, the Kaplan–Meier curve demonstrated that implementation of mitral HT improved survival for patients with severe primary MR at 30 days (7.8% versus 13%) and 2 years (19% versus 32%) (P value by log-rank test=0.03; Figure 4). Performing sensitivity analysis with less restrictive parameters did not change the results (Table S3; Figure S3). A Cox proportional hazards model was fitted using the same set of covariates as the propensity-score matching as an additional sensitivity analysis; the hazard ratio associated with mitral heart team was 0.63 (95% CI, 0.41–0.96, P=0.03; Table S4).

Multivariable Logistic Regression

On multivariable logistic regression model, implementation of mitral HT and heart failure symptoms were associated with higher odds of undergoing multidisciplinary HT evaluation (OR, 16 [95% CI, 8.25–32.9] and OR, 3.56 [95% CI, 1.74–7.44], respectively). Whereas female sex and older age were associated with lower odds of undergoing multidisciplinary HT evaluation (OR, 0.38 [95% CI, 0.20–0.72] and OR, 0.92 [95% CI, 0.89–0.95], respectively; Table 5).

Table 1. Patient Characteristics, Risk Scores, and Outcomes

Characteristic	Total (N=391)	Pre-mitral HT (n=126)	Post-mitral HT (n=265)	*P* value
Age, y	77 (65–85)	79 (68–89)	76 (64–83)	0.007*
Female	180 (46%)	76 (60%)	104 (39%)	<0.001*
Race				0.03*
White	328 (84%)	104 (83%)	224 (85%)	
Black	32 (8.2%)	16 (13%)	16 (6.0%)	
Other	31 (7.9%)	6 (4.8%)	25 (9.4%)	
Inpatient echocardiogram	248 (63%)	105 (83%)	143 (54%)	<0.001*
Hypertension	245 (63%)	80 (63%)	165 (62%)	0.8
Diabetes	53 (14%)	19 (15%)	34 (13%)	0.5
Prior CABG	10 (2.6%)	3 (2.4%)	7 (2.6%)	>0.9
Heart failure	85 (22%)	32 (25%)	53 (20%)	0.2
PVD	56 (14%)	20 (16%)	36 (14%)	0.5
MI	29 (7.4%)	16 (13%)	13 (4.9%)	0.006*
Atrial fibrillation/flutter	116 (30%)	38 (30%)	78 (29%)	0.9
CVD	52 (13%)	18 (14%)	34 (13%)	0.7
Renal failure	42 (11%)	14 (11%)	28 (11%)	0.9
Liver disease	5 (1.3%)	2 (1.6%)	3 (1.1%)	0.7
Rheumatoid arthritis	8 (2.0%)	6 (4.8%)	2 (0.8%)	0.016*
Dementia	10 (2.6%)	8 (6.3%)	2 (0.8%)	0.002*
Depression	32 (8.2%)	12 (9.5%)	20 (7.5%)	0.5
Cancer	88 (23%)	27 (21%)	61 (23%)	0.7
HF symptoms	291 (74%)	71 (56%)	220 (83%)	<0.001*
MAC				<0.001*
Moderate	43 (11%)	24 (19%)	19 (7.2%)	
Severe	16 (4.1%)	9 (7.1%)	7 (2.6%)	
LVEDD, mm	51 (45–56)	49 (43–54)	51 (46–58)	<0.001*
LA volume, mL/m^2	102 (76–128)	103 (83–125)	96 (75–131)	0.3
LVEF, %	61 (55–66)	61 (54–67)	61 (56–67)	0.7
STS PROM: replacement	4.2 (2.2–8.0)	5.7 (2.4–10.4)	3.8 (2.0–6.7)	0.002*
STS PROM for MV repair	2.1 (0.9–5.5)	2.9 (1.1–9.3)	1.9 (0.8–4.6)	0.004*
Surgical evaluation	272 (70%)	37 (29%)	235 (89%)	<0.001*
Surgery	192 (49%)	26 (21%)	166 (63%)	<0.001*
TEER	36 (9.2%)	4 (3.2%)	32 (12%)	0.004*
Follow-up duration, d	730 (729–730)			
Days to intervention	51 (5–146)	37 (5–146)	51 (5–143)	>0.9

Data are presented as n (%) or median (interquartile range). CABG indicates coronary artery bypass graft; CVD, cerebral vascular disease; HF, heart failure; HT, heart team; LA, left atrial; LVEDD, left ventricular end-diastolic diameter; LVEF, left ventricular ejection fraction; MAC, mitral annular calcification; MI, myocardial infarction; MV, mitral valve; PVD, peripheral vascular disease; STS PROM, Society of Thoracic Surgeons Predicted Risk of Mortality; and TEER, transcatheter edge-to-edge repair. This table summarizes the characteristics, risk scores, and outcomes of the 391 patients with new diagnoses of severe, primary MR between 2016 and 2020. Other indicates race not otherwise captured.

**P* values were statistically significant.

DISCUSSION

Our study evaluated the impact of implementing a formal mitral heart team on survival for patients presenting with primary severe MR within a large healthcare network in the northeastern United States. Key findings of this study are the following: First, the rate of referral to a multidisciplinary heart team for patients with severe primary MR increased substantially from 29% to 89% following the implementation of a formal mitral HT. Second, the proportion of patients undergoing intervention, including mitral valve repair, replacement, or TEER, increased following mitral HT implementation. Finally, patients presenting with severe primary MR, including those with and without mitral valve intervention or operation, had improved overall survival following the implementation of formal mitral HT. Together, these findings provide one of the first evidence behind the

Table 2. Effect of Formal HT Implementation on STS PROM

Characteristic	Pre-formal HT, N=126			Post-formal HT, N=265		
	Unevaluated, n=89	Evaluated, n=37	*P* value	Unevaluated, n=30	Evaluated, n=235	*P* value
STS PROM, median (IQR)	4.0 (1.3–9.8)	1.5 (0.6–4.8)	0.007	4.7 (2.8–8.6)	1.7 (0.8–4.2)	<0.001

HT indicates heart team; IQR, interquartile range; and STS PROM, Society of Thoracic Surgeons Predicted Risk of Mortality. This table displays the STS PROM scores for mitral valve repair for unevaluated and evaluated patients before and after the implementation of formal HT.

current guideline recommendation to adopt formalized, team-based evaluation of patients presenting with mitral valve disease.

This study adds to the literature as there is a lack of data demonstrating the efficacy of a multidisciplinary heart team approach in the evaluation and treatment of patients with mitral valve disease, despite strong guideline recommendations. The guideline recommendation of a multidisciplinary heart team approach for severe primary MR had been based on observational, nonrandomized studies, and expert opinion.[1,8] Within valvular disease, implementation of transcatheter aortic valve replacement programs and multidisciplinary teams was associated with improved survival for patients with severe aortic stenosis, however that study lacks specificity on the rate of referral to multidisciplinary team evaluation.[9] To our knowledge, our study is the first to show that the implementation of a multidisciplinary mitral heart team is associated with improved survival and outcomes of these patients based on a network-wide capturing of patients with severe primary MR.

Following the implementation of a formal mitral HT, both the rate of referral to a multidisciplinary team and the volume of patients with new diagnoses of severe primary MR increased. A report in aortic stenosis patients also observed the number of patients referred to multidisciplinary HT increasing over time, although the increase was not as drastic as the one we observed.[19] The proportion of patients referred from an outpatient setting increased following mitral HT implementation from 21% to 46%, which may reflect a change in referral patterns accompanying formalized mitral HT, American Heart Association center of excellence designation, or with expansion of the outpatient network within the health system.

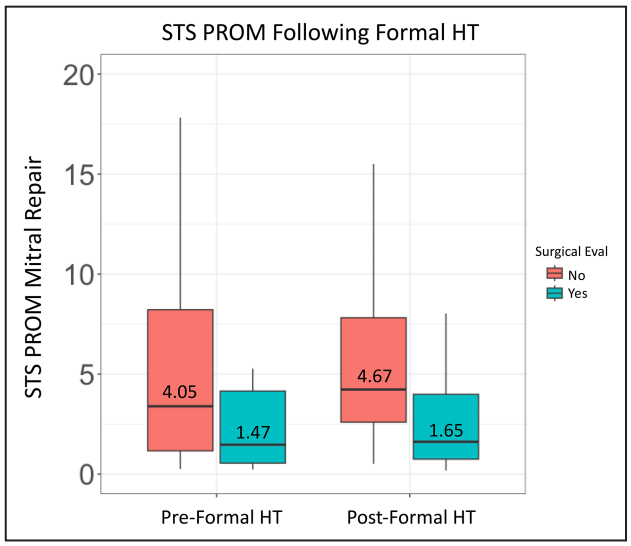

Figure 3. STS PROM scores following formal HT implementation.
The STS PROM scores for patients who were unevaluated (red) and evaluated (blue) by a multidisciplinary team before and after the implementation of formal mitral HT. Eval indicates evaluated; HT, heart team; and STS PROM, Society of Thoracic Surgeons Predicted Risk of Mortality.

Implementation of formal mitral HT substantially increased the proportion of patients undergoing intervention, including surgery and TEER. Additionally, following the implementation of mitral HT, the lowest quartile of STS predicted 30-day mortality for unevaluated patients increased from 1.3% to 2.8%. This indicates possible finer risk-based triaging for multidisciplinary evaluation, with fewer low-risk, potential operative candidates being missed for evaluation and subsequently potential intervention or operation. The time-to-intervention for evaluated patients both before and after mitral HT implementation was prompt, although patients with post-mitral HT had somewhat longer time-to-intervention at 51 days compared with 37 days. The difference in the interval is likely clinically negligible, and the longer interval may be because of waiting for the mitral HT to reach a decision, more workup needed to fully assess TEER candidacy, or the increased volume of patients. Following mitral HT implementation, patients were younger and increasingly referred from an outpatient setting, which may suggest that patients are being referred earlier in the phase of clinical stability following initial detection. Mitral HT implementation coincided with finer risk-based patient triaging where higher proportions of low-risk potential interventional or operative candidates are appropriately referred for multidisciplinary evaluation.

The implementation of a formal mitral HT improved the overall survival of patients with primary severe MR. Providing optimal care for patients with advanced mitral valve disease requires timely detection and referral and navigating an increasing number of treatment options.[20] A multidisciplinary mitral HT standardizes and streamlines these processes through increased adherence to guidelines, increased surgical volume and experience, enhanced decision-making between patients and

Table 3. Patient Characteristics, Risk Scores, and Outcomes After Propensity-Score Matching

Characteristic	Total (N=180)	Pre-mitral HT (n=90)	Post-mitral HT (n=90)	*P* value	Standard mean difference
Age, y	77 (67–87)	77 (68–87)	76 (65–85)	0.4	−0.20
Women	97 (54%)	50 (56%)	47 (52%)	0.5	−0.02
Race				0.6	
White	157 (87%)	78 (87%)	79 (88%)		0.06
Black	14 (7.8%)	6 (6.7%)	8 (8.9%)		0.04
Other	9 (5.0%)	6 (6.7%)	3 (3.3%)		−0.11
Inpatient echocardiogram	145 (81%)	72 (80%)	73 (81%)	0.5	−0.09
Hypertension	109 (61%)	53 (59%)	56 (62%)	1	
Diabetes	27 (15%)	14 (16%)	13 (14%)	0.5	
Prior CABG	4 (2.2%)	3 (3.3%)	1 (1.1%)	0.7	
Heart failure	38 (21%)	21 (23%)	17 (19%)	0.3	
PVD	20 (11%)	14 (16%)	6 (6.7%)	0.04	
MI	15 (8.3%)	8 (8.9%)	7 (7.8%)	0.3	−0.05
Atrial fibrillation/flutter	48 (27%)	26 (29%)	22 (24%)	0.5	
CVD	25 (14%)	10 (11%)	15 (17%)	0.8	
Renal failure	13 (7.2%)	6 (6.7%)	7 (7.8%)	0.6	
Liver disease	1 (0.6%)	1 (1.1%)	0 (0%)	0.3	
Rheumatoid arthritis	6 (3.3%)	5 (5.6%)	1 (1.1%)	0.2	
Dementia	2 (1.1%)	0 (0.0%)	2 (2.2%)	1	0
Depression	16 (8.9%)	7 (7.8%)	9 (10%)	1	
Cancer	38 (21%)	18 (20%)	20 (22%)	0.4	
HF Symptoms	113 (63%)	54 (60%)	59 (66%)	0.6	0.09
MAC				<0.001*	
Moderate	23 (13%)	16 (18%)	12 (13%)		
Severe	9 (5.0%)	7 (7.8%)	2 (2.2%)		
LVEDD, mm	50 (44–54)	50 (45–54)	49 (45–56)	0.2	
LA volume, mL/m^2	103 (82–125)	104 (85–125)	98 (79–118)	0.4	
LVEF, %	61 (54–65)	60 (54–65)	62 (56–65)	0.2	
STS PROM: replacement	4.2 (2.3–8.4)	4.7 (2.4–8.2)	3.9 (2.1–8.6)	0.1	
STS PROM: repair	2.2 (0.9–6.0)	2.2 (1.0–6.6)	1.8 (0.8–5.5)	0.1	−0.07
Surgical evaluation	104 (58%)	30 (33%)	74 (82%)	<0.001*	
Surgery	77 (43%)	22 (24%)	55 (61%)	<0.001*	
TEER	9 (5.0%)	2 (2.2%)	7 (7.8%)	0.05	
Days to follow-up	730 (729–730)				
Days to intervention	24 (0–114)	35 (5–153)	14 (0–87)	0.4	

Data are presented as n (%) or median (interquartile range). CABG indicates coronary artery bypass graft; CVD, cerebral vascular disease; HF, heart failure; HT, heart team; LA, left atrial; LVEDD, left ventricular end-diastolic diameter; LVEF, left ventricular ejection fraction; MAC, mitral annular calcification; MI, myocardial infarction; MV, mitral valve; PVD, peripheral vascular disease; STS PROM, Society of Thoracic Surgeons Predicted Risk of Mortality; TEER, transcatheter edge-to-edge repair. This table summarizes the characteristics, risk scores, and outcomes of the 180 patients after propensity-score matching with new diagnoses of severe, primary MR between 2016 and 2020. Other indicates race not otherwise captured.

**P* values were statistically significant.

Table 4. Cox Proportional Hazards Model on Unbalanced Variables after Propensity-Score Matching

Characteristic	Hazard ratio	95% CI	*P* value
Post-HT implementation (reference=pre-HT)	0.59	0.35–0.99	0.046
PVD	1.39	0.75–2.55	0.3

HT, heart team; and PVD, peripheral vascular disease.

their families, and improved interdisciplinary collaboration.[3,4,21] Additionally, it has been well-established that early intervention is critical for improving survival for patients with primary severe MR.[20,22,23] The implementation of mitral HT substantially increased the proportion of patients undergoing intervention, which likely played a key role in the subsequent improvement in survival. Baseline mortality in both groups was higher than predicted by the STS score. This was likely

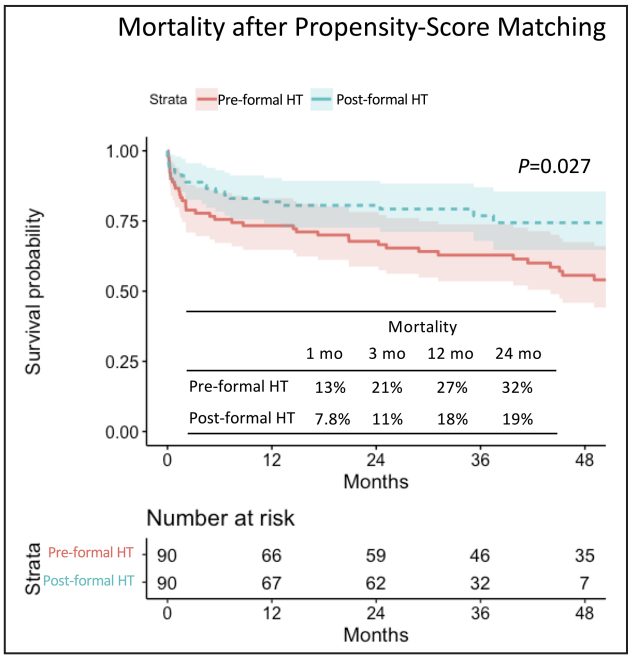

Figure 4. Kaplan–Meier curve after propensity-score matching.
This Kaplan–Meier curve shows the 2-year survival of patients after propensity-score matching before (red) and after (blue) the implementation of a formal mitral heart team. HT indicates heart team.

attributable to multifactorial reasons including the high proportion of inpatient echocardiograms which likely included patients with higher acuity that may not have been comprehensively captured by the STS score or extracted comorbidities. Furthermore, an increasing proportion of patients underwent TEER, which may reflect improved triaging leading to improved overall patient outcomes. Additional factors potentially influencing improved outcomes include changes in the cohort risk profile that were not extracted and the escalation of the robotic mitral program during the same period that potentially attracted patients with a better baseline health status. Despite this, improved mortality following multidisciplinary team evaluation has been seen in other disease entities, including breast cancer, coronary artery disease, and aortic stenosis.[9,13,24] These findings underscore the implementation of formalized mitral heart teams to optimize treatment and outcomes for individual patients.

Our analysis demonstrated that referral to multidisciplinary evaluation depended on patients' factors, in addition to the presence of formalized mitral HT. There was a tendency for lower risk patients or higher level of indication to be referred, such as those of a younger age and with heart failure symptoms. The reason behind female sex having the lowest odds of undergoing multidisciplinary evaluation is unclear but is consistent with prior literature demonstrating sex-based difference in the treatment approach and outcomes of cardiovascular disease.[25,26] This requires further investigation. As the multidisciplinary approach to mitral valve disease gains further emphasis with evolving treatment approaches, it is important to define the optimal triaging pathway and threshold for heart team referral to eliminate care variation and avoid under evaluation of patients who would benefit from multidisciplinary evaluation and possible intervention.

Table 5. Characteristics Associated with Odds of Patient Receiving Multidisciplinary Evaluation

Characteristic	Odds ratio	95% CI	*P* value
Post-HT implementation (reference=pre-HT)	16	8.25–32.9	<0.001*
Women	0.38	0.20–0.72	0.003*
STS PROM mitral repair	0.96	0.90–1.02	0.2
Age (per 1-y increase)	0.92	0.89–0.95	<0.001*
White race (reference)	…	…	…
Black race	0.25	0.07–0.87	0.03*
Other race	0.51	0.15–1.83	0.3*
Heart failure symptom	3.56	1.74–7.44	<0.001*
Ejection fraction (per 1% increase)	1.01	0.98–1.04	0.7
Inpatient echocardiogram	0.36	0.17–0.75	0.008*
History of MI	1.8	0.55–5.84	0.3
History of dementia	1.66	0.19–10.6	0.6

HT indicates heart team; MI, myocardial infarction; and STS PROM, Society of Thoracic Surgeons Predicted Risk of Mortality. This table displays the results from multivariable logistic regression of characteristics associated with evaluation by multidisciplinary heart team. Other indicates race not otherwise captured.
**P* values were statistically significant.

Limitations

This study has several limitations. The single-center nature of this study limits generalizability, however the health system is large and includes a broad range of case settings throughout the state of Connecticut and Rhode Island. Additionally, multidisciplinary heart teams are heterogeneous, and our center's practice may not reflect the structure and deployment of the mitral HT used at other centers. Patients meeting the criteria for our study within our system may have been missed. Limitations of the propensity score matching include the relatively small matched cohort size and variably balanced covariates. The observational nature of this study prevents determining causal relationships. While there are no other obvious significant inter-era alterations to account for these findings, the potential for unaccounted confounders remains present.

CONCLUSIONS

Formal institution of a system-wide mitral HT with experienced mitral valve surgical teams and structural

teams resulted in a drastic reduction in the missed multidisciplinary evaluation for patients with severe primary MR. This implementation coincided with a higher proportion of patients with severe primary MR undergoing mechanical correction of MR. The implementation of mitral HT was associated with an improvement in the overall survival of patients with severe primary MR.

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Supplemental Material

Tables S1–S4
Figures S1–S3

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