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RESEARCH ARTICLE

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Prevalence and survival associated with pulmonary hypertension after mitral valve replacement: National echocardiography database of Australia study

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Abstract

The specific prevalence and outcome of pulmonary hypertension after mitral valve replacement (MVR) is not well documented. The aim of the study was to determine the prevalence and prognostic impact of pulmonary hypertension after MVR. In addition, we sought to determine the threshold of mortality risk according to echocardiography derived pulmonary pressures and those echocardiographic characteristics that are associated with increased mortality. Using the National Echocardiography Database of Australia, patients who had undergone MVR were identified with estimated right ventricular systolic pressure (eRVSP) assessed and linked to patient mortality during mean follow up of 1917 days. Classification and regression tree analysis was used to identify the most powerful predictors of mortality. A total of 10,994 patients who had undergone echocardiography following MVR (mean age 65.2 ± 16, 44.8% women) were studied (mean follow-up 1917 days). The prevalence of PH (defined as eRSVP ≥40 mmHg) was 64.1% (7042/10,994). Severe PH (eRVSP ≥60 mmHg) was seen in 42.3% (4671/10,994). Mortality in individuals with PH was greater than amongst individuals without PH (41.1% vs. 26.3%). Age, tricuspid regurgitation and left ventricular dysfunction were also associated with mortality. There is a high prevalence of PH after MVR which confers an adverse prognosis. Improved therapeutic approaches to mitral valve disease and the subsequent development of PH are essential.

KEYWORDS
cohort study, mitral valve replacement, mitral valve surgery, mortality, pulmonary hypertension

BACKGROUND

Pulmonary hypertension (PH), currently defined by an elevated mean pulmonary artery pressure of ≥25 mmHg during right heart catheterization, may complicate intrinsic abnormalities in the pulmonary vasculature (pulmonary arterial hypertension [PAH]), as well as a myriad of conditions affecting the cardiorespiratory system.[1] While effective therapies are available for PAH, specific treatment for PH complicating left heart disease is lacking.[2] Identification of groups at particular risk is essential to determine more effective therapeutic strategies to prevent development of PH.

PH is a well-recognized consequence of mitral valve disease. The underlying mechanism of PH in this context reflects the initial effects of elevated left atrial pressure and pulmonary vascular congestion. Persisting elevation in left atrial pressure is associated with changes in pulmonary vasculature with concomitant increase in pulmonary vascular resistance and loss of vascular compliance.[3,4] Consequently, PH represents an indication for intervention in asymptomatic patients with mitral valve pathology.[5] Higher degrees of PH preoperatively are associated with poorer outcomes postoperatively.[6–8]

A small observational study has previously reported a high prevalence (64.9%) of preoperative PH in patients undergoing mitral valve replacement (MVR)[7] with the prevalence of persistent PH after MVR noted in small series (42.3%).[9] Small-to-medium sized studies have suggested that mortality rates are higher in patients with PH than those without following MVR irrespective of aetiology.[9–12] Overall, however, the prevalence and prognostic implications of persisting PH after MVR are poorly understood.

STUDY AIMS AND HYPOTHESIS

To address the above-described paucity of data, our primary aim was to utilize the National Echocardiography Database of Australia (NEDA)[13–16] to determine the prevalence and related prognostic impact of PH following MVR. We specifically tested the hypothesis that PH noted after MVR is associated with a poorer prognosis when compared to those individuals with normal pulmonary pressures post MVR. Moreover, we sought to determine if there is a specific threshold of risk for all-cause mortality according to severity of PH based on echocardiographic assessment and identify echocardiographic parameters that independently predict mortality in this context.

MATERIALS AND METHODS

Study design

NEDA is an observational registry utilizing echocardiographic data obtained from participating centers (23 at the time of this study) in Australia with individual linkage to mortality outcomes.[16] Patients included in the cohort are referred from primary care or specialist settings for diagnosis and follow up of underlying cardiac disease. NEDA is registered with the Australian New Zealand Clinical Trials Registry (ACTRN12617001387314).

Study data

Study data comprises echocardiographic measurements and basic demographic profiling (biological sex and date of birth) of individuals and the date of investigation when presenting to participating centers during the study period. All data from each site is then transformed into a standard NEDA format to generate uniform echocardiographic profiling data with removal of duplicate investigations and added to the central NEDA dataset. The NEDA database incorporates a data dictionary and allows for identification of free text items, including clinical comments and conclusions to identify patients who had undergone previous MVR.[17] The indications for MVR were not routinely recorded in follow up examinations. Studies where pulmonary artery pressure was adequately estimated using tricuspid regurgitant velocity (TRV) were used for analysis. In keeping with previous reports,[13] estimated right ventricular systolic pressure (eRVSP) was determined using the modified Bernoulli equation and assuming constant right atrial pressure of 5 mmHg ($eRVSP = 4TRV^2 + RAP$).[18] PH was graded as normal (eRVSP <30 mmHg), borderline (eRVSP 30–39 mmHg), mild (eRVSP 40–49 mmHg), moderate (eRVSP 50–59 mmHg) and severe (eRVSP ≥60 mmHg).

Study cohort

During the period 29/05/1985 to 26/6/2019 the NEDA dataset comprised a total of 1,077,145 echocardiograms derived from 332,397 men (aged 60.1 ± 18.7 years) and 299,517 women (aged 60.1 ± 16.9 years). After excluding those aged <18 years, investigated before 2000 and without MVR, a total of 10,994 adults underwent MVR during the study period and were identified (Figure 1).

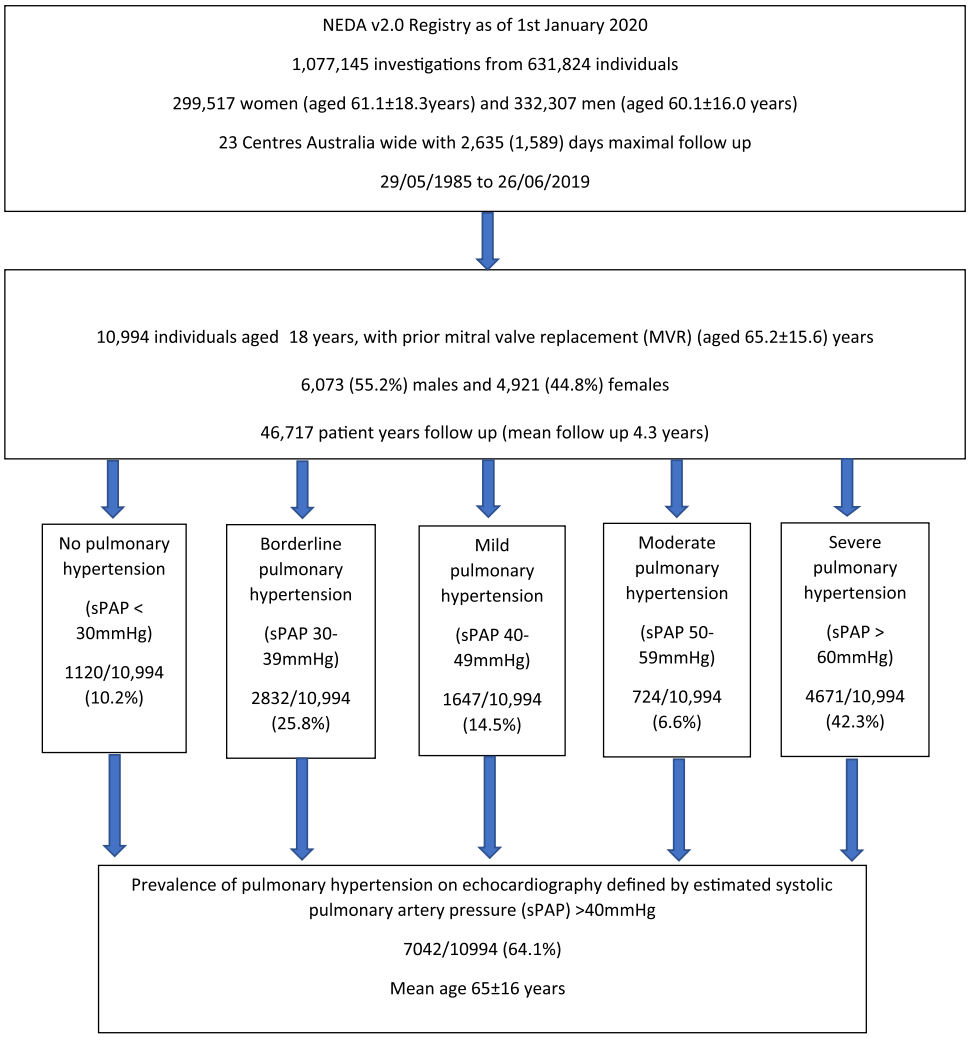

FIGURE 1 Consort diagram

Study follow-up

Individual data-linkage to the Australian National Death Index starting from the date of the last recorded echocardiogram to a census date of 21/5/2019 was performed. The listed causes of death were categorized according to ICD-10 coding. Consistent with previous study,[13,19] all ICD-10AM chapter codes I00-I99 recorded as the primary cause of death were categorized as a cardiovascular-related death.

Statistical analysis

Baseline demographics, echocardiography parameters and mortality were collected prospectively and reported using simple descriptive methods (mean [±SD], median [interquartile range, IQR], or proportions as appropriate). No formal calculations of study power were performed given the large number of individuals, patient-years of follow-up and death. Unless otherwise specified, between-group comparisons were performed using Student's *t* tests, Mann–Whitney *U* tests and Chi-square tests (with calculation of odd ratios and 95% confidence intervals [CIs]) as appropriate). Post hoc analysis was further performed to detect the difference between two particular groups using Kruskal–Wallis *H* test. Survival analysis was performed to analyse potential differences among those with echocardiographic evidence of PH versus those without echocardiographic evidence of PH and then conventional categories of increasing PH severity by echocardiography-derived sRVSP. The level of significance was set at a two-sided *p* value of <0.05. Cox proportional hazard models were used given the complete nature of mortality data to derive hazard ratios adjusted for age. Logistic regression analysis was used to analyse the effect of eRVSP as a continuous variable.

Classification and regression tree (CART) analysis was chosen to identify important predictors of survival time after MVR. CART analysis was used for detailed assessment of echocardiographic parameters to overcome limitations of missing data. Primary splits were defined by the variable with the greatest level of model improvement. Employing surrogate splits at each node accounted for missing predictor data and minimized information loss by allowing individuals with missing data for the current splitting variable to be carried down to the next node using cut-off values of other predictors and remain in the analyses. A full tree was initially grown using recursive partitioning, where all 30 possible predictors were included in the tree and the complexity parameter (*cp*) was set to zero; the minimum (10-fold) cross-validation error and corresponding standard error (SE) were identified. The sum of the two was calculated and the smallest number of node splits with a cross-validation error less than this sum was chosen. This *1-SE* rule was utilized to obtain an optimal *cp* value, related to the selected number of splits. The full tree was subsequently pruned using this optimal *cp* parameter and number of splits to create an appropriate tree size and outline important predictors. Individuals were characterized into new groups based on cut-off values of the predictors, each with their own relative risk and survival estimates. The pruned tree was subsequently mapped. Bootstrap aggregation was used to create multiple regression tree replicates and investigate model stability. Integrated Brier scores were calculated for both single tree and bootstrap models to determine and compare predictive accuracy. The Brier score ranges from 0 to 1; the lower the value the more accurate the prediction model. Statistical analyses were conducted using STATA/SE 14.2 and R version 4.0.4 (R Core Team [2021]. *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria); *rpart* package was employed to conduct regression tree analysis (Terry Therneau & Beth Atkinson [2019]. *rpart: Recursive Partitioning and Regression Trees*. R package version 4.1–15).

CART analysis was used to identify the most powerful predictors of mortality. CART analyses of 105 possible anthropometric and echocardiographic variables identified 38 as possible contributors to survival time and mortality. The list of 30 variables for use in the regression tree included age at echocardiograph, biological sex, body mass index, body surface area, left atrium area, left atrium area (two chamber view), left atrium volume, left ventricular diastolic diameter (parasternal long-axis view), left ventricular ejection fraction, mitral valve E-wave/A-wave velocity ratio, mitral valve area (pressure half time), mitral valve mean gradient, mitral valve mean velocity, mitral valve peak gradient, mitral valve peak velocity, mitral valve velocity time integral, pulmonary artery systolic pressure (PASP), right atrial pressure, tricuspid regurgitation (TR) peak gradient, right atrial dilation, right ventricular dilation, mechanical mitral valve, paravalvular leak, right ventricular impairment, mitral regurgitation, right ventricular size, right ventricular function, right atrial size and heart rhythm. Weight, height, right ventricular systolic pressure, TR peak velocity, mitral valve A-wave point velocity and mitral valve E-wave point velocity had been used to calculate other relevant predictors and were subsequently dropped from inclusion in the regression tree analyses of survival time due to correlation.

RESULTS

Cohort characteristics

Table 1 summarizes the study cohort of 10,994 cases according to the degree of eRVSP. The mean age was 65.2 ± 16 years ± 15.6 years. Women comprised 44.8% (4921) of the study population. Residual moderate and severe mitral valve incompetence was infrequent, noted in 5.7% and 3.3% of the total cohort, respectively. There were no significant differences with regard to left heart echocardiographic parameters, with similar left ventricular sizes and systolic function noted across each grade of PH severity. Mitral valve inflow velocities were similar across each group, consistent with similar valve function in each group of patients. Right ventricular size and function did not differ across groups.

Prevalence of PH post-MVR

Of the total cohort, 1120/10,994 (10.2%) had normal resting pulmonary artery pressure, with borderline PH seen in 2832/10,994 (25.6%). The prevalence of PH, as defined by eRVSP ≥40 mmHg, was 64.1% (7042/10,994). Within the total study population, 1647 (14.5%) had mild PH, 724 (6.6%) had moderate PH and 4671 (42.3%) had severe PH.

There were no significant differences with regard to left heart echocardiographic parameters, with similar left ventricular sizes and systolic function noted across each grade of PH severity. Mitral valve inflow velocities were similar across each group, consistent with similar valve function in each group of patients. Right ventricular size and function did not differ across groups.

TABLE 1 Baseline characteristics

	Study cohort ($n = 10,994$)	eRVSP <30 mmHg ($n = 1120$)	eRVSP 30–39 mmHg ($n = 2832$)	eRVSP 40–49 mmHg ($n = 1647$)	eRVSP 50–59 mmHg ($n = 724$)	eRVSP >60 mmHg ($n = 4671$)	p value
Demographic profile							
Age, years	65.2 (15.6)	59.5 (16.9)	65.7 (15.0)	70.5 (13.6)	71.8 (12.5)	63.4 (15.8)	<0.001
Female	4921 (44.8)	479 (9.7)	1262 (25.7)	821 (16.7)	382 (7.8)	1977 (40.2)	<0.001
Anthropometrics							
Body mass index, kg/m^2	26.8 (5.59)	25.8 (4.8)	26.5 (5.2)	27.0 (5.8)	27.2 (6.5)	27.1 (5.8)	<0.001
Body surface area, m^2	1.89 (0.255)	1.87 (0.24)	1.88 (0.24)	1.86 (0.25)	1.85 (0.27)	1.91 (0.26)	<0.001
Left ventricular dimensions and function							
LVEDD, cm	4.89 (0.857)	4.81 (0.76)	4.91 (0.79)	5.06 (0.89)	5.11 (0.89)	4.80 (0.89)	<0.001
LVEF, %	54.2 (14.1)	54.4 (12.1)	54.8 (13.6)	53.3 (15.5)	54.0 (16.3)	54.1 (14.0)	0.164
E-wave velocity (m/s)	1.49 (0.42)	1.28 (0.37)	1.43 (0.37)	1.62 (0.39)	1.74 (0.42)	1.49 (0.46)	<0.001
E/A ratio	1.41 (0.94)	1.29 (0.99)	1.33 (0.93)	1.68 (1.10)	1.87 (1.29)	1.36 (0.72)	<0.001
Atrial dimensions							
LA volume index, ml/m^2	71.9 (49.3)	48.6 (31.4)	63.6 (40.5)	85.8 (54.9)	96.4 (57.1)	68.0 (49.8)	<0.001
RA area, cm^2	24.0 (0.9)	20.5 (8.6)	22.3 (9.1)	27.3 (10.5)	29.5 (10.1)	22.0 (9.4)	<0.001
Pulmonary pressures							
sPAP, mmHg	41 (12.8)	26.7 (2.9)	35.0 (2.8)	44.5 (2.8)	54.5 (2.9)	71.9 (10.4)	<0.001
eRVSP, mmHg	36 (12.8)	21.7 (2.9)	30.0 (2.8)	39.5 (2.8)	49.5 (2.9)	66.9 (10.4)	<0.001
TR peak velocity, cm/s	2.73 (0.5)	2.03 (0.2)	2.50 (0.1)	2.93 (0.1)	3.33 (0.1)	3.92 (0.3)	<0.001
Right heart size and function							
RA size (data available)	(4287)	(519)	(1387)	(781)	(320)	(1280)	<0.001
Normal	2163 (19.7)	351 (31.3)	695 (24.5)	285 (17.3)	60 (8.3)	772 (16.5)	
Mild	1094 (10.0)	101 (9.0)	404 (14.3)	214 (13.0)	98 (13.5)	277 (5.9)	
Moderate	708 (6.4)	33 (2.9)	207 (7.3)	203 (12.3)	116 (16.0)	149 (3.2)	
Severe	322 (2.9)	34 (3.0)	81 (2.9)	79 (4.8)	46 (6.4)	82 (1.8)	
RV size (data available)	(7045)	(820)	(2042)	(1193)	(515)	(2475)	0.53
Normal	5050 (45.9)	623 (55.6)	1537 (54.3)	748 (45.4)	258 (35.6)	1884 (40.3)	
Mild	1201 (10.9)	123 (11.0)	346 (12.2)	264 (16.0)	130 (18.0)	338 (7.2)	
Moderate	564 (5.1)	48 (4.3)	116 (4.1)	142 (8.6)	90 (12.4)	168 (3.6)	
Severe	230 (2.1)	26 (2.3)	43 (1.5)	39 (2.4)	37 (5.1)	85 (1.8)	

(Continues)

TABLE 1 (Continued)

	Study cohort ($n = 10,994$)	eRVSP <30 mmHg ($n = 1120$)	eRVSP 30–39 mmHg ($n = 2832$)	eRVSP 40–49 mmHg ($n = 1647$)	eRVSP 50–59 mmHg ($n = 724$)	eRVSP >60 mmHg ($n = 4671$)	p value
RV impairment (data available)	(4684)	(596)	(1454)	(696)	(271)	(1667)	<0.001
Normal	4072 (37.0)	543 (48.5)	1297 (45.8)	587 (35.6)	199 (27.5)	1446 (31.0)	
Mild	358 (3.3)	32 (2.9)	104 (3.7)	68 (4.1)	40 (5.5)	114 (2.4)	
Moderate	165 (1.5)	11 (1.0)	38 (1.3)	30 (1.8)	23 (3.2)	63 (1.3)	
Severe	89 (0.8)	10 (0.9)	15 (0.5)	11 (0.7)	9 (1.2)	44 (0.9)	
Tricuspid regurgitation (data available)	(4482)	(330)	(1354)	(1075)	(536)	(1187)	<0.001
Mild	2382 (53)	198 (60)	903 (67)	576 (54)	213 (40)	492 (41)	
Moderate	1327 (30)	52 (16)	322 (24)	354 (33)	212 (40)	387 (33)	
Severe	768 (17)	80 (24)	128 (9)	143 (13)	120 (20)	307 (26)	

Note: Values are mean (*SD*), %, or *n* (%).

Abbreviations: eRVSP, estimated right ventricular systolic pressure; LA, left atrium; LVEDD, left ventricular end diastolic diameter; LVEF, left ventricular ejection fraction; RA, right atrium; RV, right ventricle; sPAP, systolic pulmonary artery pressure; TR, tricuspid regurgitation.

Survival according to presence and severity of PH

During median follow up of 1917 (IQR: 1040–3444) days (representing 46,717 patient-years). A total of 3933/10,994 (35.8%) individuals had died. All-cause mortality among individuals with post MVR PH was significantly greater than amongst individuals without PH 41.1% (2894/7074) versus 26.3% (1039/3952), $p < 0.001$) (Figure 2).

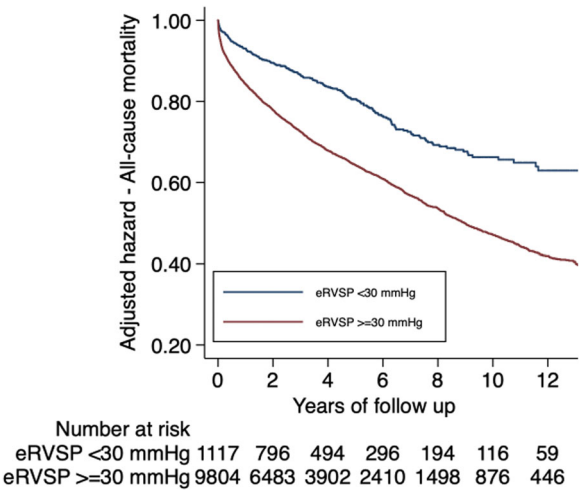

FIGURE 2 Survival according to presence pulmonary hypertension

On an age and sex adjusted basis, there was an increased risk of mortality associated with increasing PH, including those with only mild elevation in pulmonary artery pressures. The adjusted hazard ratios for mortality were 1.63 for mild PH, 2.4 for moderate PH, and 1.71 for severe PH. Ten-year survival curves confirm the development of any degree of PH compared to normal pulmonary pressure is associated with an increased risk of mortality (Figure 3). Table 2 outlines the risk for mortality at different time points, 1, 5, and 10 years, during follow up according to the severity of PH. Further analysis of eRVSP as a continuous variable using logistic regression demonstrated for each 1 mmHg increase in eRVSP the odds ratio for death at 1 year was 1.05 ($p < 0.001$; 95% CI: 1.04–1.05) and at 5 years was 1.05 ($p < 0.001$; 95% CI: 1.04–1.05).

Predictors of outcome

According to the CART analysis age, eRVSP >46 mmHg and moderate to severe TR were all associated with poor outcome (Appendix S1). Age >68.5 years was the most important predictor, with PASP followed by the presence of tricuspid incompetence noted to the next most predictive for mortality; those with all 3 factors had a median survival time of only 348 days, whereas those without

any of these factors had median survival of up to 4827 days. Individuals aged less than 62 years with low estimated PASP had the highest estimated survival probability over time. Left ventricular function (EF < 44%) was also a strong negative predictor. The Brier score for the integrated model was 0.13 indicating good fit and calibration. The survival probabilities for each of the CART classes are shown in Appendix S2.

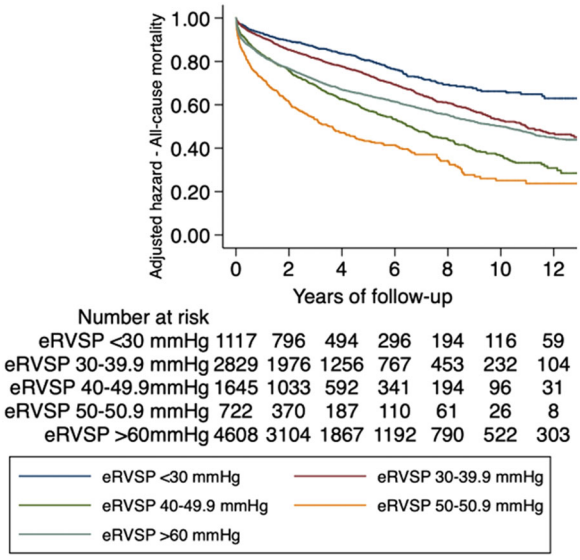

FIGURE 3 Survival according to severity pulmonary hypertension

DISCUSSION

To our knowledge, we report on the largest study of postoperative PH in MVR patients with detailed echocardiographic data linked to long term mortality. Specifically, among more than 10,000 patients undergoing MVR we documented a high prevalence of postoperative PH (64.1%). Critically, any degree of PH after MVR was associated with higher risk of subsequent mortality, with those patients with moderate and severe PH, representing 48.9% of PH cases, being most at risk. Elevated pulmonary pressures, older age, impaired left ventricular function and TR were also associated with higher predicted mortality.

While PH complicating left sided heart disease is known to be associated with worse outcomes,[20] the current study focused specifically on the mortality risk conferred by the presence of PH after MVR. Following MVR, cardiac remodeling occurs with significant reduction in chamber sizes[21] and reported improvement in pulmonary artery pressures.[7,22] However, the reported prevalence of persistent PH after MVR noted in small series remains significant (42.3%).[7] Left ventricular parameters were similar across the spectrum of PH severity in this cohort; this may reflect the likely heterogenous nature of mitral valve pathology included. Previously published predictors of persistent PH include older age, female sex, severe preoperative PH (systolic pulmonary artery pressure >60 mmHg), significant TR and smaller prosthesis size.[7] Moreover, patient-prosthesis

TABLE 2 Survival profile and adjusted risk for mortality according to severity of pulmonary hypertension

	1-year mortality	5-year mortality	10-year mortality	All fatal events
All individuals ($n = 10{,}994$)	1629 (14.8%)	3188 (29%)	3790 (34.47%)	3933 (35.77%)
No PH (<30 mmHg) ($n = 1120$)	79 (7.05%) Reference	174 (15.54%) Reference	223 (19.91%) Reference	229 (20.45%) Reference
Borderline PH (30–39.9 mmHg) ($n = 2832$)	250 (8.83%) HR: 1.10 (95% CI: 0.85–1.43)	602 (21.26%) HR: 1.12 (95% CI: 0.95–1.33)	783 (27.65%) HR: 1.12 (95% CI: 0.96–1.09)	810 (28.60%) HR: 1.13 (95% CI: 0.97–1.31)
Mild PH (40–49.9 mmHg) ($n = 1647$)	279 (16.94%) HR: 1.94 (95% CI: 1.50–2.51)	582 (35.34%) HR: 1.74 (95% CI: 1.47–2.07)	688 (41.77%) HR: 1.62 (95% CI: 1.38–1.89)	705 (42.81%) HR: 1.63 (95% CI: 1.40–1.89)
Moderate PH (50–59.9 mmHg) ($n = 724$)	202 (27.9%) HR: 3.34 (95% CI: 2.56–4.36)	356 (49.17%) HR: 2.74 (95% CI: 2.28–3.29)	392 (54.14%) HR: 2.42 (95% CI: 2.05–2.86)	394 (54.42%) HR: 2.40 (95% CI: 2.03–2.83)
Severe PH (>60 mmHg) ($n = 4671$)	817 (17.49%) HR: 2.40 (95% CI: 1.90–3.04)	1474 (31.56%) HR: 1.93 (95% CI: 1.65–2.26)	1704 (36.48%) HR: 1.71 (95% CI: 1.49–1.97)	1795 (38.43%) HR: 1.71 (95% CI: 1.48–1.96)

Abbreviations: CI, confidence interval; HR, hazard ratio; PH, pulmonary hypertension.

mismatch is associated with worsening severity of postoperative PH and higher mortality.[7] Small-to-medium sized studies have showed that mortality was higher in patients with PH than those without following MVR.[7,23,24] This study confirms the adverse prognosis seen with any degree of PH. As such, there is no apparent threshold below which PH does not confer a mortality hazard. These data are supported by similar population-based observations demonstrating a prognostic influence of even mild increases in pulmonary pressures.[13] Patients with moderate PH appeared to have a worse outcome than patients with severe PH; this may reflect the relatively smaller number of patients with moderate PH in the cohort, however, the effect of right ventricular dysfunction and TR on PH assessment may underestimate the severity of PH when assessed by echocardiography.[25] The adverse influence of residual TR on outcome likely reflects the result of annular dilatation in the presence of right ventricular dysfunction, noting limitations in right ventricular assessment by echocardiography.[26] Of note, it is well documented that right ventricular function can be preserved during a latent period of adaption in the setting of progressive PH.[27] As noted in this cohort, PH can be observed in the presence of normal left and right ventricular parameters after MVR; this highlights the need for vigilance in echocardiographic assessment after MVR to document the presence of PH which may reflect the underlying valvular disease and progressive pulmonary vascular remodeling despite apparent successful treatment of underlying mitral valve pathology.

While endothelin has been implicated in the development and severity of PH complicating left sided heart disease,[28] the use of pulmonary vasodilator therapy targeting endothelin pathways has been disappointing.[29] Similarly, the use of sildenafil did not improve outcomes in those with PH after corrective valvular surgery.[30] While existing pharmacotherapeutic agents are clearly of limited benefit in the setting of PH complicating left heart disease, recognition of ongoing contributors to PH is nonetheless important as there may be a degree of reversibility with correction of underlying haemodynamic substrate.[31] Therefore, recognition of residual mitral and tricuspid valve pathology may allow for the use of surgical or transcatheter techniques to address residual valve dysfunction.[32] Given the significant prevalence and poor outcomes of PH after MVR and lack of efficacy of pulmonary vasodilator pharmacotherapy,[2] there is an unmet need to identify opportunities to prevent the development of PH; there may be an opportunity to reconsider existing guidelines regarding the timing of mitral valve intervention with early surgery potentially preventing maladaptive pulmonary vascular responses. Furthermore, preservation of mitral valve structure following mitral valve repair may also limit left atrial remodeling and subsequent PH. The long-term nature of this dataset likely includes an important proportion of patients who would now undergo mitral valve repair, rather than MVR.

This study is limited by the lack of data on timing of valve intervention, indication for valve replacement and specific details that would allow for assessment of patient-prosthesis mismatch and pulmonary vascular resistance. Additionally, patient comorbidities, operative data and subsequent pharmacotherapy were not available, which may contribute to patient outcome and mortality. Finally, data from multiple echocardiograms from a single patient were not analysed to further evaluate any influence of change in PH on risk of mortality. Nonetheless, the study size offers important insights into prognosis of PH in patients with mitral valve disease. The nature of the NEDA database is such that individual images were not reviewed with respect to eRVSP and mitral valve function assessment. Imaging data further relies on the accuracy of physician interpretation and the reported cause of death according to ICD-10 coding. NEDA is not linked to pathology databases, such that information on hematological and biochemical parameters is not feasible. As right atrial pressure was assumed to be 5 mmHg in all patients to avoid variability in assessment, there is the possibility of underestimation of the prevalence of PH and accompanying threshold of risk.

CONCLUSIONS

Persistent PH in patients undergoing MVR is common and associated with increased mortality. Further study is required to determine if strategies of early valve intervention and use of mitral valve repair can modify the risk of developing PH and concomitant mortality.

AUTHOR CONTRIBUTIONS

All authors contributed to the design, analysis, data interpretation, manuscript collation, review and revision of the article.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

ETHICS STATEMENT

Ethical approval has been obtained from all relevant Human Research Ethics Committees and the study adheres to the Declaration of Helsinki and the Reporting of studies Conducted using Observational Routinely-collected health Data (RECORD) Statement.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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