Circulation

ORIGINAL RESEARCH ARTICLE

Contemporary Presentation and Management of Valvular Heart Disease

The EURObservational Research Programme Valvular Heart Disease II Survey

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et al

BACKGROUND: Valvular heart disease (VHD) is an important cause of mortality and morbidity and has been subject to important changes in management. The VHD II survey was designed by the EURObservational Research Programme of the European Society of Cardiology to analyze actual management of VHD and to compare practice with guidelines.

METHODS: Patients with severe native VHD or previous valvular intervention were enrolled prospectively across 28 countries over a 3-month period in 2017. Indications for intervention were considered concordant if the intervention was performed or scheduled in symptomatic patients, corresponding to Class I recommendations specified in the 2012 European Society of Cardiology and in the 2014 American Heart Association/American College of Cardiology VHD guidelines.

RESULTS: A total of 7247 patients (4483 hospitalized, 2764 outpatients) were included in 222 centers. Median age was 71 years (interquartile range, 62–80 years); 1917 patients (26.5%) were ≥80 years; and 3416 were female (47.1%). Severe native VHD was present in 5219 patients (72.0%): aortic stenosis in 2152 (41.2% of native VHD), aortic regurgitation in 279 (5.3%), mitral stenosis in 234 (4.5%), mitral regurgitation in 1114 (21.3%; primary in 746 and secondary in 368), multiple left-sided VHD in 1297 (24.9%), and right-sided VHD in 143 (2.7%). Two thousand twenty-eight patients (28.0%) had undergone previous valvular intervention. Intervention was performed in 37.0% and scheduled in 26.8% of patients with native VHD. The decision for intervention was concordant with Class I recommendations in symptomatic patients with severe single left-sided native VHD in 79.4% (95% CI, 77.1–81.6) for aortic stenosis, 77.6% (95% CI, 69.9–84.0) for aortic regurgitation, 68.5% (95% CI, 60.8–75.4) for mitral stenosis, and 71.0% (95% CI, 66.4–75.3) for primary mitral regurgitation. Valvular interventions were performed in 2150 patients during the survey; of them, 47.8% of patients with single left-sided native VHD were in New York Heart Association class III or IV. Transcatheter procedures were performed in 38.7% of patients with aortic stenosis and 16.7% of those with mitral regurgitation.

CONCLUSIONS: Despite good concordance between Class I recommendations and practice in patients with aortic VHD, the suboptimal number in mitral VHD and late referral for valvular interventions suggest the need to improve further guideline implementation.

The full author list is given on page 1167.

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Clinical Perspective

What Is New?

- Recommendations for interventions in symptomatic patients with severe valve disease are better applied than in the previous European survey conducted in 2001, particularly for aortic valve disease.
- Multimodality imaging is now more frequently used, but stress testing remains underused in asymptomatic patients.
- Transcatheter therapies are now widely used in patients with stenotic valve disease.

What Are the Clinical Implications?

- Late referral for interventions shows the need for increasing awareness of valvular heart disease by general practitioners and cardiologists.
- The high burden of elderly patients highlights the need for a multidisciplinary heart team approach to assess the risk–benefit ratio of the different modalities of valvular interventions.
- Echocardiographic quantification of regurgitations should be more accurate and pay more attention to quantitative measurements.

Valvular heart disease (VHD) affects >2% of the population and is associated with increased mortality.[1] Its treatment relies mainly on valvular interventions, which have been subject to important changes. The first Euro Heart Survey (EHS) on VHD was conducted in 2001 and provided information on the presentation and management of VHD at that time.[2] Since then, however, a number of important changes have affected the management of VHD such as the successive release of specific guidelines in Europe and in the United States, the introduction of less invasive transcatheter techniques, and the introduction of a multidisciplinary heart team approach and of Heart Valve Centers of Excellence. However, there has been no large-scale evaluation of the impact of these changes on the current management of VHD. Large national or international registries are now available but focus mainly on transcatheter techniques and do not capture the management process in the whole spectrum of VHD.[3–6]

The EURObservational Research Programme (EORP) of the European Society of Cardiology (ESC) conducted the VHD II survey in 2017 with the aim of analyzing the management of patients with severe native VHD or previous valvular intervention and to compare these practices with the latest VHD guidelines at that time, published in the 2012 by the ESC/European Association of Cardiothoracic Surgery and in 2014 by the American Heart Association/American College of Cardiology,[7,8] as well as to evaluate changes since the EHS in 2001.[2]

METHODS

Study Design

The VHD II survey is an international prospective, multicenter, observational study. All the National Cardiac Society members of the ESC were invited to participate. Participating centers were accepted on a voluntary basis through appointment by national coordinators. Centers in the same geographic area were grouped into clusters including a variety of sites (university, public, and private centers with or without onsite cardiac surgery or interventional cardiology) to ensure broad representation. The number of centers and clusters was determined by EORP according to country size. The data, analytical methods, and study materials will be available on reasonable request.

The recruitment period was 3 months for each center, with no limit to the maximum number of patients enrolled. Recruitment began on January 16, 2017, and ended on August 28, 2017, immediately before publication of the revised ESC/European Association of Cardiothoracic Surgery guidelines on VHD to capture an accurate picture of clinical practice in advance of the guideline update. Six-month follow-up was planned, either during a patient visit or by contact with the treating physician or the patient. Data collected at 6 months were vital status, hospitalizations for cardiac reasons, and the performance of a new valvular intervention.

The primary end point was the final therapeutic decision for surgical or transcatheter intervention determined during the index hospitalization or outpatient visit.

When required, the study was approved by each national or regional ethics committee or Institutional Review Board, according to local regulations. Written informed consent was obtained from all participants. Drug prescription and indications for diagnostic/therapeutic procedures were left to the discretion of the attending physician. Baseline data were collected with a web-based electronic case report form. For patients undergoing intervention during the study period, the type of intervention performed and in-hospital outcome, including mortality, were collected. The survey was overseen by an Executive Committee and managed by the EORP department of the ESC, which was also responsible for study management, data quality control, and statistical analyses.

Patients

The screened population consisted of patients with severe native VHD as defined by echocardiography using an integrative approach according to guidelines[7,8] or patients with any previous surgical or transcatheter valvular intervention, including percutaneous dilatation. Investigators were asked to include all consecutive hospitalized patients and a complete sample of outpatients presenting to the outpatient clinic 1 day each week (as selected by the center).

Patients were included if they fulfilled the following criteria: signed informed consent, age ≥18 years, severe native VHD, or previous valvular intervention. Exclusion criteria were acute infective endocarditis, enrollment in a valve intervention study affecting management, and VHD related to complex congenital heart disease.

Classification of VHD

Single left-sided VHD was defined as severe VHD affecting a single valve without concomitant moderate or severe VHD on the other ipsilateral valve and subclassified as aortic stenosis (AS), aortic regurgitation (AR), mitral stenosis (MS), or mitral regurgitation (MR). The association of severe left-sided native VHD with a moderate or severe VHD lesion on the other ipsilateral valve (according to echocardiographic criteria) was classified as multiple left-sided VHD. Isolated right-sided VHD was defined as severe tricuspid or pulmonary VHD without any severe left-sided VHD. Patients presenting with native VHD who had undergone a previous valvular intervention on another valve were classified in the previous valvular intervention group to avoid double counting.

Statistical Analysis

Descriptive analyses were performed. Continuous variables were reported as median and interquartile range and categorical variables as percentages. Comparisons between groups were performed with a χ^2 test for categorical variables and a Kruskal-Wallis test for continuous variables. Survival rates at 6 months were assessed with the Kaplan–Meier method and given with their 95% CIs.

Concordance with guidelines was analyzed in patients with AS and a mean gradient >40 mm Hg, severe AR, MS with a valve area ≤1.5 cm^2 or mean gradient >5 mm Hg, and severe primary MR and expressed by the percentage of patients (with 95% CI) in whom intervention was performed or scheduled among symptomatic patients, which corresponds to conditions fulfilling Class I recommendations for intervention according to both 2012 ESC/European Association of Cardiothoracic Surgery and 2014 American Heart Association/American College of Cardiology guidelines.[7,8] This analysis was also performed according to the type of center.

A 2-sided value of $P<0.05$ was considered statistically significant. All analyses were performed with SAS statistical software version 9.4 (SAS Institute Inc, Cary, NC).

RESULTS

Enrollment

Twenty-eight ESC countries participated in the VHD II survey. A total of 222 active centers grouped into 108 clusters included 7247 patients (Appendix I in the online-only Data Supplement); 4483 were inpatients and 2764 were outpatients. Reasons for inclusions are detailed in Table I in the online-only Data Supplement. The majority of patients with native VHD (75.4%) were referred because of a change in clinical status, complications, or need for diagnostic evaluation.

The distribution of the types of centers is detailed in Figure I in the online-only Data Supplement. A cardiac surgery department was present in 60.7% of centers, and 85.2% of centers had at least 1 cardiac catheterization laboratory.

The numbers of patients enrolled were 2418 (33.4%), 2095 (28.9%), 2013 (27.8%), and 503 (6.9%) for Eastern, Western, Southern, and Northern Europe, respectively, and 218 (3.0%) in North Africa, according to the classification of United Nations. Inclusions per country are detailed in Appendix I in the online-only Data Supplement.

Patients

The overall median age was 71 years (interquartile range, 62–80 years); 1917 patients (26.5%) were ≥80 years of age; 3416 were female (47.1%); and the median EuroSCORE II score was 2.1 (interquartile range, 1.1–4.3). Patient characteristics are detailed in Table 1.

Among the 5219 patients with native VHD, 3779 (72.4%) had single left-sided native VHD: AS was most frequent (2152 patients, 41.2% of native VHD), followed by MR (1114 patients, 21.3%; primary MR in 746 and secondary MR in 368), AR (279 patients, 5.3%), and MS (234 patients, 4.5%). Multiple left-sided VHD was present in 1297 patients (24.9% of native VHD), and isolated right-sided VHD was seen in 143 (2.7% of native VHD). The causes of left-sided native VHD are summarized in Figure 1. Overall, 67.8% of native VHD was of degenerative pathogenesis, followed by rheumatic heart disease in 11.8%. Of the 368 patients with secondary MR, 190 (51.6%) were classified as having ischemic MR and 178 (48.4%) as having nonischemic MR.

Of the 2028 patients who had previously undergone ≥1 valvular interventions, there were 1665 surgical valve replacements, 622 surgical valve repairs, and 335 transcatheter interventions (including 110 percutaneous dilatations).

Patient characteristics and management are detailed according to the 5 regions for patients with native valve disease (Table 2) and for patients with previous valve surgery (Table II in the online-only Data Supplement). Inpatient and outpatient characteristics and management are detailed in Table III in the online-only Data Supplement.

Investigations

Investigations are described in Table 3. Stress tests were used in <5% of all patients and <10% of patients in New York Heart Association class I. Cardiac catheterization was used in 5% to 10% of patients (7.5% in the whole population). The most frequent reasons for performing cardiac computed tomography were an evaluation before transcatheter aortic valve replacement (TAVR; 78% of patients with AS) and assessment of the ascending aorta (94% of patients with AR). The results of transthoracic echocardiography for patients with single left-sided native VHD are detailed in Table IV in the online-only Data Supplement.

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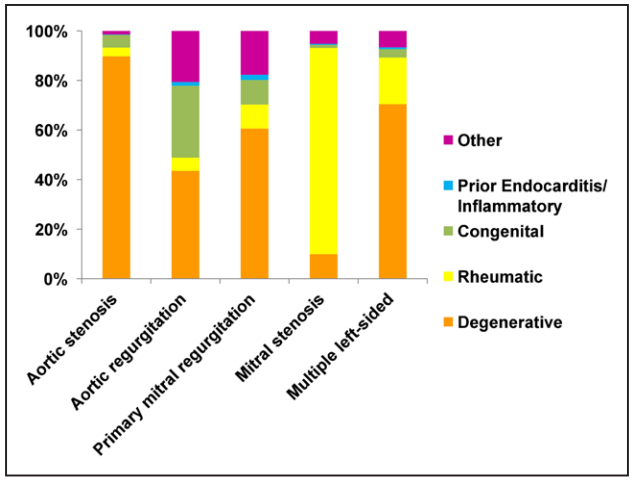

Figure 1. **Types of left-sided native valvular heart diseases.**

Decision for Intervention and Concordance With Guidelines

Intervention was considered as indicated in 63.8% (performed in 37.0%, scheduled in another subset of 26.8%) and not indicated by the investigator in 36.2% of patients with native VHD (Table 4). Figure 2 details the percentages of symptomatic patients with severe single left-sided native VHD in whom the intervention was either performed or scheduled. The decision for intervention was concordant with Class I recommendations for symptomatic patients with severe VHD in 79.4% (95% CI, 77.1–81.6) of those with AS, 77.6% (95% CI, 69.9–84.0) with AR, 68.5% (95% CI, 60.8–75.4) with MS, and 71.0% (95% CI, 66.4–75.3) with primary MR. The concordance with Class I recommendations in symptomatic patients is described according to the type of center in Figure II in the online-only Data Supplement.

Interventions Performed During the Study Period

Valvular interventions were performed in 2150 patients during the recruitment period (Table 5). Of the 1435 patients with single left-sided native VHD undergoing intervention, 686 (47.8%) were in New York Heart Association class III or IV, and 230 (16.0%) had signs of congestive heart failure. Patients with MR were frequently operated on at an advanced stage of disease, as attested by high rates of heart failure, atrial fibrillation, and reduced left ventricular ejection fraction.

With regard to the mode of intervention (Table 6), transcatheter procedures were performed in 38.7% of patients with AS and 16.7% of those with MR. Of the 59 transcatheter interventions for MR, 58 were edge-to-edge repairs. Percutaneous mitral balloon commissurotomy was performed in 45.0% of patients with MS, and surgical valve repair was done in 55.7% of patients with primary MR. Bioprostheses accounted for 62.1% of surgical implants in the aortic position and 36.5% in the mitral position. At least 1 nonvalvular surgical procedure was associated with valvular intervention in 506 patients (23.5%). Concomitant tricuspid valve surgery was performed in 31.7% of patients who underwent interventions for mitral VHD. In terms of only surgical interventions, 50.0% of patients with MS and 39.3% with primary MR underwent concomitant tricuspid surgery.

Overall in-hospital mortality after intervention was 2.1% (41 of 1973) with a median EuroSCORE II score of 2.0 (interquartile range, 1.1–4.0).

Six-Month Follow-Up

Overall, 97 patients died during the index hospitalization. Of the 7150 patients discharged alive, vital status at 6 months was known in 6373 (89.1%) of them: 6075 (95.3%) were alive, and 298 (4.7%) died between hospital discharge and 6 months. Detailed 6-month follow-up was available in 6137 patients who represented 84.7% of the whole population (7247 patients) and 85.8% of the 7150 patients who were discharged alive from the index hospitalization.

Six-month Kaplan–Meier survival rates were 93.5% (95% CI, 92.2–94.5) for AS, 97.5% (95% CI, 94.5–98.9) for AR, 96.6% (95% CI, 92.6–98.5) for MS, 94.1% (95% CI, 91.9–95.7) for primary MR, 88.0% (95% CI, 83.7–91.2) for secondary MR, 90.7% (95% CI, 88.8–92.3) for multiple left-sided VHD, 91.3% (95% CI, 84.3–95.2) for isolated right-sided VHD, and 95.3% (95% CI, 94.2–96.2) for previous valvular intervention.

Hospitalization was needed for cardiac reasons during follow-up in 1590 of 5957 patients (26.7%). The most frequent reason was new valvular intervention, most often planned during index hospitalization. Heart failure was the second most frequent reason for hospitalization during follow-up. Mortality and hospitalizations according the type of valvular disease are detailed in Table V in the online-only Data Supplement.

Of the 1506 patients who had an intervention scheduled but not performed during the index hospitalization (Table 4), information on new valvular intervention during the 6-month follow-up was available in 1222 (81.1%). Of them, 527 patients (43.1%) underwent a valvular intervention during the 6-month follow-up: 48.1% for AS, 42.9% for AR, 46.2% for MS, 37.0% for MR, 36.6% for multiple left-sided VHD, 33.3% for isolated right-sided VHD, and 39.3% for previous valvular intervention.

DISCUSSION

This contemporary survey reinforces the findings of the 2001 EHS on VHD in demonstrating the predominance

of degenerative AS and MR, the high frequency of elderly patients with VHD, and the inherent burden of comorbidities. Multimodality imaging is represented mainly by the use of computed tomography in aortic VHD, whereas physiological assessment (ie, stress tests) is seldom used. The concordance between Class I indications for interventions in symptomatic patients and practice is good for aortic VHD and suboptimal for mitral VHD. Transcatheter interventions are now largely used in the treatment of left-sided native VHD. The most important differences with the EHS on VHD and the VHD II are summarized in Table VI in the online-only Data Supplement.

Population

As was observed in the original 2001 EHS,[2] Northern Europe was underrepresented, in particular as a result of mandatory national registries, and there was otherwise a good balance among Eastern, Western, and Southern Europe. The distribution of VHD was similar to that of the EHS, which also included moderate native VHD, and the distribution between native VHD and previous valvular intervention was the same. The proportion of patients with native VHD with AS increased from 33.9% in 2001 to 41.2% in 2017, probably as a consequence of population aging; the prevalence of AS increases sharply in the elderly.[9] It may also reflect increased awareness of AS and the availability of TAVR in patients at high risk for surgery who were frequently denied or not referred for surgery. The falling proportion with MS is related to the continuous decline of rheumatic fever in Europe; MS remains predominantly of rheumatic origin. This distribution of native VHD is consistent with the findings of a recent nationwide Swedish registry based on hospital discharge codes and thereby excluding any assessment of VHD severity.[10] Here, the only discrepancy concerns the frequency of AR, which was higher in the Swedish registry. This may result from the inclusion of patients referred for aneurysm of the ascending aorta and mild or moderate AR, who were not included in the VHD II survey.

Consistent with the predominance of degenerative VHD, elderly patients were affected frequently by most types of VHD. More than a quarter of all patients (26.5%) were ≥80 years of age, whereas they accounted for only 8.3% in the 2001 EHS. Comorbidities, as assessed by the Charlson index, were most frequent in patients with AS and multiple VHD when patients were the oldest.

There were important differences with regard to patient presentation according to the 5 regions. Patients were younger in Eastern Europe and North Africa, where the frequency of rheumatic heart disease was higher than in Northern and Western Europe. This was particularly marked in North Africa, where 72% of native VHD was of rheumatic origin with a particularly high frequency of MS. However, median patient age was 75 years in Southern Europe, although the frequency of rheumatic heart disease was >10%. Patients referred to the outpatient clinic were younger and presented with less severe symptoms and less severe comorbidities than those requiring hospitalization.

Patients with native VHD were still referred at a late stage of the natural history, with >40% in New York Heart Association class III to IV at the time of assessment (except for AR) and 10% to 30% requiring hospitalization for heart failure within the preceding year. Late referral was more frequent for hospitalized patients than for outpatients. As expected, patients with secondary MR frequently presented with heart failure and left ventricular dysfunction. Late referral may be the result of a number of factors, including insufficient awareness of VHD among patients and practitioners, insufficient detection related to underuse of auscultation, deferred referral related to inappropriate evaluation of severity or symptoms, use of medical therapy despite lack of evidence (with the exception of secondary MR), and inappropriate analysis of risk–benefit ratio of valvular interventions, as confirmed by surveys among patients, general practitioners, and cardiologists.[11–13] Population-based studies have also shown that VHD is frequently undiagnosed in the community.[1,14]

Investigations

According to Table IV in the online-only Data Supplement, valve area and mean gradient were available in most patients with single left-sided stenotic VHD (>85% and >90%, respectively). Conversely, quantitative measurement of regurgitation was available in <45% and <60% of patients with AR and MR, respectively. In addition, ≈10% of patients with AR and MR were classified as having moderate disease according to echocardiographic quantification and were excluded from the analysis of the concordance with guidelines. Overall, adherence to the recommendations of guidelines on quantification with echocardiography is suboptimal in patients with regurgitant VHD.[15,16]

Transesophageal echocardiography was performed in ≈30% of patients with mitral VHD. Computed tomography was used mainly in patients with aortic VHD before TAVR or for assessment of the ascending aorta. A striking finding was the underuse of stress testing, particularly in asymptomatic patients with severe native VHD. Stress tests were used in only 2.9% of patients with native VHD and 5.6% in asymptomatic patients, whereas they were used in 8.9% of patients with native VHD in 2001.[2] Even with the growing interest in the use of cardiac magnetic resonance for the evaluation of VHD, in particular in regurgitant and right-sided VHD,[16,17] its use remained limited to <10% of patients.

Table 1. Baseline Patient Characteristics

	AS (n=2152)	AR (n=279)	MS (n=234)	Primary MR (n=746)	Secondary MR (n=368)	Multiple Left-Sided (n=1297)	Isolated Right-Sided (n=143)	Previous Valve Intervention (n=2028)
Patient characteristics								
Age, y [25th–75th percentile], n	76.0 [67.0–83.0] 2152	58.0 [48.0–69.0] 279	59.0 [45.0–68.0] 234	67.0 [58.0–76.0] 746	70.0 [62.0–78.0] 368	75.0 [65.0–82.0] 1297	74.0 [65.0–81.0] 143	70.0 [59.0–78.0] 2028
Age ≥80 y, n (%)	810 (37.6)	16 (5.7)	13 (5.6)	122 (16.4)	62 (16.8)	423 (32.6)	40 (28.0)	431 (21.3)
Female sex, n (%)	920 (42.8)	53 (19.0)	176 (75.2)	355 (47.6)	136 (37.0)	697 (53.7)	85 (59.4)	994 (49.0)
Body mass index, kg/m^2 [25th–75th percentile], n	27.8 [24.8–31.2] 2109	26.1 [23.3–29.4] 271	26.0 [22.8-–29.7] 227	25.7 [23.1–28.6] 729	16.6 [24.0–30.2] 344	26.8 [23.6–30.1] 1260	26.8 [24.0–30.5] 139	26.4 [23.7–29.7] 1964
Previous coronary intervention, n (%)	349/2146 (16.3)	18/278 (6.5)	9/232 (3.9)	60/742 (8.1)	124/367 (33.8)	186/1292 (14.4)	15/142 (10.6)	430/2012 (21.4)
Hospitalization for heart failure during the last year, n (%)	352 (16.4)	30 (10.8)	39 (16.7)	144 (19.3)	155/367 (42.2)	309 (23.8)	36 (25.2)	352 (17.4)
NYHA class, n (%)								
I	409 (19.0)	115 (41.2)	27 (11.5)	182 (24.4)	29 (7.9)	180 (13.9)	22 (15.4)	771 (38.0)
II	941 (43.7)	111 (39.8)	101 (43.2)	269 (36.1)	114 (31.0)	459 (35.4)	47 (32.9)	725 (35.7)
III	730 (33.9)	51 (18.3)	96(41.0)	258 (34.6)	177 (48.1)	568 (43.8)	58 (40.5)	460 (22.7)
IV	72 (3.4)	2 (0.7)	10 (4.3)	37 (5.0)	48 (13.0)	90 (6.9)	16 (11.2)	72 (3.6)
Angina pectoris, n (%)	417 (19.4)	19 (6.8)	16 (6.8)	63 (8.4)	63 (17.1)	268 (20.7)	13 (9.1)	128 (6.3)
Congestive heart failure, n (%)	333 (15.5)	32 (11.5)	46 (19.7)	183 (24.5)	184 (50.0)	376 (29.0)	64 (44.8)	390 (19.2)
Atrial fibrillation, n (%)	290/2149 (13.5)	16 (5.7)	108/233 (46.4)	247/745 (33.2)	140/368 (38.0)	392 (30.2)	81 (56.6)	643/2011 (32.0)
Creatinine clearance, mL·min^{-1}·1.73 m^{-2} [25th–75th percentile], n	65.1 [47.3–87.2] 2044	93.4 [70.8–118.3] 254	76.6 [58.4–97.7] 225	72.0 [52.0-–96.0] 691	61.0 [45.3–80.3] 340	59.7 [42.7–84.7] 1224	56.1 [45.8–80.0] 136	68.9 [49.0–94.8] 1836
Risk factors, n (%)								
Active smoking	210 (9.8)	47 (16.8)	28 (12.0)	80 (10.7)	56 (15.2)	146 (11.3)	8 (5.6)	123 (6.1)
Hypertension	1646 (76.5)	171 (61.3)	100 (42.7)	420 (56.3)	253 (68.8)	932 (71.9)	105 (73.4)	1244 (61.3)
Dyslipidemia	1222 (56.8)	86 (30.8)	60 (25.6)	247 (33.1)	190 (51.6)	650 (50.1)	56 (39.2)	899 (44.3)
Diabetes mellitus	610 (28.3)	19 (6.8)	36 (15.4)	96 (12.9)	104/367 (28.3)	284 (21.9)	41 (28.7)	377 (18.6)
Family history of cardiovascular disease	236/1777 (13.3)	33/243 (13.6)	22/213 (10.3)	96/603 (15.9)	58/258 (22.5)	166/1006 (16.5)	17/110 (15.5)	174/1620 (10.7)
Comorbidities, n (%)								
Chronic dialysis	22 (1.0)	4 (1.4)	1 (0.4)	7 (0.9)	8 (2.2)	18 (1.4)	2 (1.4)	18 (0.9)
Chronic pulmonary disease	258/2140 (12.1)	19/277 (6.9)	20/233 (8.6)	85/737 (11.5)	47/364 (12.9)	161/1288 (12.5)	19/139 (13.7)	204/2014 (10.1)
Previous myocardial infarction	195/2136 (9.1)	13/277 (4.7)	3/233 (1.3)	36/741 (4.9)	126/363 (34.7)	140/1283 (10.9)	11/140 (7.9)	176/2008 (8.8)
Lower limb atherosclerosis	138/2013 (6.9)	5/265 (1.9)	4/221 (1.8)	12/666 (1.8)	25/322 (7.8)	63/1146 (5.5)	2/122 (1.6)	69/1853 (3.7)
Limited mobility	156 (7.2)	5 (1.8)	9 (3.8)	39 (5.2)	39 (10.6)	111 (8.6)	20 (14.0)	114 (5.6)
Cancer								
Previous	166 (7.7)	12 (4.3)	3 (1.3)	48 (6.4)	20 (5.4)	94 (7.2)	13(9.1)	103 (5.1)

(*Continued*)

Table 1. Continued

	AS (n=2152)	AR (n=279)	MS (n=234)	Primary MR (n=746)	Secondary MR (n=368)	Multiple Left-Sided (n=1297)	Isolated Right-Sided (n=143)	Previous Valve Intervention (n=2028)
Active	51 (2.4)	2 (0.7)	1 (0.4)	10 (2.1)	5 (1.4)	25 (1.9)	4 (2.8)	48 (2.4)
Age-adjusted Charlson Comorbidity Index [25th–75th percentile], n	4.0 [3.0–6.0] 1971	2.0 [1.0–3.0] 253	2.0 [1.0–3.0] 221	3.0 [2.0–4.0] 683	4.0 [3.0–6.0] 354	4.0 [3.0–6.0] 1218	4.0 [3.0–6.0] 133	3.0 [2.0–5.0] 1779
EuroSCORE II score [25th–75th percentile], n	1.9 [1.1–3.4] 1951	1.0 [0.6–1.9] 239	1.2 [0.8–2.2] 214	1.5 [0.9–2.8] 673	3.4 [2.0–7.3] 337	2.3 [1.3–4.7] 1203	2.3 [1.4–4.3] 123	3.0 [1.6–6.0] 1630
Drug therapy at admission, n (%)								
Antiplatelet drug								
Aspirin	992 (46.1)	79 (28.3)	44 (18.8)	150 (25.2)	157 (42.7)	523 (40.3)	26 (18.2)	633 (31.2)
Other antiplatelet drug	280 (13.0)	18 (6.5)	5 (2.1)	56 (9.4)	58 (15.8)	170 (13.1)	5 (3.5)	165 (8.1)
Anticoagulants								
Vitamin K antagonists	271 (12.6)	22 (7.9)	104 (44.4)	181 (24.3)	105 (28.5)	314 (24.2)	58 (40.6)	1283 (63.3)
NOACs	142 (6.6)	6 (2.2)	12 (5.1)	99 (13.3)	61 (16.6)	118 (9.1)	31 (21.7)	105 (5.2)
Diuretics	1048 (48.7)	98 (35.1)	136 (58.1)	406 (54.4)	262 (71.2)	814 (62.8)	103 (72.0)	1199 (59.1)
β-Blockers	1118 (52.0)	126 (45.2)	147 (62.8)	400 (53.6)	262 (71.2)	773 (59.6)	82 (57.3)	1350 (66.6)
Calcium channel blockers	475 (22.1)	35 (12.5)	20 (8.5)	77 (10.3)	44 (12.0)	236 (18.2)	26 (18.2)	274 (13.5)
ACEI/ARB/MRA	1164 (54.1)	142 (50.9)	62 (26.5)	375 (50.3)	233 (63.3)	688 (53.0)	79 (55.2)	1097 (54.1)
Sacubitril/valsartan	53 (2.5)	9 (3.2)	7 (3.0)	14 (1.9)	20 (5.4)	38 (2.7)	2 (1.4)	44 (2.2)
Statins	1135 (52.7)	79 (28.3)	53 (22.6)	204 (27.3)	181 (49.2)	569 (43.9)	43 (30.1)	908 (44.8)

Values are median [25th–75th percentile] or number (percent). ACEI indicates angiotensin-converting enzyme inhibitor; AR, aortic regurgitation; ARB, angiotensin receptors blocker; AS, aortic stenosis; MR, mitral regurgitation; MRA, mineralocorticoid receptor antagonist; MS, mitral stenosis; NOAC, non–vitamin K antagonist oral anticoagulant; and NYHA, New York Heart Association. For definitions, see Appendix II in the online-only Data Supplement.

Rates of diagnostic cardiac catheterization in native VHD fell from >30% in 2001 to 7.5% in 2017.This is now more consistent with the guidelines recommendations to restrict its use to situations in which noninvasive evaluation is inconclusive or discordant with clinical findings.[7,8]

Decision for Intervention

A decision for intervention was made in the majority of patients with left-sided native VHD and more frequently for valvular stenosis than for regurgitation. An intervention was indicated in only 18.9% of patients with isolated right-sided VHD.

We chose to analyze the concordance between guidelines and interventions only in symptomatic patients with severe single left-sided VHD because this corresponds to Class I indications in the ESC/European Association of Cardiothoracic Surgery and the American Heart Association/American College of Cardiology guidelines, whereas there are discrepancies between guidelines with regard to indications for intervention in asymptomatic patients.[7,8]

Almost 80% of patients with symptomatic aortic VHD and a Class I indication for intervention had one performed or scheduled. In the 2001 EHS, surgery was considered in only 66% of symptomatic patients ≥75 years of age with severe AS.[18] This was consistent with other contemporary studies performed when surgical aortic valve replacement was the only treatment of AS, which reported that at least a third of patients with severe AS were not referred for surgery.[19,20] The present findings may relate to the availability of specific ESC guidelines on VHD in 2007 and 2012, whereas the 1997 American Heart Association/American College of Cardiology guidelines were the only guidelines available in 2001 concerning the management of VHD. It is also likely that the availability of TAVR enables clinicians to consider intervention in a wider range of patients with AS. The concordance between Class I indications and practice was only 68.5% and 71.0% in symptomatic patients with severe primary MR or MS. This is con-

Table 2. Patient Characteristics, Investigations, and Therapeutic Decision in the 5219 Patients With Native Valve Disease According to the 5 Regions

	Northern Europe (n=327)	Western Europe (n=1493)	Eastern Europe (n=1901)	Southern Europe (n=1340)	North Africa (n=158)
Patient characteristics					
Age, y [25th–75th percentile], n	76.0 [67.0–82.0] 327	78.0 [69.0–84.0] 1493	67.0 [59.0–75.0] 1901	75.0 [65.0–82.0] 1340	43.5 [32.0–57.0] 158
Age ≥80 y, n (%)	114 (34.9)	667 (44.7)	262 (13.8)	439 (32.8)	4 (2.5)
Female sex	144 (44.0)	682 (45.7)	883 (46.4)	616 (46.0)	97 (61.4)
Body mass index, kg/m^2 [25th–75th percentile], n	26.0 [23.6–29.3] 319	26.5 [23.6–29.8] 1473	27.7 [24.5–31.2] 1849	26.9 [24.2–29.7] 1287	25.6 [22.9–28.1] 151
Previous coronary intervention, n (%)	69/325 (21.2)	305/1487 (20.5)	193/1895 (10.2)	185/1336 (13.8)	9/156 (5.8)
Hospitalization for heart failure during the last year, n (%)	52 (15.9)	277 (18.6)	446 (23.5)	272/1339 (20.3)	18 (11.4)
NYHA class, n (%)					
I	38 (11.6)	287 (19.2)	283 (14.9)	311 (23.2)	45 (28.5)
II	108 (33.0)	511 (34.2)	772 (40.6)	597 (44.6)	54 (34.2)
III	155 (47.4)	607 (40.7)	750 (39.5)	379 (28.3)	47 (29.7)
IV	26 (8.0)	88 (5.9)	96 (5.0)	53 (4.0)	12 (7.6)
Angina pectoris, n (%)	73 (22.3)	164 (11.0)	397 (20.9)	208 (15.5)	17 (10.8)
Congestive heart failure, n (%)	94 (28.7)	259 (17.3)	459 (24.1)	384 (28.7)	22 (13.9)
Atrial fibrillation, n (%)	82 (25.1)	361/1489 (24.2)	426 (22.4)	371 (27.7)	34/157 (21.7)
Creatinine clearance mL·min^{-1}·1.73 m^{-2} [25th–75th percentile], n	61.8 [46.9–84.0] 303	57.5 [41.0–81.2] 1395	73.2 [54.0–95.8] 1805	62.5 [45.1–84.6] 1261	98.4 [78.3–123.0] 150
Risk factors, n (%)					
Active smoking	21 (6.4)	134 (9.0)	247 (13.0)	154 (11.5)	19 (12.0)
Hypertension	235 (71.9)	1002 (67.1)	1418 (74.6)	947 (70.7)	25 (15.8)
Dyslipidemia	183 (56.0)	648 (43.4)	975 (51.3)	690 (51.5)	15 (9.5)
Diabetes mellitus	53 (16.2)	362 (24.2)	423 (22.3)	336/1339 (25.1)	16 (10.1)
Family history of cardiovascular disease	22/202 (10.9)	138/1229 (11.2)	332/1613 (20.6)	131/1012 (12.9)	5/154 (3.2)
Comorbidities, n (%)					
Chronic dialysis	0 (0)	22 (1.5)	20 (1.1)	20 (1.5)	0 (0)
Chronic pulmonary disease	45/324 (13.9)	190/1476 (12.9)	174/1895 (9.2)	198/1326 (14.9)	2/157 (1.3)
Previous myocardial infarction	45/324 (13.9)	125/1482 (8.4)	191/1887 (10.1)	154/1322 (11.6)	9 (5.7)
Lower limb atherosclerosis	12/302 (4.0)	100/1314 (7.6)	74/1815 (4.1)	62/1176 (5.3)	1/148 (0.7)
Limited mobility	17 (5.2)	129 (8.6)	100 (5.3)	131 (9.8)	2 (1.3)
Cancer					
Previous	27 (8.3)	148 (9.9)	95 (5.0)	85 (6.3)	0 (0)
Active	4 (1.2)	50 (3.3)	19 (1.0)	25 (1.9)	1 (0.6)
Age-adjusted Charlson comorbidity index [25th–75th percentile], n	4.0 [3.0–6.0] 280	4.0 [3.0–6.0] 1266	3.0 [2.0–4.0] 1861	4.0 [3.0–6.0] 1298	1.0 [0.0–1.0] 128
EuroSCORE II score [25th–75th percentile], n	2.5 [1.3–4.7] 277	2.4 [1.4–4.6] 1281	1.7 [1.0–3.0]1845	1.9 [1.1–3.9] 1211	0.7 [0.6–1.2] 126
Type of native valve disease, n (%)					
AS	138 (42.2)	713 (47.8)	738 (38.8)	549 (41.0)	14 (8.9)
AR	11 (3.4)	62 (4.2)	114 (6.0)	86 (6.4)	6 (3.8)
MS	3 (0.9)	44 (2.9)	88 (4.6)	46 (3.4)	53 (33.5)
Primary MR	66 (20.2)	234 (15.7)	261 (13.7)	161 (12.0)	24 (15.2)
Secondary MR	25 (7.6)	78 (5.2)	152 (8.0)	103 (7.7)	10 (6.3)

(*Continued*)

Table 2. Continued

	Northern Europe (n=327)	Western Europe (n=1493)	Eastern Europe (n=1901)	Southern Europe (n=1340)	North Africa (n=158)
Multiple left-sided	76 (23.2)	325 (21.8)	510 (26.8)	344 (25.7)	42 (26.6)
Isolated right-sided	8 (2.4)	37 (2.5)	38 (2.0)	51 (3.8)	9 (5.7)
Type of valve disease					
Degenerative	241/324 (74.4)	1188/1461 (81.3)	1135/1832 (62.0)	862/1311 (65.8)	22/157 (14.0)
Rheumatic	12/324 (3.7)	59/1461 (4.0)	252/1832 (13.8)	163/1311 (12.4)	113/157 (72.0)
Congenital	20/324 (6.2)	49/1461 (3.4)	157/1832 (8.6)	78/1311 (5.9)	5/157 (3.2)
Prior endocarditis/inflammatory	1/324 (0.3)	12/1461 (0.8)	19/1832 (1.1)	8/1311 (0.6)	3/157 (1.9)
Other*	50/324 (15.6)	153/1461 (10.5)	269/1832 (14.7)	200/1311 (15.3)	14/157 (8.9)
Investigations, n (%)					
2D strain analysis	10 (3.1)	211 (14.1)	89 (4.7)	94 (7.0)	3 (1.9)
3D transthoracic echocardiography	22 (6.7)	207 (13.9)	133 (7.0)	100 (7.5)	22 (13.9)
Transesophageal echocardiography	62 (19.0)	396/1492 (26.5)	411 (21.6)	173 (12.9)	26 (16.5)
Stress test					
All patients	16 (4.9)	81 (5.4)	16 (0.8)	40 (3.0)	0 (0)
NYHA class I	0/38 (0)	30/287 (10.5)	8/283 (2.8)	16/311 (5.1)	0/45 (0)
Cardiac/vascular CT scan	63 (19.3)	462 (30.9)	203 (10.7)	163 (12.2)	6 (3.8)
Cardiac magnetic resonance	5 (1.5)	49 (3.3)	11 (0.6)	28 (2.1)	5 (3.2)
Coronary angiography	202 (61.8)	1015 (68.0)	1045 (55.0)	540 (40.3)	24 (15.2)
Cardiac catheterization	25 (7.6)	237 (15.9)	101 (5.3)	91 (6.8)	8 (5.1)
Therapeutic decision, n (%)					
Intervention performed	151 (46.2)	679 (45.5)	808 (42.5)	250/1337 (18.7)	41 (25.9)
Intervention scheduled but not performed	76 (23.2)	400 (26.8)	591 (31.1)	301/1337 (22.5)	31 (19.6)
No indication for intervention according to the investigator	100 (30.6)	414 (27.7)	502 (26.4)	786/1337 (58.8)	86 (54.4)

Values are median [25th–75th percentile] or number (percent). All *P* values for the comparisons between the 5 regions were < 0.001 except for dialysis (*P*=0.08).

AR indicates aortic regurgitation; AS, aortic stenosis; CT, computed tomography; MR, mitral regurgitation; MS, mitral stenosis; and NYHA, New York Heart Association.

*Including secondary mitral regurgitation.

sistent with the rates of mitral valve surgery in MR in other studies conducted in the hospital setting[21,22] or surveys among practitioners.[12,13,23,24] The underuse of interventions in MR was even more marked in a recent study performed in a community setting, thereby also taking into account patient management before referral to the hospital.[25] Nevertheless, even in mitral VHD, referral for intervention is increasing compared with the original EHS, in which only 51% of patients with severe symptomatic MR were referred.[21] There was no major difference in the concordance between recommendations and practice according to the type of center. An intervention was scheduled or performed in only 38.3% of patients with secondary MR, consistent with the restricted indications in guidelines compared with primary MR.[7,8]

The low rate of interventions in patients who had undergone previous valve intervention is consistent with the finding that the majority of them were referred for routine follow-up. Similarly, the rate of indications for interventions was low in outpatients, who were more frequently referred for follow-up than inpatients.

Interventions Performed During the Study Period

Patients frequently underwent valvular intervention at an advanced stage of disease, as shown by the 50.9% of patients with native VHD operated on in New York Heart Association class III to IV; the corresponding figure was 55.0% in 2001.[2] This observation was particularly marked in patients with MR and consistent with the rate of interventions among patients with a Class I indications for surgery.

Nonsurgical treatment of VHD was widely used in stenotic VHD and in 11.4% of primary and 32.2% of patients with secondary MR. The respective rates of surgical aortic valve replacement and TAVR are consistent with other contemporary European registries.[26] Between 2001 and 2017, the rate of surgical valve repair

Table 3. Investigations (Transthoracic Echocardiography Was Mandatory)

	AS (n=2152), n (%)	AR (n=279), n (%)	MS (n=234), n (%)	Primary MR (n=746), n (%)	Secondary MR (n=368), n (%)	Multiple Left-Sided (n-1297), n (%)	Isolated Right-Sided (n=143), n (%)	Previous Valve Intervention (n=2028), n (%)
2D strain analysis	187 (8.7)	24 (8.6)	14 (6.0)	69 (9.2)	26 (7.1)	76/1296 (5.9)	11 (7.7)	103/2025 (5.1)
3D transthoracic echocardiography	139 (6.5)	35 (12.5)	59 (25.2)	78 (10.5)	44 (12.0)	119 (9.2)	10 (7.0)	187/2025 (9.2)
Transesophageal echocardiography	222 (10.3)	66 (23.7)	86 (36.8)	287 (38.5)	121 (32.9)	271 (20.9)	15/142 (10.6)	273 (13.5)
Stress test								
All patients	67 (3.1)	12 (4.3)	9 (3.8)	34 (4.6)	8 (2.2)	20 (1.5)	3 (2.1)	49 (2.4)
NYHA class I	25/409 (6.1)	7/115 (6.1)	2/27 (7.4)	15/182 (8.2)	2/29 (6.9)	3/180 (1.7)	0/22 (0.0)	12/771 (1.6)
Cardiac/vascular CT scan	575 (26.7)	59 (21.1)	5 (2.1)	33 (4.4)	8 (2.2)	211 (16.3)	6 (4.2)	168 (8.3)
Cardiac magnetic resonance	14 (0.7)	20 (7.2)	7 (3.0)	14 (1.9)	19 (5.2)	13 (1.0)	11 (7.7)	22 (1.1)
Coronary angiography	1365 (63.4)	122 (43.7)	57 (24.4)	371 (49.7)	177 (48.1)	699 (53.9)	35 (24.5)	339 (16.7)
Cardiac catheterization	168 (7.8)	15 (5.4)	9 (3.8)	87 (11.7)	33 (9.0)	135 (10.4)	15 (10.5)	78 (3.8)

AR indicates aortic regurgitation; AS, aortic stenosis; CT, computed tomography; MR, mitral regurgitation; MS, mitral stenosis; and NYHA, New York Heart Association.

increased from 46.5% to 51.1% for MR (55.7% for primary MR) and from 1.7% to 21.5% for AR. Increased rates of combined tricuspid and mitral valve surgery may reflect growing awareness of the clinical relevance of associated tricuspid regurgitation.

The observed low mortality rates after intervention are consistent with the overall low-risk profile of this population (median EuroSCORE II score, 2.0), consistent with other large databases and registries of patients with AS and MR.[26–28] Values of predicted and observed mortality are in accordance with previous studies showing the good predictive performance of EuroSCORE II score in patients with VHD.[29,30]

Follow-Up

Six-month survival rates ranged between 88.0% and 97.5%. Among those with single left-sided native VHD, the lowest rates were observed in patients with AS and MR, which can be related to the type of VHD but also to the age of patients in these subgroups. The distribution of 6-month survival rates in the VHD II survey is close to corresponding 1-year survival rates previously observed in the EHS.[31] After valvular interventions planned during the index hospitalization, heart failure was the most frequent cause of hospitalization for cardiac reasons during follow-up. The frequent occurrence of heart failure during follow-up can be related to the fact that patients were referred at an advanced stage of their disease. Rates of heart failure and mortality may also be the result of delayed intervention. Only 48.1% of patients requiring scheduled intervention for AS actually underwent treatment within 6 months, despite the fact that prolonged waiting time for intervention is associated with increased mortality.[32] Even patients who undergo valvular intervention may develop heart failure, in particular when intervention is performed in old and highly symptomatic patients.[33,34]

Limitations

The VHD II survey is not a comprehensive population-based epidemiological study but a voluntary survey. Representativeness is therefore suboptimal, and selection bias cannot be excluded. Nationwide registries based on hospital discharge codes ensure representativeness but do not provide information

Table 4. Therapeutic Decision by the Investigator During Index Hospitalization/Consultation

	AS (n=2152), n (%)	AR (n=279), n (%)	MS (n=234), n (%)	Primary MR (n=746), n (%)	Secondary MR (n=368), n (%)	Multiple Left-Sided (n-1297), n (%)	Isolated Right-Sided (n=143), n (%)	Previous Valve Intervention (n=2028), n (%)
Intervention performed	866/2149 (40.3)	93 (33.3)	109 (46.6)	277 (37.1)	90 (24.5)	470 (36.2)	24 (16.8)	221/2024 (10.9)
Intervention scheduled but not performed	724/2149 (33.7)	77 (27.6)	41 (17.5)	191 (25.6)	51 (13.8)	312 (24.1)	3 (2.1)	107/2024 (5.3)
No indication for intervention according to the investigator	559/2149 (26.0)	109 (39.1)	84 (35.9)	278 (37.3)	227 (61.7)	515 (39.7)	116 (81.1)	1696/2024 (83.8)

AR indicates aortic regurgitation; AS, aortic stenosis; MR, mitral regurgitation; and MS, mitral stenosis.

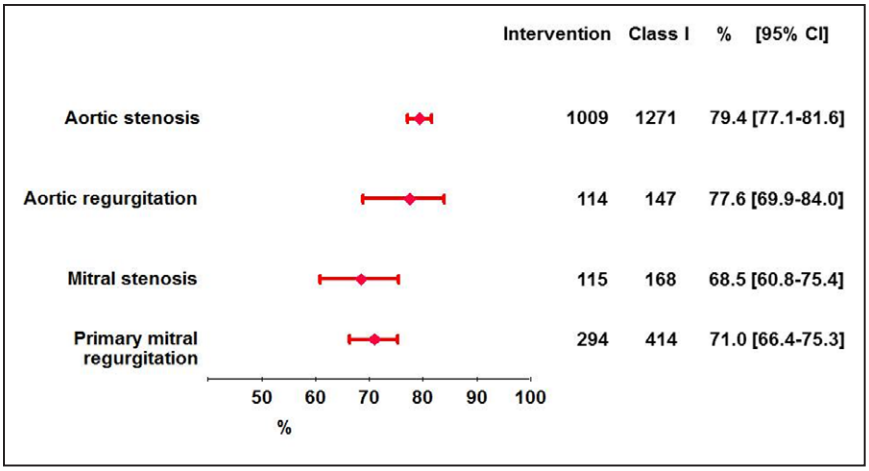

Figure 2. Concordance between Class I indication according to the 2012 European Society of Cardiology/European Association of Cardiothoracic Surgery guidelines and 2014 American Heart Association/American College of Cardiology guidelines[7,8] and performed or scheduled intervention in symptomatic patients with severe single left-sided valvular disease: percentages and 95% CIs. Symptomatic patients were in New York Heart Association class II or greater or had angina if they had aortic stenosis. Severe valvular heart disease was defined as follows: aortic stenosis, mean gradient >40 mm Hg; mitral stenosis, valve area ≤1.5 cm^2 or mean gradient >5 mm Hg; and aortic and primary mitral regurgitations, classified as severe according to echocardiographic criteria.

on either the severity of VHD or the symptomatic status of the patients and cannot be used to assess the application of guidelines. Nevertheless, the inclusion of 28 countries and the use of a wide spectrum of healthcare structures in the VHD II survey provide in-depth insight into the contemporary presentation and management of VHD.

In the absence of onsite data monitoring, there was no direct control on consecutive patient inclusion and data accuracy. This was partly compensated for by mul-

Table 5. Baseline Characteristics of the 2150 Patients Who Underwent Valve Intervention During the Survey Period

	AS (n=866)	AR (n=93)	MS (n=109)	Primary MR (n=277)	Secondary MR (n=90)	Multiple Left-Sided (n=470)	Isolated Right-Sided (n=24)	Previous Valve Intervention (n-221)
Age, y [25th–75th percentile], n	75.0 [66.0–83.0] 866	57.0 [48.0–69.0] 93	56.0 [42.0–63.0] 109	66.0 [57.0–75.0] 277	66.0 [62.0–-73.0] 90	71.0 [60.0–80.0] 470	66.5 [47.0–75.0] 24	70.0 [58.0–80.0] 221
Female sex, n (%)	382 (44.1)	16 (17.2)	84 (77.1)	118 (42.6)	35 (38.9)	247 (52.6)	10 (41.7)	107 (48.4)
NYHA class, n (%)								
I	89 (10.3)	26 (28.0)	9 (8.3)	46 (16.6)	6 (6.7)	40 (8.5)	3 (12.5)	34 (15.4)
II	365 (42.1)	35 (37.6)	41 (37.6)	108 (39.0)	24 (26.7)	150 (31.9)	6 (25.0)	75 (33.9)
III	382 (44.1)	32 (34.4)	57 (52.3)	109 (39.4)	50 (55.6)	254 (54.0)	14 (58.3)	104 (47.1)
IV	30 (3.5)	0 (0.0)	2 (1.8)	14 (5.1)	10 (11.1)	26 (5.5)	1 (4.2)	8 (3.6)
Angina pectoris, n (%)	159 (18.4)	11 (11.8)	13 (11.9)	19 (6.9)	15 (16.7)	82 (17.4)	1 (4.2)	18 (8.1)
Congestive heart failure, n (%)	102 (11.8)	11 (11.8)	18 (16.5)	63 (22.7)	36 (40.0)	110 (23.4)	6 (25.0)	67 (30.3)
Atrial fibrillation, n (%)	114 (13.2)	6 (6.5%)	45 (41.3)	99 (35.7)	35 (38.9)	122 (26.0)	8 (33.3)	77 (34.8)
Creatinine clearance $mL \cdot min^{-1} \cdot 1.73\ m^{-2}$ [25th–75th percentile], n	66.4 [49.1–90.1] 851	94.3 [70.8–124.0] 90	78.3 [60.0-106.2] 107	74.5 [56.7–96.9] 270	63.2 [51.3–82.4] 84	64.2 [46.7–89.7] 464	63.7 [53.7–93.9] 24	63.5 [47.7–88.6] 210
Charlson comorbidity index [25th–75th percentile], n	4.0 [3.0–6.0] 765	2.0 [1.0–3.0] 84	2.0 [1.0-3.5] 108	3.0 [1.0–4.0] 255	4.0 [3.0–6.0] 90	4.0 [2.0–5.0] 435	4.0 [1.0–8.0] 23	4.0 [2.0–5.0] 199
EuroSCORE II score [25th–75th percentile], n	2.0 [1.2–3.5] 793	1.1 [0.8–1.9] 83	1.1 [0.8-2.5] 106	1.7 [0.9–2.9] 256	3.2 [1.8–7.1] 90	2.3 [1.3–4.4] 435	2.3 [1.2–4.2] 23	3.9 [1.8–7.6] 193
Left ventricular ejection fraction, n (%)								
<20%	3/850 (0.4)	2/92 (2.2)	0 (0.0)	1/272 (0.4)	0 (0.0)	4/456 (0.9)	0 (0.0)	0/218 (0.0)
20%–30%	11/850 (1.3)	1/92 (1.1)	0 (0.0)	8/272 (2.9)	12 (13.3)	19/456 (4.2)	0 (0.0)	9/218 (4.1)
30%–40%	52/850 (6.1)	6/92 (6.5)	3 (2.8)	4/272 (1.5)	24 (26.7)	32/456 (7.0)	0 (0.0)	20/218 (9.2)
40%–50%	88/850 (10.4)	23/92 (25.0)	9 (8.3)	28/272 (10.3)	30 (33.3)	89/456 (19.5)	5(20.8)	27/218 (12.4)
50%–60%	240/850 (28.2)	32/92 (34.8)	39 (35.8)	91/272 (33.5)	9 (10.0)	137/456 (30.0)	8(33.3)	75/218 (34.4)
≥60%	456/850 (53.6)	28/92 (30.4)	58 (53.2)	140/272 (51.5)	15 (16.7)	175/456 (38.4)	11 (45.8)	87/218 (39.9)

AR indicates aortic regurgitation; AS, aortic stenosis; MR, mitral regurgitation; MS, mitral stenosis; and NYHA, New York Heart Association.

Table 6. Type of Intervention in the 2150 Patients Who Underwent Valve Intervention During The Survey Period

	AS (n=866), n (%)	AR (n=93), n (%)	MS (n=109), n (%)	Primary MR (n=277), n (%)	Secondary MR (n=90), n (%)	Multiple Left-Sided* (n=470), n (%)	Isolated Right-Sided (n=24), n (%)	Previous Valve Intervention* (n=221), n (%)
Critical preoperative state	19 (2.2)	2 (2.2)	0 (0.0)	18 (6.5)	6 (6.7)	29 (6.2)	1 (4.2)	12 (5.4)
Mechanical prosthesis	178/861(20.6)	36 (38.7)	46 (42.2)	49/271 (18.1)	11/87 (12.6)	163/556 (29.4)	0/22 (0)	75/230 (32.6)
Surgical bioprosthesis	322/861(37.4)	29 (31.2)	10 (9.2)	39/271 (14.4)	12/87 (13.8)	188/556 (33.9)	10/22 (45.4)	48/230 (20.9)
Surgical valve repair	3/861(0.3)	20 (21.5)	4 (3.7)	151/271 (55.7)	32/87 (36.8)	58/556 (10.5)	8/22 (36.4)	16/230 (7.0)
Autograft	10/861 (1.2)	5 (5.4)	0 (0.0)	0/271 (0.0)	0	1/556 (0.2)	0/22 (0.0)	2/230 (0.9)
Homograft	2/861(0.2)	1 (1.1)	0 (0.0)	0/271 (0.0)	0	1/556 (0.2)	0/22 (0.0)	0/230 (0.0)
Balloon dilatation	13/861 (1.5)	0 (0.0)	49 (45.0)	0/271 (0.0)	0	15/556 (2.7)	3/22 (13.6)	13/230 (5.7)
Transcatheter	333/861 (38.7)	2 (2.2)	0 (0.0)	31/271 (11.4)	28/87 (32.2)	129/556 (23.2)	1/22 (4.5)	76/230 (33.0)
Associated procedures								
Tricuspid surgery	5 (0.6)	2 (2.2)	30 (27.5)	94 (33.9)	27 (30.0)	76 (16.2)	…	36 (16.3)
Percutaneous coronary intervention	48 (5.5)	0 (0.0)	1 (0.9)	8 (2.9)	6 (6.7)	15 (3.2)	0 (0.0)	7 (3.2)
Coronary artery bypass grafting	133 (15.4)	11 (11.8)	5 (4.6)	29 (10.5)	25 (27.8)	71 (15.1)	4 (16.7)	10 (4.5)
Partial or total replacement of ascending aorta	36 (4.2)	34 (36.6)	1 (0.9)	3 (1.1)	0 (0.0)	19 (4.0)	0 (0.0)	11 (5.0)
Atrial fibrillation ablation	13 (1.5)	4 (4.3)	6 (5.5)	33 (11.9)	9 (10.0)	28 (6.0)	1 (4.2)	5 (2.3)
Left atrial appendage exclusion	20 (2.3)	4 (4.3)	10 (9.2)	51 (18.4)	15 (16.7)	37 (7.9)	4 (16.7)	8 (3.6)
In-hospital mortality	16/793 (2.0)	0/83 (0.0)	1/94 (1.1)	5/257 (1.9)	4/82 (4.9)	10/444 (2.3)	0/23 (0.0)	5/197 (2.5)

AR indicates aortic regurgitation; AS, aortic stenosis; MR, mitral regurgitation; and MS, mitral stenosis.
*The total number of procedures is higher than the number of patients because of multiple valve procedures (only left-sided procedures are considered).

tiple checks for consistency with the case report form and queries sent to investigators when data were missing or inconsistent. It is not possible to exclude survival bias in the analysis of 6-month follow-up, which was not available in 10.9% of patients.

Conclusions

This contemporary survey of patients referred with severe VHD within a wide panel of healthcare structures is unique because it was specifically designed to assess current clinical practices and guideline implementation. It shows a growing segment of elderly patients. We demonstrate that there is room for improvement in the quantification of valvular regurgitation and considerable underuse of stress tests in asymptomatic patients. Overall, however, Class I recommendations for intervention in symptomatic patients are better applied compared with the 2001 EHS, particularly for aortic VHD. Nevertheless, a large proportion of patients are still referred at a late stage of their disease (particularly those with primary MR), thereby highlighting the need for increased awareness of VHD among patients, general practitioners, and cardiologists. The implementation of guidelines and the wide use of transcatheter techniques are likely to have contributed to more appropriate interventions in VHD since 2001. Following educational initiatives, dedicated surveys play a key role in the assessment of guidelines implementation to improve patient outcome.

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APPENDIX: LIST OF EORP INVESTIGATORS

A full list of investigators is available in the online-only Data Supplement.

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