A shifting approach to management of the thoracic aorta in bicuspid aortic valve

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Objectives: The scientific understanding of aortic dilation associated with bicuspid aortic valve (BAV) has evolved during the past 2 decades, along with improvements in diagnostic technology and surgical management. We aimed to evaluate secular trends and predictors of thoracic aortic surgery among patients with BAV in the United States.

Methods: We used the 1998-2009 Nationwide Inpatient Sample, an administrative dataset representative of US hospital admissions, to identify hospitalizations for adults aged 18 years or more with BAV and aortic valve or thoracic aortic surgery. Covariates included age, gender, year, aortic dissection, endocarditis, thoracic aortic aneurysm, number of comorbidities, hospital teaching status and region, primary insurance, and concomitant coronary artery bypass surgery.

Results: Between 1998 and 2009, 48,736 $\pm$ 3555 patients with BAV underwent aortic valve repair or replacement and 1679 $\pm$ 120 patients with BAV underwent isolated thoracic aortic surgery. The overall number of surgeries increased more than 3-fold, from 4556 $\pm$ 571 in 1998/1999 to 14,960 $\pm$ 2107 in 2008/2009 ($P < .0001$). The proportion of aortic valve repair or replacement including concomitant thoracic aortic surgery increased from 12.8% $\pm$ 1.4% in 1998/1999 to 28.5% $\pm$ 1.6% in 2008/2009, which mirrored an increasing proportion of patients with a diagnosis of thoracic aortic aneurysm. Mortality was equivalent for patients undergoing aortic valve repair or replacement with thoracic aortic surgery and those undergoing isolated aortic valve repair or replacement (1.8% $\pm$ 0.3% vs 1.5% $\pm$ 0.2%; multivariable odds ratio, 1.02; 95% confidence interval, 0.67-1.57), with decreasing mortality over the study period (from 2.5% $\pm$ 0.6% in 1998/1999 to 1.5% $\pm$ 0.2% in 2008/2009; multivariable odds ratio per 2-year increment, 0.89; 95% confidence interval, 0.81-0.99; $P = .03$). Total charges for BAV surgical hospitalizations increased more than 7.5-fold from approximately \$156 million in 1998 to \$1.2 billion in 2009 (inflation-adjusted 2009 dollars).

Conclusions: There was a marked increase in the use of thoracic aortic surgery among patients with BAV. (J Thorac Cardiovasc Surg 2013;146:339-46)

Bicuspid aortic valve (BAV) is the most common congenital valvular heart defect, being present in approximately 1% of the general population.[1-3] BAV is associated with an increased risk of aortic valve stenosis and regurgitation, as well as thoracic aortic dilation and dissection. Aortic dilation was long considered to be due to valve disease itself, but increasing evidence points to an independent aortopathy associated with BAV.[3-6] Although the relative risk of aortic dissection is lower than in Marfan syndrome, there are likely as many, if not more, dissections in patients with BAV given the significantly greater prevalence of this disease.[7] Therefore, BAV-associated aortic disease has important public health implications.

Surgical management of aortic dilation and aneurysm presents a difficult clinical problem given the unpredictable lifetime risk of morbidity and mortality[7-9] related to BAV aortopathy and major surgical intervention required to address these risks. This is not a new clinical issue; the complexities of aortic aneurysmal disease have long been appreciated,[10,11] but our understanding and ability to diagnose and intervene have evolved considerably. Recommendations on when to intervene surgically for thoracic aortic dilation, in general and for patients with BAV, have been progressively expanded over the past 15

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Abbreviations and Acronyms

ACC = American College of Cardiology
AHA = American Heart Association
AVR = aortic valve repair or replacement
BAV = bicuspid aortic valve
CI = confidence interval
OR = odds ratio
TAA = thoracic aortic aneurysm
TAS = thoracic aortic surgery

years. Indeed, BAV is now widely considered to be an independent risk factor for an acute aortic event, leading to a lower threshold for aortic surgery in patients with BAV compared with "degenerative" thoracic aortic aneurysms (TAAs).[12] Bicuspid aortopathy is increasingly thought of as a genetic disease affecting aortic structure and metabolism, with some arguing that aortic dimensions indicating surgical intervention should be similar to those used for other such genetic diagnoses, such as Marfan syndrome.[13-15] Absolute aortic diameter remains the most used clinical parameter to guide intervention, although indexed and nonsize predictors also have been proposed.[16-18] Guideline recommendations for surgical intervention based on a threshold of ascending aortic diameter have decreased from more than 5 cm[19-22] to more than 4.5 cm for patients with BAV undergoing concomitant aortic valve repair or replacement (AVR), with others proposing even lower thresholds for intervention.[16,23,24] However, these recommendations remain controversial.[9,25,26]

This study aims to elucidate practice patterns in the surgical management of the thoracic aorta in patients with BAV by examination of a representative dataset of US hospitalizations over a recent 12-year period.

MATERIALS AND METHODS

We used the 1998-2009 Nationwide Inpatient Sample (Healthcare Cost and Utilization Project, Agency for Healthcare Research and Quality), the largest all-payer nationally representative hospital discharge database in the United States, to investigate the epidemiology of AVR and thoracic aortic surgery (TAS) among adults (aged $\geq$ 18 years) with BAV. This database has been used to study other aspects of hospitalizations for congenital heart disease and noncongenital cardiac surgery.[27-30] Because this study used publicly available anonymous data, the institutional review board of Brigham and Women's Hospital granted exemption from review.

The primary aims of the study were to describe temporal trends in the incidence of TAS and AVR (surgical repair/replacement or endovascular repair) among patients with BAV. We collated patients hospitalized with an International Classification of Diseases 9th Revision code of BAV (746.4) undergoing concomitant AVR (35.10 or 35.11); AVR (mechanical = 35.22 or tissue = 35.21) or resection of the thoracic vessel with replacement (38.45); resection of vessel with anastomosis, aorta (38.34); or endovascular implantation of the graft in the thoracic aorta (39.73).

Covariates included age, gender, number of comorbidities as described by Elixhauser and colleagues,[31] aortic dissection, subacute bacterial endocarditis, diagnosis of TAA, number of comorbidities, year and type of surgery, and concomitant coronary artery bypass surgery or mitral valve repair. Inpatient hospital characteristics ascertained were hospital teaching status, hospital region (Northeast, Midwest, South, and West), and primary insurance for the admission. Hospitalizations were grouped into 2-year increments (1998/1999, 2000/2001, 2002/2003, 2004/2005, 2006/2007, and 2008/2009).

Continuous and categorical variables are presented as mean $\pm$ standard error of the mean and percent $\pm$ standard error percent, respectively. Standard errors of the estimates are presented to show the variance of the estimate when extrapolated from the representative Nationwide Inpatient Sample to the whole US population. Linear regression and logistic regression were used to model continuous dependent variables (eg, total charges, length of stay) and the odds for dichotomous outcomes (eg, TAS, death), respectively. Statistical analyses were performed using SAS for Windows 9.3 (SAS Institute Inc, Cary, NC). All analyses used provided sample weights and accounted for complex sample design and hospital clustering.[32,33]

RESULTS

Hospitalizations of 50,415 $\pm$ 3671 patients with BAV who underwent AVR or TAS were examined. Demographic and clinical characteristics are detailed in Table 1.

Aortic Valve and Thoracic Aortic Surgery

Between 1998 and 2009, 48,736 $\pm$ 3555 patients with BAV underwent AVR (50.3% $\pm$ 2.2% with a mechanical prosthesis; 47.6% $\pm$ 1.9% with a tissue prosthesis), whereas only 2.4% $\pm$ 0.5% underwent valve repair. Of patients undergoing AVR, 22.6% $\pm$ 1.0% underwent concomitant TAS. During the same period, 1679 $\pm$ 162 patients underwent isolated TAS. An endovascular approach, possibly suggestive of descending thoracic aortic intervention, was applied in 0.4% $\pm$ 0.1% of cases.

During the study period, the overall number of surgeries per 2-year epoch increased 3.3-fold, with the number of isolated AVRs increasing 2.7-fold, the number of AVRs with concomitant TAS increasing 7.3-fold, and the number of isolated TAS increasing 4.5-fold (Figure 1 and Table 2). The proportion of AVRs that included a concomitant thoracic aortic intervention increased from 12.8% $\pm$ 1.4% to 28.5% $\pm$ 1.6% over the study period (Figure 2). Among those who underwent AVR, mechanical valves were implanted in 69.2% $\pm$ 3.2% of patients in 1998/1999, but that number had decreased to just 37.8% $\pm$ 3.7% of patients in 2008/2009 (Table 2). The same trend also was seen in the subset of patients who underwent AVR in conjunction with TAS (76.1% $\pm$ 4.7% mechanical in 1998/1999 to 41.0% $\pm$ 4.5% in 2008/2009, $P < .0001$). The frequency of mitral valve repair also increased over the study period, but the proportion of patients undergoing mitral repair was lower (Table 2). In contrast, the proportion of patients with BAV who underwent concomitant coronary artery bypass grafting remained unchanged over the study period.