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Impact of concomitant aortic stenosis on the management and outcomes of acute myocardial infarction hospitalizations in the United States

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Abstract

Objective: To evaluate the prevalence, management and outcomes of concomitant aortic stenosis (AS) in admissions with acute myocardial infarction (AMI).

Methods: We used the HCUP-NIS database (2000–2017) to identify adult AMI admissions with concomitant AS. Outcomes of interest included prevalence of AS, in-hospital mortality, use of cardiac procedures, hospitalization costs, length of stay, and discharge disposition.

Results: Among a total of 11,622,528 AMI admissions, 513,688 (4.4 %) were identified with concomitant AS. Adjusted temporal trends revealed an increase in STEMI and NSTEMI hospitalizations with concomitant AS. Compared to admissions without AS, those with AS were

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Declaration of competing interest
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data
Supplementary data to this article can be found online at https://doi.org/10.1016/j.ahjo.2022.100217.

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on average older, of female sex, had higher comorbidity, higher rates of NSTEMI (78.9 % vs 62.1 %), acute non-cardiac organ failure, and cardiogenic shock. Concomitant AS was associated with significantly lower use of coronary angiography (45.5 % vs 64.4 %), percutaneous coronary intervention (20.1 % vs 42.5 %), coronary atherectomy (1.7 % vs. 2.8 %) and mechanical circulatory support (3.5 % vs 4.8 %) (all $p < 0.001$). Admissions with AS had higher rates of coronary artery bypass surgery and surgical aortic valve replacement (5.9 % vs 0.1 %) compared to those without AS. Admissions with AMI and AS had higher in-hospital mortality (9.2 % vs. 6.0 %; adjusted OR 1.12 [95 % CI 1.10–1.13]; $p < 0.001$). Concomitant AS was associated with longer hospital stay, more frequent palliative care consultations and less frequent discharges to home.

Conclusions: In this 18-year study, an increase in prevalence of AS in AMI hospitalization was noted. Concomitant AS was associated with lower use of guideline-directed therapies and worse clinical outcomes among AMI admissions.

Keywords

Aortic stenosis; Acute myocardial infarction; Mortality; Outcomes research; Geriatric cardiology

1. Introduction

In contemporary practice, the coexistence of aortic stenosis (AS) and coronary artery disease (CAD) is frequently encountered due to the overlap in the disease process and shared risk factors [1,2]. The reported prevalence of CAD in patients presenting for management of AS ranges from 50 %–60 % [2–4]. Presence of CAD has been associated with poor long-term prognosis in patients with AS and has been shown to increase long-term risk after aortic valve interventions compared to those without CAD [2,5]. While the impact of CAD in patients with AS has been extensively studied, limited data exist on the prevalence and impact of AS in patients presenting with acute myocardial infarction (AMI). Understanding the effects of AS on management and outcomes of AMI is gaining increasing importance, given the aging population in the United States and the potential association of AS with thrombus formation and pathogenesis of AMI [6–8]. Existing reports have either evaluated the burden of all valvular heart diseases in AMI or limited their evaluation of AS burden to a subset of acute coronary syndrome [9–11]. In light of this information, using a large contemporary national database, we sought to evaluate the prevalence of concomitant AS and its associated impact on management and outcomes in AMI. We hypothesized that due to higher morbidity and potentially higher age, these patients would have worse outcomes compared to those without AS.

2. Material and methods

2.1. Study population, variables and outcomes

The National (Nationwide) Inpatient Sample (NIS) contains discharge data from a 20 % stratified sample of community hospitals in the United States [12]. It is the largest all-payer database of hospital inpatient stays in the United States and captures information on demographics, hospital characteristics, diagnoses, and procedures of each discharge [12]. Due to the publicly available nature of this de-identified database, we did not seek approval from the Institutional Review Board approval. These data are available to other authors via the Healthcare Quality and Utilization Project-NIS (HCUP-NIS) database through the Agency for Healthcare Research and Quality [12].

We utilized the HCUP-NIS data from January 1, 2000 through December 31, 2017, to identify a cohort of adult admissions (>18 years) with AMI in the primary diagnosis field (International Classification of Diseases 9.0 Clinical Modification [ICD-9CM] 410.x and ICD-10CM I21. x-22.x) [13,14]. Presence of concomitant AS was identified using ICD-9CM (395.0, 395.2, 396.0, 396.2, 424.1, 746.3), and ICD-10 CM (I06.0, I06.2, I08.0, I35.0, I35.2, Q23.0) codes in any of the secondary diagnosis fields similar to prior published studies [15,16]. The Deyo's modification of the Charlson Comorbidity Index was used to identify the burden of comorbid diseases [17]. Demographic characteristics, hospital characteristics, cardiac arrest, cardiogenic shock, acute organ failure, mechanical circulatory support, cardiac procedures, and other non-cardiac organ support use were identified for all admissions using previously published methodologies (Supplementary Table 1) [13,14,18–20].

The primary outcome of interest was the in-hospital mortality of AMI admissions with and without concomitant AS. The secondary outcomes included use of cardiac procedures like coronary angiography, percutaneous coronary intervention (PCI), coronary artery bypass grafting (CABG), mechanical circulatory support (MCS), coronary atherectomy, surgical and transcatheter aortic valve replacement (AVR), hospitalization costs, hospital length of stay, and discharge disposition in those with and without AS. Coronary atherectomy was evaluated in the subset of AMI admissions from 2012 to 2017 as administrative codes for these procedures came into existence in late 2011 [21,22]. Multiple sub-group analyses were performed to confirm the results of the primary analysis stratifying the population by age (≤/>75 years), sex (male/female), race (white/non-white), type of AMI (ST-segment elevation [STEMI] vs. non-ST-segment elevation [NSTEMI]), receipt of PCI, MCS, and type of aortic valve (bicuspid/tricuspid).

2.2. Statistical analysis

In accordance with HCUP-NIS recommendations, survey procedures using discharge weights provided with the HCUP-NIS database were used to generate national estimates [23]. Samples from 2000 to 2011 were re-weighted using the trend weights provided by the HCUP-NIS to adjust for the 2012 HCUP-NIS re-design [23]. Chi-square and *t*-tests were used to compare categorical and continuous variables, respectively. Multivariable logistic regression was used to analyze trends over time (referent year 2000) accounting for clustering for hospital characteristics. Univariable analysis for trends and outcomes was performed and was represented as odds ratio (OR) with 95 % confidence interval (CI). Temporal trends of prevalence of AS and use of coronary angiography, PCI, and MCS were plotted. Multivariable logistic regression analysis incorporating age, sex, race, primary payer status, socio-economic stratum, hospital characteristics, comorbidities, cardiac arrest, cardiogenic shock, acute organ failure, AMI-type, cardiac procedures, and non-cardiac procedures was performed for assessing adjusted temporal trends and adjusted in-hospital mortality. For the multivariable modeling, regression analysis with purposeful selection of statistically (liberal threshold of $p < 0.20$ in univariate analysis) and clinically relevant variables was conducted. Two-tailed $p < 0.05$ was considered statistically significant.

The inherent restrictions of the HCUP-NIS database related to research design, data interpretation, and data analysis were reviewed and addressed [23]. Pertinent considerations include not assessing individual hospital-level volumes (due to changes to sampling design detailed above), treating each entry as an 'admission' as opposed to individual patients, restricting the study details to inpatient factors since the HCUP-NIS does not include outpatient data, and limiting administrative codes to those previously validated and used for similar studies. All statistical analyses were performed using SPSS v25.0 (IBM Corp, Armonk NY).

3. Results

3.1. Prevalence, characteristics, and management of AMI admissions with AS

Over the 18-year study period, there were a total of 11,622,528 admissions for AMI. Among these 513,688 (4.4 %) were identified as having concomitant AS. Prevalence of AS among AMI hospitalizations presenting with STEMI remained relatively stable whereas an increase was seen among those presenting with NSTEMI (Fig. 1A). Temporal trends adjusting for patient and hospital characteristics, however, revealed an increase in both STEMI (adjusted OR 1.15 in 2017 with reference to 2000) and NSTEMI (adjusted OR 1.28 in 2017 with reference to 2000) hospitalizations with concomitant AS (Fig. 1B). In comparison to those without AS, AMI admissions with concomitant AS were on average older, of female sex, White race, bearing Medicare insurance, had higher rates of congestive heart failure, and higher comorbidity index scores (Table 1). AMI admissions with AS had higher rates of NSTEMI presentation (78.9 % vs 62.1 %), acute non-cardiac organ failure, cardiogenic shock, and lower rates of cardiac arrest (Tables 1 and 2).

Presence of concomitant AS in AMI admissions was associated with significantly lower use of coronary angiography (45.5 % vs 64.4 %, adjusted OR 0.98 [95 % CI 0.98–0.99]; $p < 0.001$), PCI (20.1 % vs 42.5 %, adjusted OR 0.57 [95 % CI 0.56–0.57]; $p < 0.001$), and MCS (3.5 % vs 4.8 %, adjusted OR 0.85 [95 % CI 0.83–0.87]; $p < 0.001$) (all $p < 0.001$; Table 2). Among MCS devices, intra-aortic balloon pump (3.2 % vs 4.6 %) and ECMO were less frequently used in admissions with AS whereas use of percutaneous left ventricular devices was comparable to those without AS (Table 2). Use of coronary atherectomy procedures was also lower in AMI admissions with AS (1.7 % vs 2.8 %, $p < 0.001$). Temporal trends revealed an increase in use of angiography, PCI, MCS, and transcatheter AVR among AMI admissions with AS (Fig. 2A–D). Admissions with AS had higher rates of CABG and AVR compared to AMI admissions without AS (Table 2).

3.2. Clinical outcomes and resource utilization associated with AS

Admissions with AMI and concomitant AS had significantly higher unadjusted (9.2 % vs. 6.0 %; OR 1.58 [95 % CI 1.56–1.59]; $p < 0.001$) and adjusted all-cause in-hospital mortality (OR 1.12 [95 % CI 1.10–1.13]; $p < 0.001$) (Supplementary Table 2). Unadjusted and adjusted temporal trends over the 18-year study period demonstrated a steady decline in-hospital mortality among both STEMI and NSTEMI admissions with and without AS (Fig. 1C and D). Although presence of AS in AMI admissions was associated with longer median lengths of hospital stay (5 [3–8] days vs 3 [2–6] days, $p < 0.001$), median hospitalization charges were lower compared to AMI admissions without AS (Table 3). Palliative care consultations and do-not-resuscitate status were more frequent among AMI admissions with AS. The cohort with AMI and AS had lower discharges to home and higher rates of discharges to skilled nursing facilities (Table 3).

In a sensitivity analysis, presence of AS in AMI admissions was associated with higher in-hospital mortality in subgroups of age, sex, race, admissions with and without PCI, admissions with and without MCS, those presenting with NSTEMI and those with a tricuspid aortic valve (Fig. 3). Admissions presenting with STEMI and those with a bicuspid aortic valve did not have differences in outcomes by AS status (Fig. 3). Additional sensitivity analyses for those with STEMI and NSTEMI separately are presented in Supplementary Tables 3–5.

4. Discussion

In this contemporary national study of AMI hospitalizations, we noted concomitant AS in 4.4 % of admissions with the prevalence of AS increasing over time. Admissions with concomitant AS were on average older, had greater comorbidity burden and higher rates of cardiogenic shock and acute organ failure. Concomitant AS was associated with significantly lower use of coronary angiography and PCI, and higher in-hospital mortality. These admissions also had longer hospital stays and were discharged home less often. Importantly, a steady decline in in-hospital mortality was identified in AMI admissions with and without AS.

In a prospective survey of patients admitted due to acute coronary syndromes in hospitals across Europe, significant valvular heart disease was noted in 4.8 % of the study cohort [10]. Among those identified with significant valvular heart disease, moderate to severe AS occurred in 31.7 % of patients [10]. In another single-center analysis of over 2000 patients admitted with STEMI, AS was identified in 2.7 % using echocardiography [9]. The authors reported AS prevalence of up to 16 % with increase in age [9]. More recently, in their evaluation of the Elderly-ACS 2 database, Crimi et al. identified significant AS in 1.8 % of AMI patients older than 74 years and undergoing PCI [11]. While these are reports of selected populations from institute- and registry-specific datasets, the present analysis includes a significantly larger nationally representative sample of all-comer AMI hospitalizations. This together with the higher mean age of the study population, higher rates of NSTEMI and identification of AS through administrative codes may explain the comparatively greater prevalence of AS in the present study. Also, the use of granular echocardiographic information to include moderate-severe AS was not available in our study, and therefore the full spectrum of AS severity may have been included leading to the higher prevalence. The above studies exclusively include the European population whereas the present report includes those from the United States. The diversity in race/ethnicity across both regions may also have resulted in differences in prevalence rates [24,25]. Varying echocardiographic clinical practices such as focusing only on evaluating left ventricular function without estimating AS is another possible cause for the variations in the stated prevalence rates. It is also possible that practice changes with increased use of echocardiography and/or changes in administrative codes may have resulted in greater identification of AS in the more recent years.

Importantly, our analysis and prior reports consistently demonstrate greater acuity of illness associated with AS in AMI hospitalizations [10,11]. Those presenting with both AMI and AS not only had higher comorbidity index scores at baseline but also had a complicated in-hospital course with higher rates of atrial fibrillation, cardiogenic shock and acute multiorgan failure when compared to those without AS. Similar findings of more frequent occurrence of atrial fibrillation or flutter, advanced stages of heart failure (including cardiogenic shock), and renal failure were identified in other investigations of AMI patients with significant valvular heart disease [10,11]. The higher proportion of elderly population who may have higher prevalence of frailty and greater comorbidity burden could have contributed to higher rates of these acute in-hospital events [26–28]. Together, all these factors may influence management decisions wherein guideline directed therapies might be considered futile resulting in the observed lower rates of angiography and PCI in these patients with both AS and AMI [29].

There are limited data on the outcomes of AMI in AS patients. Prior studies with comparable subset of patients demonstrated increased mortality risk after AMI in patients with coexisting AS [9–11]. In a retrospective single-center study by Singh et al. reported 81 % higher risk of late all-cause mortality in patients with concomitant AS [9]. In another study, patients with significant AS and acute coronary disease had three times higher risk of composite of all-cause death, myocardial infarction, disabling stroke, and re-hospitalization for heart failure at one-year and a numerically higher risk of cardiovascular mortality [11]. Higher risk of death in these patients could be attributed not only to poor prognosis from the synergistic effect of ongoing ischemia and increased afterload and myocardial oxygen demand on the left ventricle due to the stenotic aortic valve, but also to the above mentioned factors such as older age, comorbidities and frailty in AS than in those without AS. Further, masking of AMI, especially NSTEMI without angina, in those with symptomatic AS could possibly result in delayed recognition of coronary disease likely contributing to delay in care and increased mortality. Indeed, AMI admissions with AS in the present evaluation had higher adjusted in-hospital mortality compared to those without AS [1,30]. However, the steady decline in in-hospital mortality over time is reassuring and is likely due to advances in management of AS and concomitant AS and CAD over the last decade with the increased availability of TAVR.

4.1. Limitations

This study has several limitations despite the HCUP-NIS database's attempts to mitigate potential errors by using internal and external quality control measures. Important factors such as the delay in presentation from time of onset of AMI symptoms, out-of-hospital deaths after symptom onset, and reasons for not receiving aggressive medical care, and timing of multi-organ failure, could not be reliably identified in this database. Importantly, echocardiographic data evaluating severity of AS, valve characteristics, left ventricular function and presence of concomitant mitral valve disease was not available. Information on type of AS (congenital, rheumatic, calcific) is not included in the present study and this may have affected the results. However, since AMI was the primary diagnosis on all admissions, it represents the reason the patient was most likely admitted to the hospital. Inability to differentiate between the complexities of NSTEMI due to limitations of the database may have influenced observed results. With higher sensitivity of troponin assays, it is certainly possible that there may have been higher rates of NSTEMI classification in patients with AS. The results of our study should be interpreted with caution as even small differences that may not be clinically relevant appear statistically significant due to large sample sizes. It is possible that despite best attempts at controlling for confounders by a multivariate analysis, observed results could be due to residual confounding. Although sensitivity analyses were performed to evaluate the potential independent impact of AS, it is possible that AS is only a marker of frailty or more advanced disease. Finally, our data are only reflective of in-hospital outcomes. Despite these limitations, this study addresses an important knowledge gap highlighting the prevalence and outcomes associated with AS in AMI in a contemporary population.

5. Conclusions

In this large 18-year national study, we demonstrate a steady increase in the prevalence of AS in admissions with AMI. Presence of AS was associated with lower use of guideline-directed therapies and significantly higher mortality. However, it appears the advances in management of AS and AMI has resulted in a steady decline in in-hospital mortality over the study period. Further research to identify the role of severity of AS on long-term outcomes of AMI patients is essential to improve management and outcomes of an aging United States population where prevalence of concomitant AMI and AS is expected to increase.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations:

AMI	acute myocardial infarction
AS	aortic stenosis
AVR	aortic valve replacement
CABG	coronary artery bypass grafting

CAD	coronary artery disease
CI	confidence interval
HCUP	Healthcare Cost and Utilization Project
ICD-9CM	International Classification of Diseases-9 Clinical Modification
ICD-10CM	International Classification of Diseases-10 Clinical Modification
NIS	National/Nationwide Inpatient Sample
NSTEMI	non-ST-segment elevation myocardial infarction
OR	odds ratio
PCI	percutaneous coronary intervention
STEMI	ST-segment elevation myocardial infarction

References

[1]. Paradis J-M, Fried J, Nazif T, et al. , Aortic stenosis and coronary artery disease: what do we know? What don't we know? A comprehensive review of the literature with proposed treatment algorithms, Eur. Heart J 35 (31) (2014) 2069–2082. [PubMed: 24970334]

[2]. D'Ascenzo F, Conrotto F, Giordana F, et al. , Mid-term prognostic value of coronary artery disease in patients undergoing transcatheter aortic valve implantation: a meta-analysis of adjusted observational results, Int. J. Cardiol 168 (3) (2013) 2528–2532. [PubMed: 23628298]

[3]. Goel SS, Ige M, Tuzcu EM, et al. , Severe aortic stenosis and coronary artery disease–implications for management in the transcatheter aortic valve replacement era: a comprehensive review, J. Am. Coll. Cardiol 62 (1) (2013) 1–10. [PubMed: 23644089]

[4]. El Sabbagh A, Nishimura RA, Clinical conundrum of coronary artery disease and aortic valve stenosis, J. Am. Heart Assoc (2017), 10.1161/JAHA.117.005593.

[5]. Dewey TM, Brown DL, Herbert MA, et al. , Effect of concomitant coronary artery disease on procedural and late outcomes of transcatheter aortic valve implantation, Ann. Thorac. Surg 89 (3) (2010) 758–767, discussion 767. [PubMed: 20172123]

[6]. Dimitrow PP, Hlawaty M, Undas A, et al. , Effect of aortic valve stenosis on haemostasis is independent from vascular atherosclerotic burden, Atherosclerosis 204 (2) (2009) e103–e108. [PubMed: 19171341]

[7]. Chirkov YY, Holmes AS, Willoughby SR, Stewart S, Horowitz JD, Association of aortic stenosis with platelet hyperaggregability and impaired responsiveness to nitric oxide, Am. J. Cardiol 90 (5) (2002) 551–554. [PubMed: 12208424]

[8]. Aronow WS, Ahn C, Shirani J, Kronzon I, Comparison of frequency of new coronary events in older persons with mild, moderate, and severe valvular aortic stenosis with those without aortic stenosis, Am. J. Cardiol 81 (5) (1998) 647–649. [PubMed: 9514469]

[9]. Singh GK, van der Bijl P, Goedemans L, et al. , Prevalence of aortic valve stenosis in patients with ST-segment elevation myocardial infarction and effect on long-term outcome, Am. J. Cardiol 153 (2021) 30–35. [PubMed: 34167785]

[10]. Hasdai D, Lev EI, Behar S, et al. , Acute coronary syndromes in patients with pre-existing moderate to severe valvular disease of the heart: lessons from the euro-heart survey of acute coronary syndromes, Eur. Heart J 24 (7) (2003) 623–629. [PubMed: 12657220]

[11]. Crimi G, Montalto C, Ferri LA, et al. , Clinical impact of valvular heart disease in elderly patients admitted for acute coronary syndrome: insights from the elderly-ACS 2 study, Can. J. Cardiol 36 (7) (2020) 1104–1111. [PubMed: 32479749]

[12]. Introduction to the HCUP national inpatient sample (NIS), Available at: https://www.hcup-us.ahrq.gov/db/nation/nis/NIS_Introduction_2018.jsp, 2018. (Accessed 2 March 2021).

[13]. Vallabhajosyula S, Dunlay SM, Prasad A, et al. , Acute noncardiac organ failure in acute myocardial infarction with cardiogenic shock, J. Am. Coll. Cardiol 73 (14) (2019) 1781–1791. [PubMed: 30975295]

[14]. Patlolla SH, Kanwar A, Cheungpasitporn W, et al. , Temporal trends, clinical characteristics, and outcomes of emergent coronary artery bypass grafting for acute myocardial infarction in the United States, J. Am. Heart Assoc 10 (15) (2021), e020517. [PubMed: 33998286]

[15]. Alqahtani F, Aljohani S, Almustafa A, et al. , Comparative outcomes of transcatheter aortic valve replacement in a frican a merican and C aucasian patients with severe aortic stenosis, Catheter. Cardiovasc. Interv 91 (5) (2018) 932–937. [PubMed: 28941139]

[16]. Chaker Z, Badhwar V, Alqahtani F, et al. , Sex differences in the utilization and outcomes of surgical aortic valve replacement for severe aortic stenosis, J. Am. Heart Assoc 6 (9) (2017), 10.1161/JAHA.117.006370.

[17]. Quan H, Sundararajan V, Halfon P, et al. , Coding algorithms for defining comorbidities in ICD-9-CM and ICD-10 administrative data, Med. Care 43 (11) (2005) 1130–1139. [PubMed: 16224307]

[18]. Vallabhajosyula S, Patlolla SH, Murphree DH, Cheungpasitporn W, Holme DR Jr., Gersh BJ, Temporal trends, management and outcomes of acute myocardial infarction with concomitant respiratory infections, Am. J. Cardiol 150 (2021) 1–7. [PubMed: 34001337]

[19]. Vallabhajosyula S, Patlolla SH, Miller PE, et al. , Weekend effect in the management and outcomes of acute myocardial infarction in the United States, 2000–2016, Mayo Clin. Proc. Innov. Qual. Outcomes 4 (4) (2020) 362–372. [PubMed: 32793864]

[20]. Vallabhajosyula S, Kanwar S, Aung H, et al. , Temporal trends and outcomes of left ventricular aneurysm after acute myocardial infarction, Am. J. Cardiol 133 (2020) 32–38. [PubMed: 32807388]

[21]. Arora S, Panaich SS, Patel N, et al. , Coronary atherectomy in the United States (from a Nationwide inpatient Sample), Am. J. Cardiol 117 (4) (2016) 555–562. [PubMed: 26732421]

[22]. Elbadawi A, Elzeneini M, Elgendy IY, et al. , Temporal trends and outcomes of percutaneous coronary atherectomy in the United States, J. Invasive Cardiol 32 (5) (2020) E110–E121. [PubMed: 32357132]

[23]. Khera R, Krumholz HM, With great power comes great responsibility: big data research from the National Inpatient Sample, Circ. Cardiovasc. Qual. Outcomes 10 (7) (2017), 10.1161/CIRCOUTCOMES.117.003846.

[24]. Patel DK, Green KD, Fudim M, Harrell FE, Wang TJ, Robbins MA, Racial differences in the prevalence of severe aortic stenosis, J. Am. Heart Assoc 3 (3) (2014), e000879. [PubMed: 24870936]

[25]. Czarny MJ, Shah SJ, Whelton SP, et al. , Race/Ethnicity and prevalence of aortic stenosis by echocardiography in the multi-ethnic study of atherosclerosis, J. Am. Coll. Cardiol 78 (2) (2021) 195–197. [PubMed: 33989712]

[26]. Philip Green, Mark Russo, Suzanne Arnold, TCT-36 frailty in intermediate risk patients undergoing transcatheter or surgical aortic valve replacement, cut points and relationship with outcomes: an analysis of the placement of aortic transcatheter valves (PARTNER) 2 Cohort a randomized trial, J. Am. Coll. Cardiol 68 (18_Supplement) (2016). B15–B15.

[27]. Ahluwalia SC, Gross CP, Chaudhry SI, Leo-Summers L, Van Ness PH, Fried TR, Change in comorbidity prevalence with advancing age among persons with heart failure, J. Gen. Intern. Med 26 (10) (2011) 1145–1151. [PubMed: 21573881]

[28]. Ha FJ, Bissland K, Mandrawa C, Palmer SC, Frailty in patients with aortic stenosis awaiting intervention, Intern. Med. J 51 (3) (2021) 319–326. [PubMed: 31908088]

[29]. Rothman MD, Van Ness PH, O'Leary JR, Fried TR, Refusal of medical and surgical interventions by older persons with advanced chronic disease, J. Gen. Intern. Med 22 (7) (2007) 982–987. [PubMed: 17483977]

[30]. Rapp AH, Hillis LD, Lange RA, Cigarroa JE, Prevalence of coronary artery disease in patients with aortic stenosis with and without angina pectoris, Am. J. Cardiol 87 (10) (2001) 1216–1217. A7. [PubMed: 11356405]

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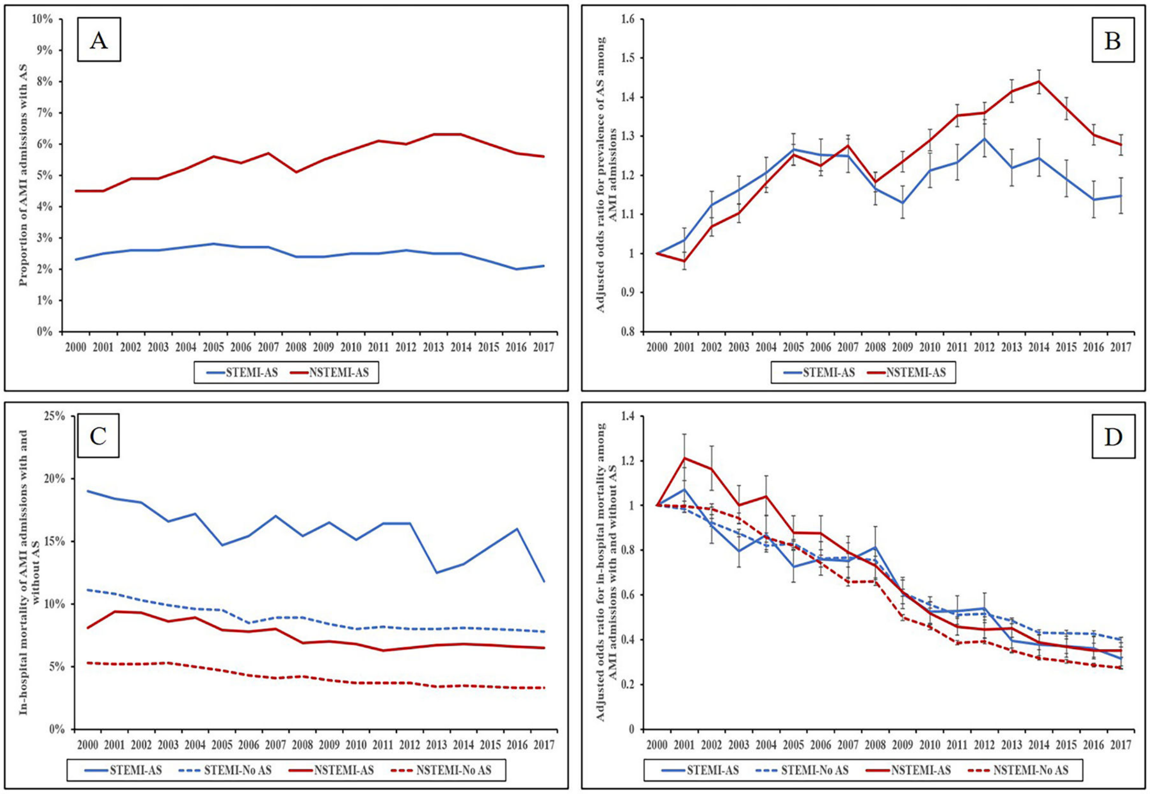

Fig. 1.

Temporal trends in the prevalence of AS and in-hospital mortality of AMI admissions with and without AS.

Legend: A: Unadjusted trends of the proportion of AMI admissions with AS stratified by type of AMI ($p < 0.001$ for trend over time); B: Adjusted odds ratio* for prevalence of AS in STEMI and NSTEMI admissions by year (with 2000 as the referent) ($p < 0.001$ for trend over time); C: Unadjusted in-hospital mortality in AMI admissions stratified by type of AMI and the presence of AS ($p < 0.001$ for trend over time); D: Adjusted odds ratio** for in-hospital mortality by year (with 2000 as the referent) in AMI admissions stratified by type of AMI and the presence of AS ($p < 0.001$ for trend over time).

*Adjusted for age, sex, race, household income quartile, comorbidity, primary payer, hospital region, hospital location and teaching status, hospital bed size.

**Adjusted for age, sex, race, primary payer status, socio-economic stratum, hospital characteristics, comorbidities, cardiac arrest, cardiogenic shock, acute organ failure, AMI-type, cardiac procedures, and non-cardiac procedures.

Abbreviations: AMI: acute myocardial infarction; AS: aortic stenosis.

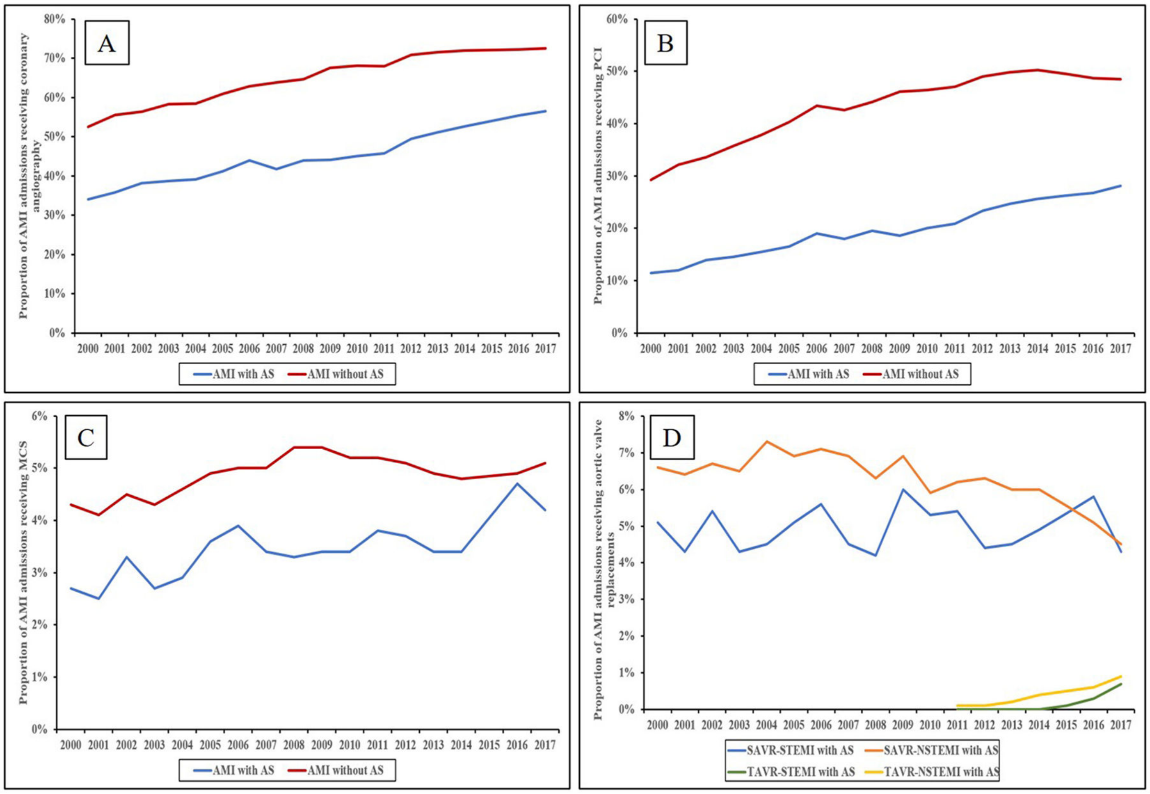

Fig. 2.

Temporal trends in use of cardiac procedures in AMI admissions with and without AS.

Legend: Trends in use of A) coronary angiography; B) PCI; C) MCS; and D) concomitant aortic valve replacement.

Abbreviations: AMI: acute myocardial infarction; AS: aortic stenosis; MCS: mechanical circulatory support; PCI: percutaneous coronary intervention; SAVR: surgical aortic valve replacement; TAVR: transcatheter aortic valve replacement.

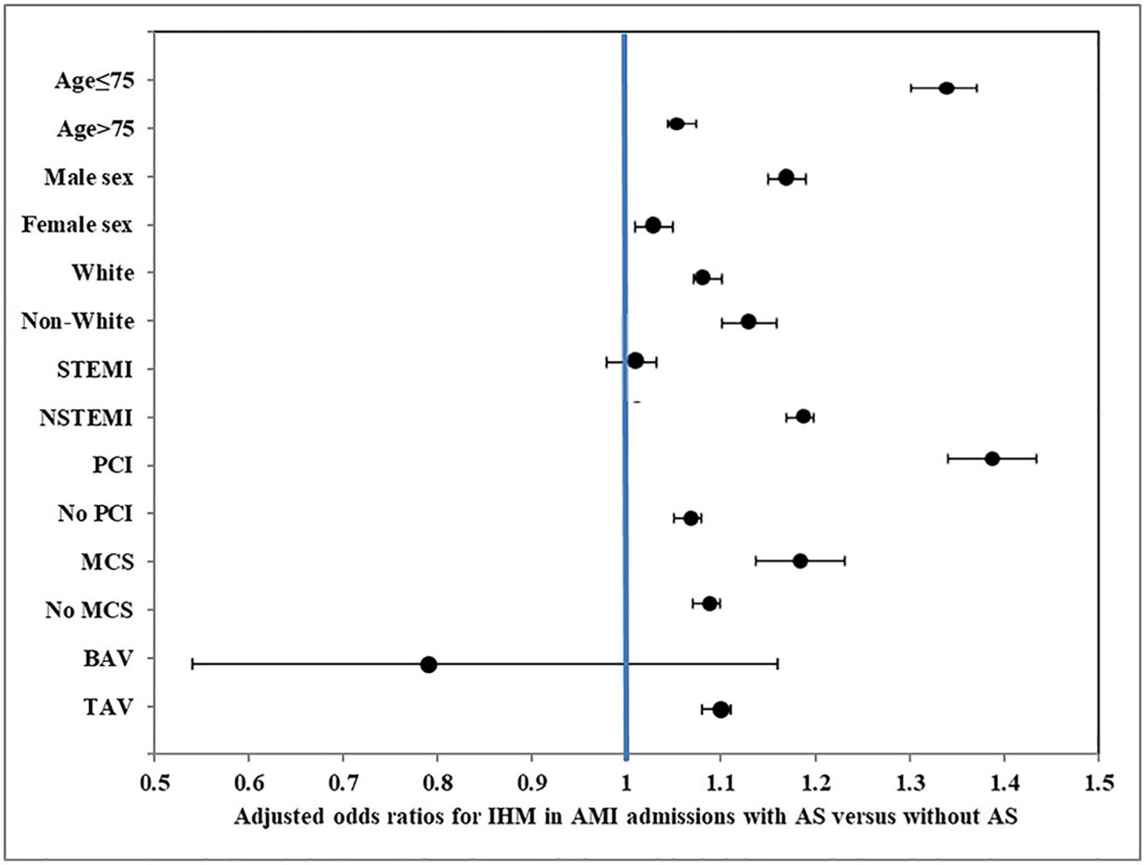

Fig. 3.

Sub-group analyses in AMI admissions with AS compared to those without AS.

Legend: In-hospital mortality in various sub-groups of AMI admissions comparing those with AS versus without AS.

Multivariable adjusted odds ratios (95 % confidence intervals) for each sub-group; adjusted for age, sex, race, comorbidity, primary payer, hospital region, hospital location and teaching status, hospital bed size, cardiac arrest, acute organ failure, cardiogenic shock, coronary angiography, percutaneous coronary intervention, coronary artery bypass grafting, pulmonary artery catheterization, mechanical circulatory support, invasive mechanical ventilation, acute hemodialysis, admission year, surgical and transcatheter aortic valve replacement.

The blue line corresponds to odds ratio of 1.0. Adjusted odds ratios and 95 % confidence intervals >1 signifies a higher in-hospital mortality in AMI admissions with AS compared to AMI admissions without AS.

Abbreviations: AMI: acute myocardial infarction; AS: aortic stenosis; BAV: bicuspid aortic valve; IHM: in-hospital mortality; MCS: mechanical circulatory support; NSTEMI: non-ST-segment elevation myocardial infarction; PCI: percutaneous coronary intervention; STEMI: ST-segment elevation myocardial infarction; TAV: tricuspid aortic valve. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 1

Baseline characteristics AMI admissions with and without AS.

Characteristic		AS (N = 513,668)	No AS (N = 11,108,860)	P
Age (years)		78.8 ± 10.9	67.1 ± 14.1	<0.001
Female sex		47.3	39.4	<0.001
Race	White	71.8	63.2	<0.001
	Black	5.2	8.1	
	Others[a]	23.0	28.7	
Primary payer	Medicare	83.9	56.4	<0.001
	Medicaid	2.3	6.3	
	Others[b]	10.9	28.7	
Quartile of median household income for zip code	0–25th	21.5	24.5	<0.001
	26th–50th	26.7	27.2	
	51st-75th	25.6	24.5	
	75th–100th	26.2	23.8	
Charlson Comorbidity Index	0–3	9.4	38.9	<0.001
	4–6	52.6	44.1	
	≥7	38.0	17.0	
Hospital teaching status and location	Rural	11.4	11.2	<0.001
	Urban non-teaching	41.0	39.5	
	Urban teaching	47.6	49.4	
Hospital bed-size	Small	12.3	11.1	<0.001
	Medium	26.3	25.4	
	Large	61.4	63.4	
Hospital region	Northeast	24.4	19.4	<0.001
	Midwest	22.7	22.9	
	South	35.0	40.4	
	West	17.8	17.3	
AMI type	STEMI	21.1	37.9	<0.001
	NSTEMI	78.9	62.1	
Congestive heart failure		52.0	28.2	<0.001
Atrial fibrillation/flutter		31.0	16.7	<0.001
Ventricular tachycardia/fibrillation		6.6	8.1	<0.001

Represented as percentage or mean ± standard deviation.

Abbreviations: AMI: acute myocardial infarction; AS: aortic stenosis; NSTEMI: non-ST-segment-elevation myocardial infarction; STEMI: ST-segment-elevation myocardial infarction.

[a]Hispanic, Asian or Pacific Islander, Native American, Others.

[b]Private, Self-Pay, No Charge, Others.

Table 2

Unadjusted comparisons of in-hospital management of AMI admissions with and without AS.

Characteristic	AS (N = 513,668)	No AS (N = 11,108,860)	P
Cardiac arrest	4.1	5.1	<0.001
Cardiogenic shock	5.1	4.8	<0.001
Multi-organ failure	13.4	9.2	<0.001
Coronary angiography	45.5	64.4	<0.001
Percutaneous coronary intervention	20.1	42.5	<0.001
Coronary artery bypass grafting	9.4	9.2	<0.001
Surgical aortic valve replacement	5.9	0.1	<0.001
Transcatheter aortic valve replacement (from 2012)	0.4	0.0	<0.001
Coronary atherectomy (from 2012)	1.7	2.8	<0.001
Intra-aortic balloon pump	3.2	4.6	<0.001
Percutaneous left ventricular assist device	0.2	0.2	0.13
Extracorporeal membrane oxygenation	0.0	0.1	<0.001
Pulmonary artery catheterization	1.5	1.1	<0.001
Invasive mechanical ventilation	6.4	6.0	<0.001
Acute hemodialysis	0.8	0.6	<0.001

Represented as percentage.

Abbreviations: AMI: acute myocardial infarction; AS: aortic stenosis.

Table 3

Clinical outcomes of AMI admissions with and without AS.

Characteristic		AS (N = 513,668)	No AS (N = 11,108,860)	P
In-hospital mortality		9.2	6.0	<0.001
Length of stay (days)		5 (3–8)	3 (2–6)	<0.001
Palliative care consultations		2.8	1.2	<0.001
Do-not-resuscitate status		6.5	2.3	<0.001
Hospitalization costs (×1000 United States dollars)		33.6 (16.5–71.1)	39.6 (19.3–72.3)	<0.001
Discharge disposition	Home	44.6	63.3	<0.001
	Transfer	10.9	12.7	
	Skilled nursing facility	25.9	12.9	
	Home with home health care	18.1	10.2	
	Against medical advice	0.5	0.9	

Represented as percentage or median (interquartile range).

Abbreviations: AMI: acute myocardial infarction; AS: aortic stenosis.