

consistent upward trend in overall PCI numbers in those aged ≥ 90 years, with no change in in-hospital mortality. A recent study conducted among veterans showed a significant increase in proportion of patients ≥ 90 years undergoing PCI from 2008 to 2014.

The current study has certain limitations. As with any administrative dataset, the NIS database is liable to coding errors and incomplete or missing documentation. The data collected for the NIS database are related to PCI procedures specifically completed in inpatients; therefore procedures performed in an outpatient setting would not be represented in our study. Many useful data for our study could not be retrieved, that include clinical variables, medications information, laboratory data and long-term outcomes. Despite these limitations, this study fills the current gap in literature regarding the true volume and outcomes of PCI in the elderly in the United States.

Disclosures

The investigators have no conflicts of interest to disclose.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at <https://doi.org/10.1016/j.amjcard.2018.11.053>.

Ayman Elbadawi, MD^{a,b,*}

Islam Y. Elgendy, MD^c

Le Dung Ha, MD^d

Marwan Saad, MD, PhD^{e,b}

Karim Mahmoud, MD^f

Gbolahan O. Ogunbayo, MD^g

Paul Kumfa, MD^a

Umamahesh C. Rangasetty, MD^a

Syed Gilani, MD^a

^a Division of Cardiovascular Medicine, University of Texas Medical Branch, Galveston, TX

^b Department of Cardiovascular Medicine, Ain Shams University, Cairo, Egypt

^c Division of Cardiovascular Medicine, University of Florida, Gainesville, FL

^d Department of Cardiovascular Medicine, New York Presbyterian Brooklyn Methodist Hospital, Brooklyn, NY

^e Division of Cardiovascular Medicine, University of Arkansas for Medical Sciences, Little Rock AR

^f Department of Internal Medicine, Houston Medical Center, Warner Robbins, GA

^g Department of Cardiovascular Medicine, University of Kentucky, Lexington, KY

3 October 2018

12 November 2018

19 November 2018

- Antonsen L, Jensen LO, Thyssen P, Christiansen EH, Junker A, Tilsted H-H, Terkelsen CJ, Kalltoft A, Maeng M, Hansen KN. Comparison of outcomes of patients ≥ 80 years of age having percutaneous coronary intervention according to presentation (stable vs unstable angina pectoris/non-ST-segment elevation myocardial infarction vs ST-segment elevation myocardial infarction). *Am J Cardiol* 2011;108:1395–1400.
- Batchelor WB, Anstrom KJ, Muhlbaier LH, Grosswald R, Weintraub WS, O'Neill WW, Peterson ED, Collaboration NCN. Contemporary outcome trends in the elderly undergoing percutaneous coronary interventions: results in 7,472 octogenarians. *J Am Coll Cardiol* 2000;36:723–730.
- Taddei S, Virdis A, Mattei P, Ghiadoni L, Gennari A, Fasolo CB, Sudano I, Salvetti A. Aging and endothelial function in normotensive subjects and patients with essential hypertension. *Circulation* 1995;91:1981–1987.
- Solhpour A, Chang K-W, Balan P, Cai C, Sdringola S, Denktas AE, Smalling RW, Anderson HV. Comparison of outcomes for patients ≥ 75 years of age treated with pre-hospital reduced-dose fibrinolysis followed by percutaneous coronary intervention versus percutaneous coronary intervention alone for treatment of ST-elevation myocardial infarction. *Am J Cardiol* 2014;113:60–63.
- Team RC. *R: A Language and Environment for Statistical Computing*. Vienna, Austria: R Foundation for Statistical Computing; 2015. URL <http://www.R-project.org>. Accessed June 25, 2015.
- Pinheiro J, Bates D, DebRoy S, Sarkar D. R Core Team (2014) nlme: linear and nonlinear mixed effects models. <http://CRAN.R-project.org/package=nlme>; 2014.
- Boden WE, O'Rourke RA, Teo KK, Hartigan PM, Maron DJ, Kostuk WJ, Knudtson M, Dada M, Casperson P, Harris CL. Optimal medical therapy with or without PCI for stable coronary disease. *N Engl J Med* 2007;356:1503–1516.
- Group BDS. A randomized trial of therapies for type 2 diabetes and coronary artery disease. *N Engl J Med* 2009;209:2503–2515.
- Kumbhani DJ, Marso SP. Inpatient or outpatient status for elective percutaneous coronary intervention. 2016.
- Bangalore S, Gupta N, Généreux P, Guo Y, Pancholy S, Feit F. Trend in percutaneous coronary intervention volume following the COURAGE and BARI-2D trials: insight from over 8.1 million percutaneous coronary interventions. *Int J Cardiol* 2015;183:6–10.
- Pothineni NV, Shah NN, Rochlani Y, Nairouz R, Raina S, Leeser MA, Uretsky BF, Hakeem A. US trends in inpatient utilization of fractional flow reserve and percutaneous coronary intervention. *J Am Coll Cardiol* 2016;67:732–733.
- Schoenenberger AW, Radovanovic D, Stauffer JC, Windecker S, Urban P, Eberli FR, Stuck AE, Gutzwiller F, Erne P. Age-related differences in the use of guideline-recommended medical and interventional therapies for acute coronary syndromes: a cohort study. *J Am Geriatr Soc* 2008;56:510–516.
- Johnman C, Oldroyd KG, Mackay DF, Slack R, Pell AC, Flapan AD, Jennings KP, Eteiba H, Irving J, Pell JP. Percutaneous coronary intervention in the elderly: changes in case-mix and periprocedural outcomes in 31 758 patients treated between 2000 and 2007. *Circ Cardiovasc Interv* 2010;3:341–345.
- Bromage DI, Jones DA, Rathod KS, Grout C, Iqbal MB, Lim P, Jain A, Kalra SS, Crake T, Astroulakis Z. Outcome of 1051 octogenarian patients with ST-segment elevation myocardial infarction treated with primary percutaneous coronary intervention: observational cohort from the London Heart Attack Group. *J Am Heart Assoc* 2016;5:e003027. <https://doi.org/10.1016/j.amjcard.2018.11.053>

Trends of Uptake and In-Hospital Mortality for Transcatheter Aortic Valve Implantation Versus Surgical Aortic Valve Replacement in Nonagenarians



Several large multicenter randomized trials have documented that transcatheter aortic valve implantation (TAVI) is a reasonable alternative for surgical aortic valve replacement (SAVR) in intermediate to high-risk patients.^{1,2} However, nonagenarians were underrepresented in these trials. As the incidence of severe aortic stenosis increases with age and the proportion of nonagenarian patients rises in the United States, we sought to investigate the temporal trends in the rates of use and in-hospital mortality of TAVI versus SAVR in this growing population.

Data were obtained from the National Inpatient Sample database from 2012 to 2015. The corresponding International Classification of Diseases procedure codes-9 and 10 were used to identify records for TAVI versus SAVR in nonagenarians. To focus on those who underwent SAVR primarily for severe aortic stenosis, we excluded records of patients with aortic insufficiency (without aortic stenosis), and those who underwent other concomitant cardiac surgery such as coronary artery bypass grafting, mitral valve, tricuspid, or pulmonary valve surgeries. The trend weights were developed to account for the stratified sampling design of the National Inpatient Sample. The trends of total TAVI and SAVR performed each year, and the rates of in-hospital mortality for TAVI

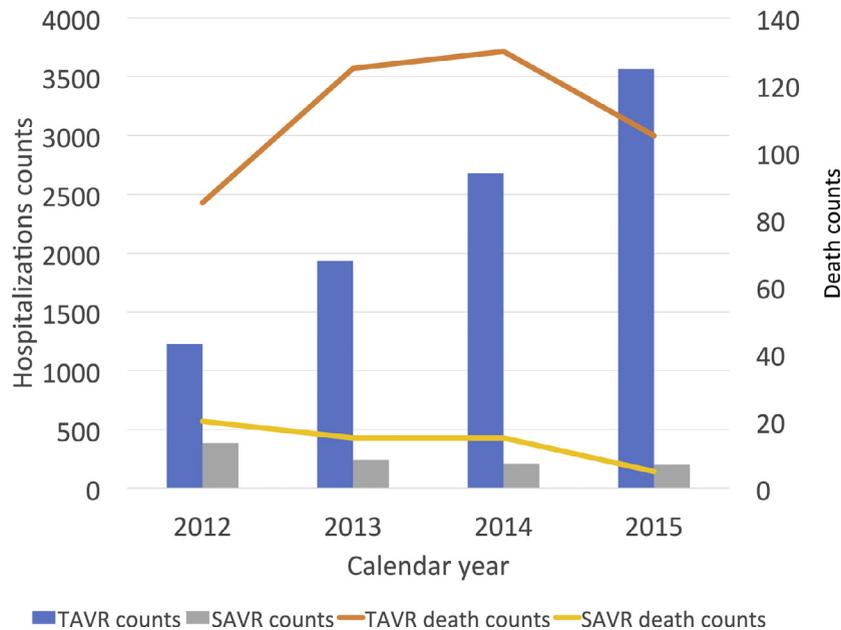


Figure 1. Temporal trends of nonagenarians undergoing surgical (silver bars) and transcatheter (blue bars) aortic valve replacement in the United States from 2012 to 2015. There was a steady increase in the numbers of TAVIs from 2012 to 2015 and a decrease in the number of SAVRs ($p < 0.01$); temporal trends of in-hospital mortality for surgical (yellow line) versus transcatheter (orange line) aortic valve replacement in nonagenarians in the United States from 2012 to 2015. There was a steady decrease of in-hospital mortality for TAVI ($p < 0.01$), but in-hospital mortality with SAVR remained unchanged ($p = 0.40$). Color version of figure is available online.

and SAVR were compared using a linear function comparison. A 2-sided p value of < 0.05 was considered statistically significant.

In 10,445 AVRs performed among nonagenarians during the study period, 9,405 (90.0%) were TAVI and 1,040 (10.0%) were SAVR. There was a significant increase in the number of TAVIs performed over time: from 1,225 procedures in 2012 to 3,565 procedures in 2015, $p < 0.01$. This was associated with a corresponding decrease in the number of SAVR: 385 procedures in 2012 versus 200 procedures in 2015 $p < 0.01$ (Figure 1). The increase in the proportion of TAVI procedures was noted in both men and women ($p < 0.01$). In-hospital mortality for TAVI has decreased from 6.9% in 2012 to 2.9% in 2015, $p < 0.01$, while SAVR in-hospital mortality did not change over time (5.2% in 2012 to 2.5% in 2015, $p = 0.40$) (Figure 1). Rates of in-hospital mortality were similar between TAVI and SAVR in 2015.

In this nationwide analysis of a real-world cohort of nonagenarians referred for AVR, the proportion of TAVI has been increasing annually, accompanied with a steady decrease in the number of SAVR procedures. The upsurge in TAVI procedures was observed irrespective of

sex. A previous analysis of the Society of Thoracic Surgeons/American College of Cardiology Transcatheter Valve Therapy registry indicated that the mortality with TAVI nonagenarians is only modestly elevated compared with their younger counterparts,³ and the current report extends these findings by showing that the rates of in-hospital mortality steadily decreased with TAVI in nonagenarians from 2012 to 2015. This deflection started in 2013 and continued to improve. This is likely attributable to many factors, including a more appropriate patient selection for TAVI, improved techniques and devices, and increased operators' experience.

It is notable that the rate of in-hospital mortality with SAVR was 2.5% in 2015, as opposed to 7.1% in 2014. While the trend was not statistically significant, the number of nonagenarians who underwent SAVR was very small (only 200), and it is plausible that in contemporary practices only a very selective group of "healthier" nonagenarians are undergoing SAVR.

This study is limited by the administrative nature of the database, which is subject to coding errors and lacks data regarding the clinical decision making for undergoing TAVI or SAVR. Despite these limitations, this study

provides important insights into the landscape of AVR in nonagenarians in the United States.

Disclosures

The authors have no conflicts of interest to disclose.

Islam Y. Elgendy, MD^{a,*}
 Ahmed N. Mahmoud, MD^a
 Ayman Elbadawi, MD^b
 Akram Y. Elgendy, MD^a
 Dhruv Mahтта, MD^a
 Mohamed A. Omer, MD^c
 Mohammad K. Mojadidi, MD^d
 Molly Szerlip, MD^e
 Hani Jneid, MD^f

^a Division of Cardiovascular Medicine, Department of Medicine, University of Florida, Gainesville, Florida

^b Department of Cardiovascular Medicine, University of Texas Medical Branch, Galveston, Texas

^c Saint Luke's Mid America Heart Institute/University of Missouri—Kansas City, Kansas City, Missouri

^d Division of Cardiovascular Medicine, Department of Medicine, Virginia Commonwealth University, Richmond, Virginia

^e Department of Interventional Cardiology, the Heart Hospital Baylor Plano, Plano, Texas

^f Division of Cardiovascular Medicine, Baylor College of Medicine, Houston, Texas

16 November 2018

14 December 2018

1. Leon MB, Smith CR, Mack MJ, Makkar RR, Svensson LG, Kodali SK, Thourani VH, Tuzcu EM, Miller DC, Herrmann HC, Doshi D, Cohen DJ, Pichard AD, Kapadia S, Dewey T, Babaliaros V, Szeto WY, Williams MR, Kereiakes D, Zajarias A, Greason KL, Whisenant BK, Hodson RW, Moses JW, Trento A, Brown DL, Fearon WF, Pibarot P, Hahn RT, Jaber WA, Anderson WN, Alu MC, Webb JG. Transcatheter or surgical aortic-valve replacement in intermediate-risk patients. *N Engl J Med* 2016;374:1609–1620.
2. Reardon MJ, Van Mieghem NM, Popma JJ, Kleiman NS, Sndergaard L, Mumtaz M, Adams DH, Deeb GM, Maini B, Gada H, Chetcuti S, Gleason T, Heiser J, Lange R, Merhi W, Oh JK, Olsen PS, Piazza N, Williams M, Windecker S, Yakubov SJ, Grube E, Makkar R, Lee JS, Conte J, Vang E, Nguyen H, Chang Y, Mugglin AS, Serruys PW, Kappelein AP. Surgical or transcatheter aortic-valve replacement in intermediate-risk patients. *N Engl J Med* 2017;376:1321–1331.
3. Arsalan M, Szerlip M, Vemulapalli S, Holper EM, Arnold SV, Li Z, DiMaio MJ, Rumsfeld JS, Brown DL, Mack MJ. Should transcatheter aortic valve replacement be performed in nonagenarians? Insights from the STS/ACC TVT registry. *J Am Coll Cardiol* 2016;67:1387–1395.

<https://doi.org/10.1016/j.amjcard.2018.12.002>