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RESEARCH LETTER

Impact of Hospital Procedural Volume on Use and Outcomes of Urgent/Emergent Transcatheter Aortic Valve Replacement

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Urgent/emergent transcatheter aortic valve replacement (TAVR) has emerged as a feasible option for patients presenting with cardiogenic shock or decompensated heart failure. Because urgent/emergent TAVR has been shown to be associated with worse in-hospital complications and higher mortality rates compared with elective procedures,[1,2] it is important to understand if hospital volume has an impact on the use and outcomes of urgent/emergent TAVR.

This study was exempted from the approval of the institutional review board because it used anonymized and deidentified data in a publicly available database. Authors will make the data, methods used in the analysis, and materials used to conduct the research available to any researcher for purposes of reproducing the results or replicating the procedure.

We identified all hospitalizations in patients undergoing TAVR from 2014 to 2017 in the United States using the National Inpatient Sample database. Patients aged <18 years and hospitals performing <5 overall TAVR procedures/year were excluded. The procedure was categorized as "urgent/emergent" if the admission was not designated as elective in the National Inpatient Sample. The outcomes included urgent/emergent TAVR rates in the study population and risk-adjusted in-hospital mortality, stroke, acute kidney injury, vascular complications, need for blood transfusion, permanent pacemaker implantation, and length of stay among the patients undergoing urgent/emergent TAVR. Annualized hospital volume of overall TAVR procedures for urgent/emergent TAVR rates and annualized hospital volume of urgent/emergent TAVR procedures for mortality and other mentioned outcomes were analyzed as both continuous and categorical variable (in tertiles). Tertiles were chosen to ensure equal number of hospitalizations in each volume category. Restricted cubic splines were used to assess the potential nonlinear relationship between annual hospital volume and outcomes. Hierarchical models were created with hospital characteristics incorporated as random effects within the model. The statistical analysis was conducted using R version 3.6.4.

Our unweighted cohort included a total of 25 933 procedures from 2014 to 2017, of which 5296 (20.42%) were urgent/emergent TAVRs. There were a total of 8949 hospitalizations in tertile 1 (low-volume hospitals; median number of TAVR procedures, 13 [interquartile range, 9–17]), a total of 8582 hospitalizations in tertile 2 (medium-volume hospitals; median number of TAVR procedures, 29 [interquartile range, 25–35]), and a total of 8404 hospitalizations in tertile 3 (high-volume hospitals; median number of TAVR procedures, 56 [interquartile range, 47–76]). Overall urgent/emergent TAVRs were more frequently performed in tertile 3 hospitals compared with tertiles 2 and 1: 22.90% versus 20.19% versus 17.37%, respectively (adjusted odds ratio [aOR] with tertile 1 as reference: tertile 2, 1.029 [95% CI, 1.024–1.034] [P<0.001]; and tertile 3, 1.057 [95% CI, 1.052–1.062] [P<0.001]).

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Among patients undergoing urgent/emergent TAVR, adjusted in-hospital mortality was significantly higher in hospitals with low-volume urgent TAVR (UT1) compared with hospitals having medium-volume urgent TAVR (UT2) and high-volume urgent TAVR (UT3): 4.32% versus 2.82% versus 2.28%, respectively (aOR with UT1 as reference: UT2, 0.660 [95% CI, 0.452–0.951] [*P*=0.028]; and UT3, 0.511 [95% CI, 0.345–0.745] [*P*<0.001]). Adjusted stroke rates were lower in UT3 hospitals (UT1, 1.65%; UT2, 1.28%; UT3, 1.19%; aOR with UT1 as reference: UT2, 0.996 [95% CI, 0.995–0.998] [*P*<0.001]; and UT3, 0.995 [95% CI, 0.994–0.997] [*P*<0.001]). Similarly, adjusted acute kidney injury, vascular complications, and mean length of stay were lower in UT3 hospitals (acute kidney injury: UT1, 30.23%; UT2, 26.91%; UT3, 23.28%; aOR with UT1 as reference: UT2, 0.850 [95% CI, 0.733–0.985] [*P*=0.031]; and UT3, 0.700 [95% CI, 0.605–0.810] [*P*<0.001]; vascular complications: UT1, 4.33%; UT2, 4.06%; UT3, 3.96%; aOR with UT1 as reference: UT2, 0.997 [95% CI, 0.994–1.000] [*P*=0.089]; and UT3, 0.996 [95% CI, 0.994–0.999] [*P*=0.007]; and mean length of stay: UT1, 11.46 [5.39]; UT2, 11.46 [5.76]; and UT3, 10.10 [5.61] [*P*<0.001]). However, there was no significant difference in adjusted blood transfusion and permanent pacemaker implantation rates across hospitals (Figure).

Although the data are replete for procedural volume-outcome relationship for TAVR,[3,4] there are limited data on the relationship between hospital volume and outcomes among patients undergoing urgent/emergent TAVR. High-volume hospitals had higher rates of urgent/emergent TAVR procedures in comparison with low- and medium-volume hospitals, and use of urgent/emergent procedures increased significantly with annual hospital volume. Decreased rates of in-hospital mortality, stroke, vascular complications, acute kidney injury, and length of stay in UT3 hospitals can be attributed to improved procedural experience of interventionalists and increased experience of managing postprocedure complications, which are common after urgent TAVR.[2] Our results resonate with the transcatheter valve therapy data,[3,4] which showed lower mortality rates in high-volume institutions. Prior studies[4] have failed to demonstrate volume-stroke relationship for overall TAVR procedures; however, decreased stroke rates in high-volume hospitals for urgent/emergent

	Tertile 1 (Low-volume TAVR)	Tertile 2 (Medium-volume TAVR)	Tertile 3 (High-volume TAVR)
Number of hospitalizations	8949	8582	8404
Median number of procedures (IQR)	13 (9-17)	29 (25-35)	56 (47-76)
Utilization of Urgent/Emergency TAVR	17.37%	20.19%	22.90%
	Urgent Tertile 1 (Low-volume urgent TAVR)	**Urgent Tertile 2 (Medium-volume urgent TAVR)**	**Urgent Tertile 3 (High-volume urgent TAVR)**
Number of hospitalizations	2013	1526	1757
Median number of urgent TAVR procedures, IQR	4 (2-5)	10 (8-12)	24 (19-33)
Adjusted Mortality*	4.32%	2.82%	2.28%
Adjusted odds ratio, p-value	Reference	0.660 (0.452-0.951), P=0.028	0.511 (0.345-0.745), P<0.001
Adjusted Stroke*	1.65%	1.28%	1.19%
Adjusted odds ratio, p-value	Reference	0.996 (0.995-0.998), p<0.001	0.995 (0.994-0.997), p<0.001
Adjusted Acute kidney injury*	30.23%	26.91%	23.28%
Adjusted odds ratio, p-value	Reference	0.850 (0.733-0.985), P=0.031	0.700 (0.605-0.810), P<0.001
Adjusted vascular complications*	4.33%	4.06%	3.96%
Adjusted odds ratio, p-value	Reference	0.997 (0.994-1.000), P=0.089	0.996 (0.994-0.999), P=0.007
Adjusted Blood transfusion*	15.64%	14.71%	16.94%
Adjusted odds ratio, p-value	Reference	0.930 (0.771-1.119), P=0.443	1.100 (0.925-1.309), P=0.279
Adjusted pacemaker implantation*	10.28%	11.43%	10.65%
Adjusted odds ratio, p-value	Reference	1.126 (0.909-1.394), P=0.275	1.041 (0.844-1.282), P=0.709
Length of stay, mean (SD)	11.46 (5.39)	11.46 (5.76)	10.10 (5.61)

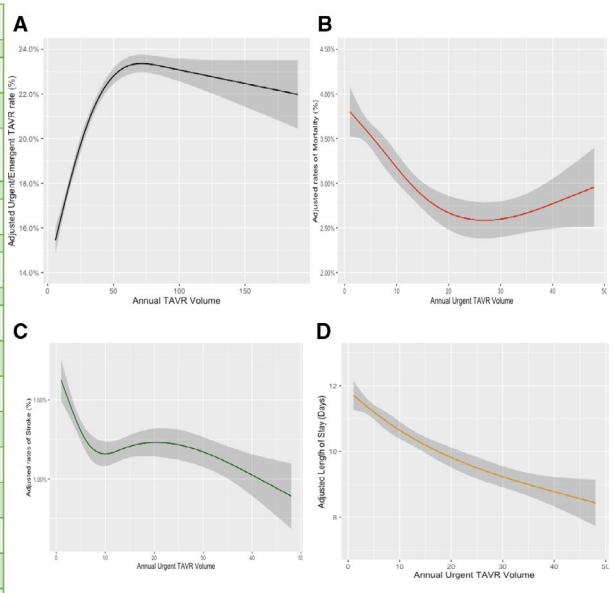

Figure. Impact of hospital volume on use and outcomes of urgent/emergent transcatheter aortic valve replacement (TAVR). *Adjusted for the following variables: *Patient characteristics:* age, sex, diabetes mellitus, hypertension, dyslipidemia, coronary artery disease, carotid artery disease, peripheral vascular disease, anemia, heart failure, chronic lung disease, chronic kidney disease (CKD) stage 1 to 2, CKD stage 3, CKD stage 4, CKD stage 5, end-stage renal disease requiring dialysis, coagulopathy, cardiac arrhythmias, lymphoma, metastatic cancer, solid tumor without metastasis, obesity, smoking, liver cirrhosis, percutaneous coronary intervention, TAVR access, cardiogenic shock, malnutrition, and use of mechanical circulatory support device. *Hospital characteristics:* hospital bed size, hospital teaching status, and hospital region. **A**, Restricted cubic spline showing the association of urgent/emergent TAVR rates based on hospital annual TAVR volume. **B**, Restricted cubic spline showing the association of adjusted in-hospital mortality rates based on hospital annual urgent TAVR volume. **C**, Restricted cubic spline showing the association of adjusted stroke rates based on hospital annual urgent TAVR volume. **D**, Restricted cubic spline showing the association of adjusted length of stay based on hospital annual urgent TAVR volume. IQR indicates interquartile range.

TAVR can be attributed to improved operator experience. There were no significant differences in the permanent pacemaker implantation rates with hospital volume. Permanent pacemaker implantation depends on several factors,[5] including leaflet calcium distribution, membranous septum height, type of valve, depth of implantation, and others, which are not accounted for in the National Inpatient Sample database.

Some strengths of the present study include treating annualized hospital volume as a continuous variable with adequate adjustment for the potential confounding factors. However, our study is inherently limited by its reliance on administrative reporting and inability to determine indications of urgent/emergency TAVR, procedural characteristics, device type, valve-in-valve TAVR, operator experience, and long-term outcomes.

We conclude that high-volume hospitals perform more urgent/emergent TAVR procedures and hospitals with higher volume of urgent/emergent TAVR procedures have significantly improved outcomes with decreased in-hospital mortality, stroke, and other complications.

ARTICLE INFORMATION

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REFERENCES

1. Kolte D, Khera S, Vemulapalli S, Dai D, Heo S, Goldsweig AM, Aronow HD, Elmariah S, Inglessis I, Palacios IF, et al. Outcomes following urgent/emergent transcatheter aortic valve replacement: insights from the STS/ACC TVT registry. *JACC Cardiovasc Interv*. 2018;11:1175–1185. DOI: 10.1016/j.jcin.2018.03.002.
2. Elbadawi A, Elgendy IY, Mentias A, Saad M, Mohamed AH, Choudhry MW, Ogunbayo GO, Gilani S, Jneid H. Outcomes of urgent versus nonurgent transcatheter aortic valve replacement. *Catheter Cardiovasc Interv*. 2020;96:189–195. DOI: 10.1002/ccd.28563.
3. Vemulapalli S, Carroll JD, Mack MJ, Li Z, Dai D, Kosinski AS, Kumbhani DJ, Ruiz CE, Thourani VH, Hanzel G, et al. Procedural volume and outcomes for transcatheter aortic-valve replacement. *N Engl J Med*. 2019;380:2541–2550. DOI: 10.1056/NEJMsa1901109.
4. Carroll JD, Vemulapalli S, Dai D, Matsouaka R, Blackstone E, Edwards F, Masoudi FA, Mack M, Peterson ED, Holmes D, et al. Procedural experience for transcatheter aortic valve replacement and relation to outcomes: the STS/ACC TVT registry. *J Am Coll Cardiol*. 2017;70:29–41. DOI: 10.1016/j.jacc.2017.04.056.
5. Kapadia SR, Wazni O, Krishnaswamy A. Pacemaker implantation after TAVR. *JACC Cardiovasc Imaging*. 2017;10:1148–1150. DOI: 10.1016/j.jcmg.2016.09.032.