Outcomes of Patients Undergoing Transcatheter Aortic Valve Implantation With Incidentally Discovered Masses on Computed Tomography

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Routine preprocedural chest and abdomen computed tomography is done prior to transcatheter aortic valve implantation (TAVI), which, in turn, have led to the discovery of radiographic potentially malignant incidental masses (pMIM). It is largely unknown whether pMIM impact the outcomes of patients undergoing TAVI. In this retrospective cohort study from a single center, 1,081 patients underwent TAVI from 2012 to 2016, who had available computed tomographies, survived the index hospitalization, and also had 1 year follow-up data for review. Machine learning (backward propagation neural network)—augmented multivariable regression for mortality by pMIM was conducted. In this cohort of 1,081 patients, the mean age was 79.1 (± 9.0), 48.8% were females, 16.8% had a history of prior malignancy, and 21.1% had pMIM. One-year mortality for the entire cohort was 12.6%. The most common prior malignancies were prostate, breast, and lymphoma and the most common pMIM were present in the lung, kidneys, and thyroid. In a fully adjusted regression analysis, neither prior malignancy nor pMIM increased mortality odds. However, having both was associated with a higher 1-year mortality (odds ratio 4.02, 95% confidence interval 1.50 to 10.73, p = 0.006). In conclusion, presence of pMIM alone was not associated with an increased 1-year mortality among patients undergoing TAVI. However, the presence of pMIM and a history of prior malignancy was associated with a significant increase in 1-year mortality. **(Am J Cardiol 2020;132:114−118)**

Indications for transcatheter aortic valve implantation (TAVI) are rapidly expanding. Gated computed tomography (CT) of the chest, abdomen, and pelvis has become a standard method for evaluation prior to TAVI for procedural planning.[1] The majority of the patients who undergo TAVI are elderly.[2,3] As a result, multiple radiographic potentially malignant incidental masses (pMIM) are detected in otherwise asymptomatic patients.[4−6] Since TAVI is recommended to be performed only if the expected survival of these patients is more than a year, the finding of pMIM introduces a potential dilemma since it is not well known how its presence may impact outcomes of these patients. Only a few small studies have reported outcomes on the patients with pMIM undergoing TAVI,[3,7−13] and the data from larger cohorts with long-term follow-up is lacking. Given the decision-making implications of such pMIM in patients evaluated for TAVI, it is critical to understand their impact on outcomes and particularly on mortality. In this retrospective study, we examined the outcomes of patients with pMIM undergoing TAVI.

Methods

This is a retrospective cohort study from a single high-volume tertiary center.

Inclusion criteria were all adults who underwent TAVI from January 2012 to December 2016. Only patients who survived the index hospitalization, had available CT images, and 1-year follow-up data for review were included for further analysis. All CTs were screened for pMIM by a board-certified radiologist prior to TAVI evaluation. There is no single definition of pMIM but rather dependent on the history, location, size and characteristics of the mass. Furthermore, all pMIM were classified with appropriate follow-up imaging recommendations based on American College of Radiology guidelines. For masses that were most likely malignant, oncology team was consulted for further evaluation. A heart team, including interventional and imaging cardiologists, and cardiothoracic surgeons made the final decision regarding treatment options. Baseline characteristics, procedural data and outcome data were also collected. Follow-up outpatient visit data were collected at 30 days, and 12 months post TAVI. The primary outcome was 1-year mortality. The study was reviewed and

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approved by the Institutional Review Board of the University of Texas Health Science Center, Houston, Texas.

All CT examinations were performed on a 64-slice CT scanner (Toshiba Aquilion 64, Toshiba Medical Systems, Tustin, California) using retrospective ECG-gated helical acquisition and the following scan parameters: 400 ms gantry rotation time, detector collimation 0.5 mm, tube voltage of 100 to 120 kVp and tube current of 500 mA. Two scout views of the thorax and abdomen (from mandible to pubic symphysis) were taken prior to data acquisition, followed by gated contrast-enhanced cardiac imaging and arterial phase of a second nongated scan. One minute later, a venous phase of chest and the abdomen and pelvis was acquired. A total of 150 mL of contrast agent (Omnipaque 350 or Visipaque 320) was administered intravenously at a flow rate of 5 mL/s, followed by 50 mL of saline bolus chaser.

We used Stata/IC -14.2 (College Station, StataCorp LP, College Station, Texas) for our analysis. Descriptive statistics were performed for the entire sample. Bivariable analysis based on 1-year mortality was separately conducted using independent sample t-test comparing means. Machine learning (backward propagation neural network)—augmented multivariable regression for mortality by pMIM was conducted. Wilcoxon rank sum tests were used to compare medians for continuous variables as appropriate, and Pearson's chi-square test or Fisher's exact test were used to compare proportions for categorical variables as appropriate. Forward and backward stepwise regression augmented multivariable regression was conducted in 3 phases.

First, statistically significant results from bivariable analysis and those identified as clinically significant were considered for possible inclusion in the final regression models. Next, those variables were run through stepwise forward and backward regression to support statistical and clinical determination of final model inclusion. Hosmer-Lemeshow's goodness-of-fit test, Akaike's and Schwarz's Bayesian information criteria, and area under the curve were utilized to determine if the final models fit the data well. All regression estimates with 95% confidence intervals (CIs) are reported as fully adjusted results. Finally, Kaplan Meier curves were constructed based on the days from TAVI to death with log-rank test for equality of curves. Statistical significance was set at 2-tailed p value <0.05.

Results

A total of 1,177 patients underwent TAVI from 2012 to 2016. Of those, 1,081 patients survived the index hospitalization, had available CTs and 1 year follow-up, and hence were included in the final analysis. For the 1,081 patients, mean age was 79.1 (±9.0), 16.8% had prior malignancy, and 21.1% had pMIM. Of the 228 patients with pMIM, 18.9% had prior history of malignancy. The most common prior malignancies were prostate, breast, and lymphoma and the most common pMIM locations were lung, kidneys, and thyroid in that order. All patients with prior malignancies were in remission when being evaluated for TAVI. There were 228 (21.1%) patients with pMIM, and they were significantly more likely to have a history of Non-Hodgkin's lymphoma (2.6% vs 0.7%, p = 0.014) if they had a prior malignancy.

Total 1-year mortality for the cohort was 12.6% (Table 1). In patients with pMIM, crude mortality was 40 (17.5%), compared with 90 (10.6%) in patients without pMIM. In fully adjusted regression analysis controlling for age, sex, race, and Society of Thoracic Surgery risk score, prior malignancy and pMIM did not separately increase the odds of 1-year mortality. But the mortality was significantly higher when pMIM was present in patients with history of prior malignancy (odds ratio 4.02, 95% CI 1.50 to 10.73, p = 0.006) (Table 2). In sub-group regression analysis by prior malignancy or pMIM type, no specific malignancy or location of pMIM significantly increased the mortality odds. The Kaplan-Meier analysis for mortality is depicted in Figure 1.

A limited number of patients with pMIM underwent further work up before or soon after the TAVI, based on the

Table 1
Descriptive and bivariable analysis by 1-year mortality (n = 1,081)

Variables		1-year mortality		p Value
	Sample (n= 1,081)	No (n = 945)	Yes (n = 136)	
Age, mean (SD) (years)	79.1 (9.0%)	78.85 (9.1%)	81.1 (8.0%)	0.007
Female	525 (48.8%)	472 (50.2%)	53 (39.0%)	0.015
White	845 (79.4%)	725 (78.0%)	120 (88.9%)	
Black	56 (5.3%)	55 (5.9%)	1 (0.7%)	
Hispanic	150 (14.1%)	136 (14.6%)	14 (10.4%)	
Other	13 (1.2%)	13 (1.4%)	0	
STS Score, median (range)	8.2 (5.1-11.3)	8.1 (4.96-10.9)	9.9 (7.0-13.5)	<0.001
Prior malignancy	181	150	31	0.044
Prostate	34	26	8	0.050
Breast	28	26	2	0.565
NHL	12	11	1	1.000
pMIM	228	188	40	0.011
Lung	110	93	17	0.338
Renal	51	41	10	0.121
Thyroid	33	26	7	0.129

pMIM = potentially malignant incidental mass; STS = Society of Thoracic Surgery.

Table 2
Multivariable regression of 1-year mortality (n = 1,081)

Predictor	Odds Ratio (95% CI; p Value)
Age (10-year intervals)	1.02 (1.00-1.04; p = 0.069)
Female	0.62 (0.42-0.90; p = 0.013)
Non-White	0.21 (0.06-0.67; p = 0.008)
Prior malignancy	1.01 (0.56-1.82; p = 0.970)
pMIM	1.19 (0.73-1.94; p = 0.490)
pMIM + Prior malignancy	4.02 (1.51-10.73; p = 0.006)
STS score	1.05 (1.02-1.08; p = 0.001)

pMIM = potentially malignant incidental mass ; STS = Society of Thoracic Surgery.

Table 3
Descriptive and bivariable analysis by 1-year mortality (n = 1,081)

Variable	Sample n	1-year mortality		p Value
		No	Yes	
pMIM	228	188	40	0.011
pMIM + Prior malignancy	43	28	15	0.001
Prior malignancy	181	150	31	0.044
Prior + Active malignancy	27	22	5	0.835
Active malignancy	27	22	5	0.347
Malignancy by biopsy				0.769
None	3	3	0	
Neuroendocrine	1	1	0	
Lung	1	1	0	
Bladder	1	1	0	
Liver	1	1	0	
B-cell lymphoma	2	1	1	
Colon	2	2	0	
Renal	2	2	0	
Subsequent treatment	17	17	0	0.147
Surgery	11	11	0	
Chemotherapy	9	9	0	
Radiation	1	1	0	

pMIM = potentially malignant incidental mass.

evaluation and recommendations from an oncologist. Out of 228 patients with pMIM, 27 patients were found to have active malignancy. The patients then appropriately underwent required treatment and surveillance prior to TAVI (Table 3). Identification of new active malignancy did not affect 1-year mortality. In fully adjusted regression model using the same variables as in the previously mentioned models with the additional variable of the interaction term between active and prior malignancy, there was neither significant association between 1-year mortality and active malignancy, nor with having both active and prior malignancy.

Discussion

This is a large study of TAVI subjects demonstrating that pMIM detected during the preprocedural work-up do not increase 1-year mortality after TAVI in patients with no prior history of malignancy. This supports findings from prior small studies showing that the vast majority of pMIM are nonmalignant (95.6% of cases in our study).

With the favorable results of low risk TAVI trials,[14,15] it is expected that the number of TAVIs performed will increase. As a result, more pre-TAVI CTs will be performed leading to the increasing diagnosis of pMIM. Physicians face a dilemma as some pMIM may require additional workup delaying TAVI. Often, it is not possible to prognosticate these patients without a tissue diagnosis. Risk stratification for the invasive biopsy procedure in patients with symptomatic AS can be challenging and remains at the discretion of the treating physician and oncologist, in the absence of specific guidelines.

Most patients are at high risk for peri-procedural complications for any invasive biopsies. Therefore, more often, TAVI is recommended and performed prior to a definitive diagnosis and treatment of underlying pMIM.

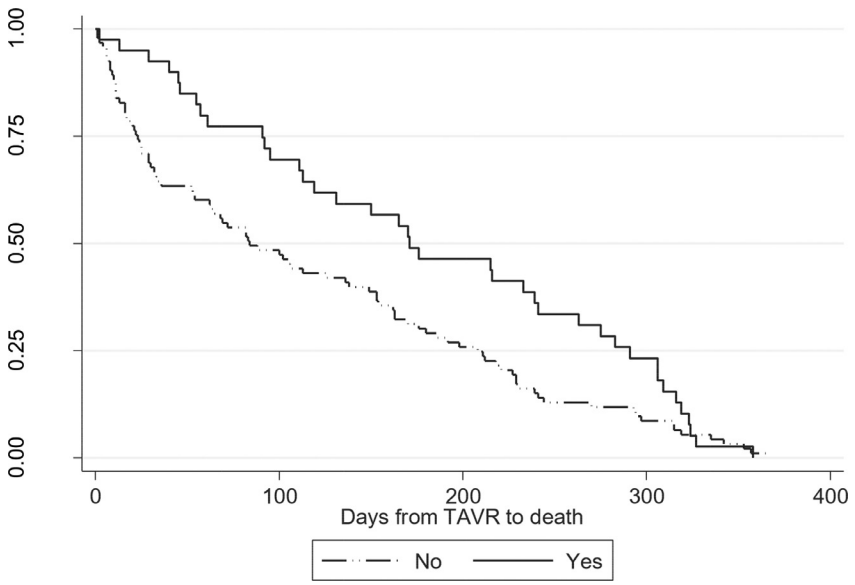

Figure 1. Kaplan-Meier analysis from TAVI to death within 1-year by potentially malignant incidental mass (n = 1,081). Log-rank test for equality of curves: 40 for potentially malignant incidental mass versus 96 for no mass, p = 0.663. Median days (range) to death: 215 (91 – 316) for mass versus 153 (29 – 319) for no mass, p = 0.163.

In our cohort, 21.1% of patients undergoing TAVI had pMIM and 4.4% of those were found to be malignant. This prevalence is similar to previously published studies with 23.7% noncardiovascular incidental findings and 3.8% highly suspicious malignant findings.[11,16,17] Clinical significance of pMIM as it relates to additional diagnostic workup or prognosis remains unclear. Recently, several diagnostic algorithms were proposed[18,19] that may benefit the typical elderly, symptomatic TAVI patients, with multiple comorbidities. In such patients, it is critical to expedite the workup in order to proceed with the appropriate therapy in a timely manner.

Noncardiac clinically significant findings have been reported in 1.2% to 28.0% of cardiac CT examinations.[20] In 1 study, Solitary pulmonary nodules (<3 cm) was found in 18.0% of the subjects who underwent TAVI; no difference in mortality was noted at 1 year.[13,20] In our study, we noted Solitary pulmonary nodules incidence of 10.2% which is likely due to lower incidence of smoking (32% in our cohort vs 52% in the other study).

In another study, the rate of prior malignancy in the TAVI group was 19.1%. Having prior malignancy alone did not increase the risk of mortality in patients undergoing TAVI. However, if the prior malignancy was within 1 year of TAVI, mortality was increased.[21] In our study, the patients with pMIM experienced higher mortality if they also had prior history of malignancy.

In 1 study, selected active cancer patients with severe AS who underwent TAVI had similar survival rates compared with patients without cancer.[22] Patients with active cancer also experienced better survival than medical therapy along group, regardless of cancer type or cancer treatment.[10] Although we did not focus on patients with active cancer in our study due to limited numbers, it is reassuring that these patients also had favorable outcomes.

Our data show that mortality is not significantly different in patients with pMIM and severe AS undergoing TAVI. However, in patients with history of malignancy and pMIM, 1-year mortality is increased. Our study suggests that clinicians may be reasonably assured about the absence of mortality benefit for extensive pre-TAVI workup of a pMIM, particularly if the patient does not have a prior history of malignancy.

There are several limitations to our study. First, the study is a single center study and includes only patients who underwent TAVI. This introduces selection bias, which is unavoidable due to the single center nature of the study. Data were not available for patients who were deemed poor candidates, based due to either nonsuitable anatomy for TAVI, or widespread nature of the pMIM.

Secondly, mass size was not available. However, majority of the patients with pMIM were evaluated by medical oncologist and patient's history, size and location of mass (es) were taken into consideration prior to TAVI.

In addition, cause of death and rate of re-hospitalization was not available. We also do not have information about newly diagnosed cancer in patients without pMIM post TAVI. Furthermore, most patients with pMIM did not get biopsy, due to small size of the mass. Therefore, it is unknown if those lesions were truly benign.

Single arterial phase was scanned during the body CTA and certain tumors of liver, pancreas, colorectal, prostate, kidney and bladder may have been missed.[9,11]

In conclusion, preprocedural TAVI planning requires a chest and abdomen CT which leads to the discovery of pMIM. Expanding indications for TAVI will lead to more CTs, thus increasing incidence of pMIM. Our data indicate that after careful consideration of risks and benefits discussion with heart team, patients with pMIM can proceed with TAVI. However, patients with prior malignancy and pMIM were associated with increase in 1-year mortality and additional workup prior to TAVI is recommended.

Authors' contributions

All authors have contributed to the study as details below:

Ghotra and Monlezun: Design, analysis and interpretation of data, drafting of the manuscript with final approval of the manuscript submitted.

Boone, Jacob, Poosti, and Johnson and Zhao: Input on data analysis, manuscript critical revision for important intellectual content with final approval of the manuscript submitted.

Loghin, Garcia-Sayan, Balan, Nguyen, Estrera, Gregoric, Loyalka, Kar and Smalling: manuscript critical revision for important intellectual content with final approval of the manuscript submitted.

Dhoble: Conception, design, analysis and interpretation of data and manuscript critical revision with final approval of the manuscript submitted.

Disclosures

Dr. Dhoble is consultant for Edwards Lifesciences, Abbott Vascular, and Keystone Heart. Dr. Smalling is consultant for Edwards Lifesciences, Abbott Vascular, and received grant support from Edwards Lifesciences, Boston Scientific, and Abbott vascular. Dr. Nguyen has received speaker's honorarium from Edwards Lifesciences and LivaNova. Other authors reported no relevant disclosures.

1. Bavaria JE, Tommaso CL, Brindis RG, Carroll JD, Deeb GM, Feldman TE, Gleason TG, Horlick EM, Kavinsky CJ, Kumbhani DJ, Miller DC, Seals AA, Shhian DM, Shemin RJ, Sundt TM III, Thourani VH. 2018 AATS/ACC/SCAI/STS expert consensus systems of care document: operator and institutional recommendations and requirements for transcatheter aortic valve replacement: a joint report of the American Association for Thoracic Surgery, American College of Cardiology, Society for Cardiovascular Angiography and Interventions, and Society of Thoracic Surgeons. *J Am Coll Cardiol* 2019; 73:340–374.
2. Patel A, Mahendran K, Collins M, Abdelaziz M, Khogali S, Luckraz H. Incidental abnormal CT scan findings during transcatheter aortic valve implantation assessment: incidence and implications. *Open Heart* 2018;5:e000855.
3. Gufler H, Schulze CG, Wagner S. Incidental findings in computed tomographic angiography for planning percutaneous aortic valve replacement: advanced age, increased cancer prevalence? *Acta Radiol* 2014;55:420–426.
4. Staab W, Bergau L, Lotz J, Sohns C. Prevalence of noncardiac findings in computed tomography angiography before transcatheter aortic valve replacement. *J Cardiovasc Comput Tomogr* 2014;8:222–229.
5. Orme NM, Wright TC, Harmon GE, Nkomo VT, Williamson EE, Sorajja P, Foley TA, Greason KL, Suri RM, Rihal CS, Young PM.

Imaging Pandora's Box: incidental findings in elderly patients evaluated for transcatheter aortic valve replacement. *Mayo Clin Proc* 2014;89:747–753.
6. Feyz L, El Faquir N, Lemmert ME, Misier KR, Van Zandvoor LJC, Budde RPJ, Boersma E, Zijlstra F, De Jaegere P, Van Mieghem NM, Daemen J. Prevalence and consequences of noncardiac incidental findings on preprocedural imaging in the workup for transcatheter aortic valve implantation, renal sympathetic denervation, or MitraClip implantation. *Am Heart J* 2018;204:83–91.
7. Landes U, Iakobishvili Z, Vronsky D, Oren Z, Barsheshet A, Jaffe R, Jubran J, Yoon SH, Makkar RR, Taramasso M, Russo M, Maisano F, Sinning JM, Shamekhi J, Biasco L, Pedrazzini G, Moccetti M, Latib A, Pagnesi M, Colombo A, Tamburino C, Arrigo P, Windecker S, Pilgrim T, Tchethe D, Biase C, Guerrero M, Iftikhar O, Bosmans J, Bedzra E, Dvir D, Mylotte D, Sievert H, Watanabe Y, Sondergaard L, Dagnegard H, Codner P, Kodali S, Leo M, Kornowski R. Transcatheter aortic valve replacement in oncology patients with severe aortic stenosis. *JACC Cardiovasc Interv* 2019;12:78–86.
8. Mangner N, Woitek FJ, Haussig S, Holzhey D, Stachel G, Schlotter F, Hollriegel R, Mohr FW, Schuler G, Linke A. Impact of active cancer disease on the outcome of patients undergoing transcatheter aortic valve replacement. *J Interv Cardiol* 2018;31:188–196.
9. Roller FC, Schuhbaeck A, Achenbach S, Krombach GA, Schneider C. CT before transcatheter aortic valve replacement: value of venous phase imaging for detection and interpretation of findings with impact on the TAVR procedure. *J Cardiovasc Comput Tomogr* 2015;9:422–427.
10. Schechter M, Balanescu DV, Donisan T, et al. An update on the management and outcomes of cancer patients with severe aortic stenosis. *Catheter Cardiovasc Interv* 2019;94:438–445.
11. Stachon P, Kaier K, Milde S, Pache G, Sorg S, Siepe M, von zur Muhlen C, Zirlik A, Beyersdorf F, Langer M, Zehender M, Bode C, Reinohl J. Two-year survival of patients screened for transcatheter aortic valve replacement with potentially malignant incidental findings in initial body computed tomography. *Eur Heart J Cardiovasc Imaging* 2015;16:731–737.
12. Ha FJ, Tham JLM, Paleri S, Wright C, Yap KK, Adams HS, Whitbourn RJ, Palmer SC. Outcomes of incidental findings on multi-detector computed tomography for transcatheter aortic valve implantation assessment: a singlecentre study and review of the literature. *J Med Imaging Radiat Oncol* 2019;63:446–453.
13. Markowiak T, Holzamer A, Hilker M, Pregler B, Debl K, Hofmann H, Ried M. Incidental thoracic findings in computed tomography scans before transcatheter aortic valve implantation. *Interact Cardiovasc Thorac Surg* 2019;28:559–565.
14. Mack MJ, Leon MB, Thourani VH, Makkar R, Kodali SK, Russo M, Kapadia SR, Malaisrie SC, Cohen DJ, Pibarot P, Leipsic J, Hahn RT, Blanke P, Williams MR, McCabe JM, Brown DL, Babaliaros V, Goldman S, Szeto WY, Genereux P, Pershad A, Pocock SJ, Alu MC, Webb JG, Smith CR. Transcatheter aortic-valve replacement with a balloon-expandable valve in low-risk patients. *N Engl J Med* 2019;380:1695–1705.
15. Popma JJ, Deeb GM, Yakubov SJ, Mumtaz M, Gada H, O'Hair D, Bajwa T, Heiser JC, Merhi W, Kleiman NS, Askew J, Sorajja P, Rovin J, Chetcuti SJ, Adams DH, Teirstein PS, Zorn GL, Forrest JK, Tchetche D, Resar J, Walton A, Piazza N, Ramlawi B, Robinson N, Petrossian G, Gleason TG, Oh JK, Boulware MJ, Qiao H, Mugglin AS, Reardon MJ. Transcatheter aortic-valve replacement with a self-expanding valve in low-risk patients. *N Engl J Med* 2019;380:1706–1715.
16. van Kesteren F, Wiegerinck EMA, van Mourik MS, Vis MM, Koch KT, Piek JJ, Stoker J, Tijssen JG, Baan Jr J, Planken RN. Impact of potentially malignant incidental findings by computed tomographic angiography on long-term survival after transcatheter aortic valve implantation. *Am J Cardiol* 2017;120:994–1001.
17. Thompson RJ, Wojcik SM, Grant WD, Ko PY. Incidental findings on CT scans in the emergency department. *Emerg Med Int* 2011;2011:624847.
18. Berland LL, Silverman SG, Gore RM, Mayo-Smith WW, Megibow AJ, Yee J, Brink JA, Baker ME, Federle MP, Foley WD, Francis IR, Herts BR, Israel GM, Krinsky G, Platt JF, Shuman WP, Taylor AJ. Managing incidental findings on abdominal CT: white paper of the ACR incidental findings committee. *J Am Coll Radiol* 2010;7:754–773.
19. Munden RF, Carter BW, Chiles C, MacMahon H, Black WC, Ko JP, McAdams HP, Rossi SE, Leung AN, Boisell PM, Kent MS, Brown K, Dyer DS, Harman TE, Goodman EM, Naidich DP, Kazerooni EA, Berland LL, Pandharipande PV. Managing incidental findings on thoracic CT: mediastinal and cardiovascular findings. A white paper of the ACR incidental findings committee. *J Am Coll Radiol* 2018;15:1087–1096.
20. Schmidt LH, Vietmeier B, Kaleschke G, Schulke C, Gorlich D, Schliemann C, Kessler T, Schulze AB, Buerke B, Kuemmel A, Thrull M, Wiewrodot R, Baumgartner H, Berdel WE, Mohr M. Thoracic malignancies and pulmonary nodules in patients under evaluation for transcatheter aortic valve implantation (TAVI): incidence, follow up and possible impact on treatment decision. *PLoS One* 2016;11:e0155398.
21. Berkovitch A, Guetta V, Barbash IM, Fink N, Regev E, Maor E, Vered Y, Grossman Y, Younis A, Kuperstein R, Feinberg M, Asher E, Segev A, Fefer P. Favorable short-term and long-term outcomes among patients with prior history of malignancy undergoing transcatheter aortic valve implantation. *J Invasive Cardiol* 2018;30:105–109.
22. Watanabe Y, Kozuma K, Hioki H, Kawashima H, Nara Y, Kataoka A, Shirai S, Tada N, Araki M, Takagi K, Yamanaka F, Yamamoto M, Hayashida K. Comparison of results of transcatheter aortic valve implantation in patients with versus without active cancer. *Am J Cardiol* 2016;118:572–577.