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Review Article

The Role of Artificial Intelligence in Predicting Mortality Risk of Transcatheter Aortic Valve Replacement: A Systematic Review

Hidtsa A. N. Arasyi[1*], Firqa A. N. Arasyi[2], Rizky Pratama[3]
[1]*Faculty of Medicine, Universitas Airlangga, Indonesia.*
[2]*Faculty of Information Systems, Institut Teknologi Sepuluh November, Surabaya, Indonesia.*
[3]*Faculty of Medicine, Universitas Gajah Mada, Yogyakarta, Indonesia.*

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**Correspondence:*
hidtsa.aqila.noor-2019@fk.unair.ac.id

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ABSTRACT

Background: Artificial intelligence plays a crucial role in the field of cardiovascular medicine, particularly in diagnosing and predicting patient mortality in heart disease. **Objective:** Therefore, we conducted a systematic review to understand the role of artificial intelligence in predicting mortality risk in patients with aortic stenosis following transcatheter aortic valve replacement (TAVR). **Method:** This study is a systematic review using secondary data. The data in this research consist of literature on the role of artificial intelligence in TAVR patients, obtained through the PubMed, ScienceDirect, and Google Scholar search engines, with a publication date range from 2019 to October 2023. Using the PRISMA flow diagram, six studies on the role of artificial intelligence in TAVR patients were identified. It was found that the ability of artificial intelligence to predict mortality in patients with aortic stenosis undergoing Transcatheter Aortic Valve Replacement (TAVR) is superior compared to the TAVI2-Score, CoreValve Score, STS/ACC Score, and several other prediction scores. **Conclusion:** Artificial intelligence has a superior ability to predict mortality risk in patients with aortic stenosis undergoing Transcatheter Aortic Valve Replacement (TAVR).

Highlights:

1. Understanding how Artificial Intelligence could play a crucial role in diagnosing patients' mortality could be challenging, however, this article could provide a discussion that readers might want to take notice.

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Introduction

AI models, particularly those based on machine learning and deep learning, are increasingly used to analyze complex datasets including patient comorbidities, procedural and post-procedural outcome. One notable application is in the prediction of mortality risk for patients undergoing Transcatheter Aortic Valve Replacement (TAVR). [10]

Machine learning is a computer science approach that employs algorithms to iteratively learn from data inputs and predict outcome from complex datasets. Deep learning, a subset of machine learning, is dedicated to training deep neural networks. These networks are modeled after the human brain's structure and function. Comprised of several layers of interconnected nodes, known as neurons, they process and transform data throughout the learning process.[7]

TAVR has emerged as a game-changing option for treating severe aortic stenosis, particularly in high-risk populations. Despite its benefits, TAVR carries risks, including mortality, which make accurate risk prediction crucial for patients' management and decision-making.[9] The integration of AI into clinical practice for predicting mortality risk post-TAVR not only enhances prognostic accuracy but also supports personalized patient care, ensuring that high-risk patients receive the necessary intervention and follow-up care. Therefore, this systematic review aims to understand the role of artificial intelligence in predicting mortality risk in post-TAVR patients.

Methods

In this systematic review, we conducted an analysis of multiple studies. This research examined scientific articles that reported on the role of artificial intelligence in predicting the mortality risk of patients post-TAVR. The subjects were patients diagnosed with severe aortic stenosis who had undergone transcatheter aortic valve replacement as a treatment. Exclusion criteria included papers published in languages other than English, non-full text papers, studies unrelated to the topic of this systematic review, articles with insufficient or unavailable data, and duplicates. The data were compiled and analyzed using the 2020 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020).[8]

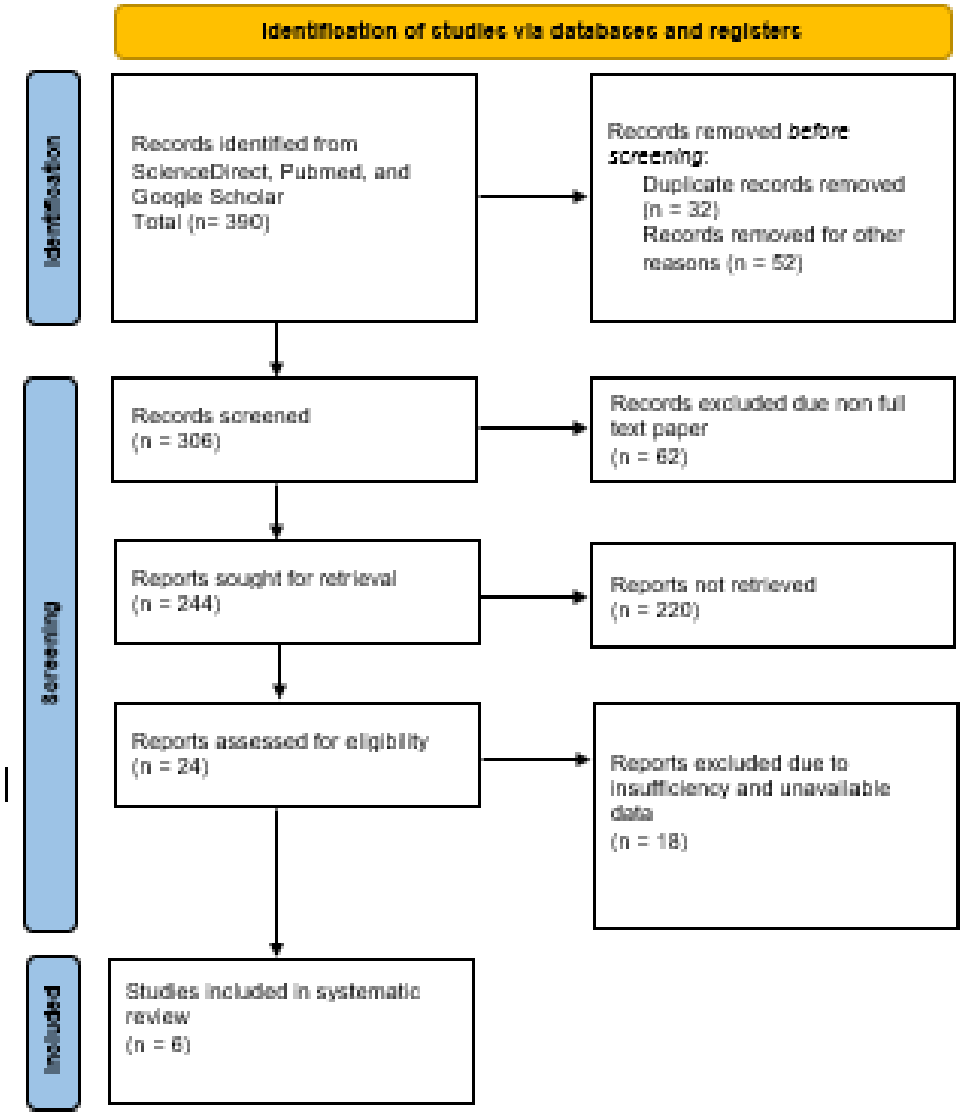

Figure 1. PRISMA flow diagram for the articles' selection

The data were extracted from a total 390 articles which were published in English language international publications. We conducted a literature search between May 15th and June 05th, 2024, to obtain the 390 research papers. The search was performed on multiple search engines, including PubMed (MEDLINE) and ScienceDirect, using specific keywords “Artificial Intelligence AND TAVR OR Mortality Risk AND TAVR”. We focused on searching for studies that examined the role of artificial intelligence in predicting mortality risk of post-TAVR patients. A similar search was done through the PROSPERO database to avoid duplication of previous reviews. Studies included in this systematic review consisted of retrospective study that discussed the role of AI in post-TAVR patients. Studies obtained from the databases were then filtered from duplication, selected by article type, and screened by their abstracts and full text using PICO framework.

Table 1. PICO and search keywords

PICO	Keywords
Population	Post-TAVR patients with aortic stenosis
Intervention	Artificial Intelligence model
Comparator	Predictive mortality score
Outcomes	Predictive performance

Results

A total of 390 journals were retrieved from electronic databases. After removing duplicates and thoroughly assessing the titles, keywords, and abstracts, 366 papers were found to not meet the research criteria. Additionally, 18 journal articles were excluded due to irrelevant or unavailable data. The remaining 6 studies focused on the role of artificial intelligence in predicting the mortality risk of Transcatheter Aortic Valve Replacement (TAVR).

Table 2 provides an overview of the role of artificial intelligence in predicting mortality risk for transcatheter aortic valve replacement (TAVR). It summarizes six articles on artificial intelligence, with publication dates ranging from 2019 to 2023.

Discussion

Machine learning was employed to predict one-year mortality among patients with high or prohibitive surgical risk who were selected for TAVR. The machine learning model outperformed both the TAVI2-SCORE and CoreValve model in predicting one-year survival following TAVR [1]. By merging human and artificial intelligence, this approach has successfully identified patients with severe AS who are unlikely to recover from extra-aortic valve cardiac damage after TAVR.[2]

CVE continues to be one of the most concerning adverse events associated with TAVR. Even after fifteen years of advancement in the technique and refinement of TAVR device, the incidence of CVE during the perioperative period remains significant. Imaging data might be just as crucial as clinical characteristic in creating predictive models for cardiovascular procedures.[6]

There is a predictive score developed using artificial intelligence (AI) called the NIS TAVR Score, which has better predictive capability compared to other TAVR scores. The NIS TAVR score includes in-hospital cardiac arrest, shock, acute kidney injury, and sepsis in its calculation. Despite some similarities with other scores, the primary utility of the NIS TAVR score lies in determining prognosis, due to its incorporation of postprocedural variables.[5]

Conclusion

In conclusion, artificial intelligence plays a crucial role in predicting mortality risk in post-TAVR patients. By integrating a wide range of clinical and imaging data, AI-driven models demonstrate superior predictive capabilities compared to traditional scoring systems. This enhanced predictive accuracy supports better risk stratification and clinical decision-making, ultimately improving patient outcomes. As AI technology continues to evolve, its application in cardiovascular procedures like TAVR is expected to expand, further revolutionizing patient care.

Study limitation

In this systematic review, there was no justification for the number of samples, research setting, and research method in comparing the role of AI in each study, so that bias might occur due to differences in these matters. In future studies, it is necessary to carry out a more detailed selection with the main consideration on these three things.

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Conflict of interest

None.

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None.

Author contribution

All authors contributed to the conception and design, analysis, and interpretation of data, drafting of the article, critical revision of the article for important intellectual content, and final approval of the article.

References

1. Agasthi P, Ashraf H, Pujari SH, et al. Artificial Intelligence Trumps $TAVI_2$-SCORE and CoreValve Score in Predicting 1-Year Mortality Post-Transcatheter Aortic Valve Replacement. Cardiovasc Revasc Med. 2021;24:33-41. DOI: 10.1016/j.carrev.2020.08.010.
2. Lachmann M, Rippen E, Schuster T, et al. Artificial intelligence-enabled phenotyping of patients with severe aortic stenosis: on the recovery of extra-aortic valve cardiac damage after transcatheter aortic valve replacement. Open Heart. 2022;9(2):e002068. DOI: 10.1136/openhrt-2022-002068.
3. Evertz R, Lange T, Backhaus SJ, et al. Artificial Intelligence Enabled Fully Automated CMR Function Quantification for Optimized Risk Stratification in Patients Undergoing Transcatheter Aortic Valve Replacement. J Interv Cardiol. 2022; 2022:1368878. Published 2022 Apr 20. DOI: 10.1155/2022/1368878.
4. Dasi A, Lee B, Polsani V, Yadav P, Dasi LP, Thourani VH. Predicting pressure gradient using artificial intelligence for transcatheter aortic valve replacement. JTCVS Tech. 2023;23:5-17. Published 2023 Nov 30. DOI: 10.1016/j.xjtc.2023.11.011.
5. Hernandez-Suarez DF, Kim Y, Villablanca P, et al. Machine Learning Prediction Models for In-Hospital Mortality After Transcatheter Aortic Valve Replacement. JACC Cardiovasc Interv. 2019;12(14):1328-1338. DOI: 10.1016/j.jcin.2019.06.013.
6. Okuno T, Overtchouk P, Asami M, et al. Deep learning-based prediction of early cerebrovascular events after transcatheter aortic valve replacement. Sci Rep. 2021;11(1):18754. Published 2021 Sep 21. DOI:10.1038/s41598-021-98265-5.
7. Benjamin MM, Rabbat MG. Artificial Intelligence in Transcatheter Aortic Valve Replacement: Its Current Role and Ongoing Challenges. Diagnostics (Basel). 2024;14(3):261. Published 2024 Jan 25. DOI:10.3390/diagnostics14030261.

8. Page MJ, McKenzie JE, Bossuyt PM, et al (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJn71. DOI: 10.1136/bmj.n71.

9. Wang M, Niu G, Chen Y, et al. Development and validation of a deep learning-based fully automated algorithm for pre-TAVR CT assessment of the aortic valvular complex and detection of anatomical risk factors: a retrospective, multicentre study. EBioMedicine. 2023;96:104794.
DOI: 10.1016/j.ebiom.2023.104794.

10. Truong VT, Beyerbach D, Mazur W, et al. Machine learning method for predicting pacemaker implantation following transcatheter aortic valve replacement. Pacing Clin Electrophysiol. 2021; 44: 334–340. DOI: https://doi.org/10.1111/pace.14163.

Table 2. The role of AI in predicting mortality risk of included systematic review

Author (Year)	Patients Characteristic	Comparison	AI Model	Outcome
Agasthi P et al (2020)	A total 1055 patients with age > 18 years who underwent TAVR with symptomatic severe aortic stenosis.	$TAVI_2$-SCORE and CoreValve Score	GBM	The GBM model outperforms $TAVI_2$-SCORE and CoreValve Score in predicting mortality one-year post TAVR
Lachmann M et al (2022)	Collected echocardiographic and haemodynamic data from patiens with severe aortic stenosis	none	ANN	ANN demonstrated an excellent performance to detect patients who will not recover from extra-aortic valve cardiac damage following TAVR
Evertz R et al (2022)	A total 146 patients with severe aortic stenosis enrolled CMR before undergoing TAVR	Conventional manual analysis	Fully automated biventricular volumetric analysis using deep learning algorithms	Fully automated biventricular volumetric assessments enable efficient and equal risk prediction compared to conventional manual approaches.
Dasi A et al (2023)	A total of 1091 patients undergoing TAVR due to aortic stenosis	none	A combination of regression and artificial neural network (ANN)-based AI learning model	The AI-based algorithm has demonstrated potential in predicting post-TAVR transvalvular pressure gradient
Suarez at al (2019)	A total 10,883 patients undergoing TAVR due to aortic stenosis from NIS database. The data was split into training set (70%) and test set (30%).	Current TAVR-related outcome scores (FRANCE-2, TARIS, OBSERVANT, $TAVI_2$, CoreValve, STS/ACC, UK TAVI, and CAPRI)	NIS TAVR Score developed using machine-learning	The NIS TAVR score outperformed current available score
Okuno T et al (2021)	A total 2279 patients undergoing TAVR due to aortic stenosis	none	Deep learning-based predictive algorithm	TAVR-related CVE can be predicted using a deep learning