The Journal of Neurological and Neurosurgical Nursing
Pielęgniarstwo Neurologiczne i Neurochirurgiczne

Wydawnictwo Państwowej Akademii
Nauk Stosowanych we Włocławku
ul. Mechaników 3, pok. 20
87-800 Włocławek

eISSN 2299-0321 ISSN 2084-8021
https://apcz.umk.pl/PNIN

DOI: 10.15225/PNN.2024.13.1.6 JNNN 2024;13(1):36–41 **Review**

Neurological Complications after Transcatheter Aortic Valve Implantation Procedure

Powikłania neurologiczne po zabiegu przezcewnikowej implantacji zastawki aortalnej

Daniel Rogowicz, Karina Motolko, Radomir Skowronek, Damian Świątkowski, Katarzyna Zaborowska, Jakub Piotrowski, Aleksandra Wojnicz, Wojciech Pawliszak

Department of Cardiac Surgery, Ludwik Rydygier Collegium Medicum in Bydgoszcz,
Nicolaus Copernicus University in Toruń, Poland

Abstract

Aortic stenosis is the most common primary valvular heart disease in both Europe and North America. In patients with symptomatic severe aortic stenosis, early surgical treatment is recommended because of the very poor prognosis and the lack of effect of conservative treatment on the natural course of this heart defect. The primary treatment options for severe aortic stenosis are surgical aortic valve replacement and transcatheter aortic valve implantation. Complication rates between therapeutic procedures used vary according to the group to which the patient has been assigned by health care professionals on the basis of the risk of possible complications or mortality. Neurological symptoms that are consequences of transcatheter aortic valve implantation remain a major challenge for providers. The aim of this study was to assess the risk of neurological complications after transcatheter aortic valve implantation. **(JNNN 2024; 13(1):36–41)**

Key Words: aortic stenosis, primary valvular heart disease, stroke, transcatheter aortic valve implantation

Streszczenie

Stenoza aortalna jest najczęstszą pierwotną wadą zastawkową serca zarówno w Europie, jak i Ameryce Północnej. Ze względu na bardzo złe rokowanie i brak wpływu leczenia zachowawczego na naturalny przebieg tej wady serca u pacjentów z ciężką objawową stenozą aortalną zaleca się wczesne leczenie chirurgiczne. Podstawowymi metodami leczenia ciężkiej stenozy aortalnej są chirurgiczna wymiana zastawki aortalnej i przezcewnikowa implantacja zastawki aortalnej. Wskaźniki powikłań między stosowanymi procedurami terapeutycznymi różnią się w zależności od grupy, do której pacjent został przypisany przez pracowników służby zdrowia ze względu na ryzyko możliwych powikłań lub śmiertelności. Objawy neurologiczne będące konsekwencją przezcewnikowej implantacji zastawki aortalnej pozostają głównym wyzwaniem dla świadczeniodawców. Celem pracy była ocena ryzyka powikłań neurologicznych po zabiegu przezcewnikowej implantacji zastawki aortalnej. **(PNN 2024;13(1):36–41)**

Słowa kluczowe: stenoza aortalna, pierwotna wada zastawkowa serca, udar, przezcewnikowa implantacja zastawki aortalnej

Introduction

Aortic stenosis (AS) is the most common primary valvular heart disease in both Europe and North America, and its incidence is increasing as the population ages. Echocardiography is the primary method for diagnosing and assessing the severity of aortic stenosis. Contrast-enhanced computed tomography, on the other hand, is an essential diagnostic tool for qualifying patients for transcatheter treatment of severe AS. It provides information about possible vascular access, the exact dimensions and anatomy of the aorta and its descending vessels, the distribution and advancement of calcification of the aortic valve and vessels. Before surgical treatment

of severe AS, coronary angiography or computed tomography of the coronary arteries should also be performed to assess coronary artery stenosis, which can be treated by coronary angioplasty performed concomitantly with coronary angiography or during traditional aortic stenosis surgery with vascular bypass grafting [1].

In patients with symptomatic severe AS, early surgical treatment is recommended because of the very poor prognosis and the lack of effect of conservative treatment on the natural course of this heart defect. Surgical intervention is not only indicated in symptomatic patients with comorbidities leading to a survival of less than 1 year or when intervention will not improve the quality of life of these patients. In asymptomatic patients, however, surgery is recommended when symptoms are present during exercise testing, when severe AS is associated with left ventricular dysfunction not due to other causes, or when there are factors indicating an unfavorable prognosis with a low risk of surgery. The primary treatment options for severe AS are surgical aortic valve replacement (SAVR) and transcatheter aortic valve implantation (TAVI) [1]. Between 2003 and 2016, the incidence of surgical treatment of aortic stenosis in patients over 60 years of age increased from 96 to 137 cases per 100 000, and the incidence of TAVI increased from 11.9% in 2012 to 43.6% in 2016 [2]. In addition, the incidence of TAVI increases with age and is 27% in patients younger than 80 years, 72% in patients aged 80–90 years, and almost 100% in patients older than 90 years [2]. The choice of TAVI for the treatment of severe AS is supported by:

— high risk for SAVR;
— advanced age of the patient;
— history of cardiac surgery or thoracic radiation therapy;
— increased frailty;
— porcelain aorta;
— significant thoracic deformity or scoliosis;
— high likelihood of a significant size mismatch between the prosthesis and the patient.

In contrast, SAVR is preferred in the following cases:

— low risk of surgical treatment;
— young age of the patient;
— vascular access is difficult or impossible;
— aortic annulus dimensions are outside the range of TAVI devices;
— bicuspid aortic valve or aortic valve morphology is unsuitable for TAVI;
— thrombus in the aorta or left ventricle;
— cardiac diseases requiring surgical intervention (significant multivessel coronary artery disease, significant cardiac defects associated with AS, significant aortic dilatation/aneurysm, ventricular septal hypertrophy requiring myectomy).

The choice of treatment for AS is determined by the cardiac group, since patients with AS are a heterogeneous group and the choice of the appropriate method should take into account many factors [1]. Patients with severe, symptomatic aortic stenosis with low-risk surgery had the following complications after 5 years of follow-up:

— all-cause mortality: 10.0% with TAVI vs. 8.2% with SAVR (p=0.35);
— cardiovascular mortality: 5.5% vs. 5.1% (p=0.8);
— stroke: 5.8% with TAVI vs. 6.4% with SAVR (p=0.6);
— rehospitalization: 13.7% with TAVI vs. 17.4% with SAVR (p=0.09);
— serious bleeding: 10.2% with TAVI vs. 14.8% with SAVR (p<0.05);
— atrial fibrillation: 13.7% with TAVI vs. 42.4% with SAVR (p<0.05);
— valve thrombosis: 2.5% with TAVI vs. 0.2% with SAVR (p<0.05);
— repeat aortic valve intervention: 2.6% with TAVI vs. 3.0% with SAVR (p=0.72);
— paravalvular regurgitation ≥ mild: 20.8% with TAVI vs. 3.2% with SAVR (p<0.05);
— mild paravalvular aortic insufficiency: 19.9% with TAVI vs. 3.2% with SAVR (p<0.001);
— moderate/severe paravalvular leak: 0.9% with TAVI vs. 0% with SAVR;
— bioprosthetic valve failure: 3.3% with TAVI vs. 3.8% with SAVR (p=NS) [3].

The aim of this study was to assess the risk of neurological complications after transcatheter aortic valve implantation.

Incidence of Neurological Complications after TAVI

Differences in the rate of complications between applied therapeutic procedures vary from the group to which the patient has been assigned by health care professionals due to the risk of possible complications or mortality, for example, using the Society of Thoracic Surgeons Predictor Risk of Mortality index (STS-PROM), which is a globally recognized score tailored to assess individual situations based on a comprehensive set of variables [4].

The Society of Thoracic Surgeons (STS) score is based on age, gender, comorbidities (including hypertension, peripheral arterial disease, cerebrovascular disease, diabetes, and lung disease), and immediate preoperative condition (including the presence of cardiogenic shock and whether the patient currently has heart failure). The STS score classifies patients into low, intermediate and high risk groups for complications [4].

Low Risk:

Mack et al. conducted a multicenter randomized trial within the PARTNER 3 trial in which they studied the outcomes of 1000 patients classified as low risk (mean STS risk score was 1.9%) who underwent either SAVR or TAVI with balloon-expanding valve. They showed that 30 days after surgery, TAVI resulted in a lower rate of stroke than surgery (0.6% vs. 2.4%, p=0.02) and a lower rate of death or stroke (1% vs. 3.3%, p=0.01). TAVI also resulted in a shorter index hospitalization than surgery (3 vs. 7 days, p<0.001) and a lower risk of 30-day poor outcome (death or low Kansas City Cardiomyopathy Questionnaire score) (3.9% vs. 30.6%, p<0.001). There were no significant between group differences in major vascular complications, new permanent pacemaker insertions, or moderate or severe paravalvular regurgitation [5].

Popma et al. investigated the non-inferiority of TAVI with self-expanding valve also in the low-risk patient group, mean STS risk score for both groups was 1.9%. At 30 days, death from any cause or disabling stroke was not higher in TAVI patients than in SAVR patients 0.5% vs. 1.3%, and at 1 year 2.9% vs. 4.6%. In both groups, 3.4% experienced TIA or stroke at 30 days, and at 1 year, these rates increased to 4.1% for TAVI and 4.3% for SAVR [6]. At 2 years, the all-cause mortality rates were 3.5% and 4.4% (p=0.366), respectively. The 2-year stroke rate was 5.8% in the TAVI group vs. 5.6% in the SAVR group [7].

Intermediate Risk:

Leon et al. in a PARTNER 2A study investigated postoperative complications of aortic valve procedures, in this case TAVI (76.3% transfemoral vs. 23.7% transapical access) and SAVR, mean STS-PROM was 5.8% in both groups. Mortality at 30 days was 3.9% for TAVI vs. 4.3% for SAVR (p<0.78), at 1 year 12.3% vs. 12.4% (p<0.69), and at 2 years 16.7% vs. 18% (p<0.45). Neurological events at 30 days were observed in 6.4% of patients in the TAVI group and 6.5% in the SAVR group (p<0.94), at 1 year 10.1% vs. 9.4% (p<0.76), at 2 years 12.7% vs. 11% (p<0.45) vs. 11% (p<0.25) [8].

Durko et al., examined the complications of TAVI in intermediate risk patients (STS >3%; <15%) within the SUTRAVI trial. Early (30-day) stroke rates were lower after TAVI compared to SAVR (3.3% vs. 5.4%; p=0.031). At 12 months, the rate of stroke was not different between TAVI and SAVR (5.2% vs. 6.9%; p=0.136). In addition, the authors of this study demonstrated that SAVR was associated with higher rates of encephalopathies (defined as altered level of consciousness after exclusion of transient ischemic attack (TIA) or stroke) than TAVI (7.8% vs. 1.6%, p<0.001) at 30 days and at 1 year (3.0% vs. 8.8%<0.001) [9].

High Risk:

Smith et al. were investigating differences between SAVI and TAVI with balloon-expanding valve in the population of high risk patients. Mean STS-PROM for patients referred into the surgical group was 11.7% and for those assigned for TAVI 11.8%. Death from any cause was 3.4% in the TAVI group and 6.5% in the SAVR group (p<0.07), at 1 year it was 24.2 vs. 26.8% (p<0.44). However, neurological complications such as TIA or stroke were observed at a higher rate in the TAVI group than in the SAVR group at 30 days 5.5% vs. 2.4% (p<0.04) and at 1 year 8.3% vs. 4.3% (p<0.04) [10].

Adams et al. all investigated postoperative complications after surgical and transcatheter aortic valve replacement therapy. STS-PROM was 7.5% vs. 7.3%. The rate of death from any cause at 1 year was lower in the TAVR group than in the SAVR group 14.2% vs. 19.1% (p<0.001). The rates of any neurological complication were 4.9% in the TAVR group and 6.2% in the surgical group at 30 days (p=0.46) and 8.8% and 12.6%, respectively, at 1 year (p=0.10) [11].

Huded et al. conducted a retrospective study based on US registry of patients who underwent TAVI, with over 101 430 patients from 2011–2017 included. Such a large population could provide us with an adequate estimate of the clinical problems that may occur in the setting of pre- and post-operative complications of TAVI. Post-procedural follow-up data showed that, at day 30, there were 2 290 patients (2.3%) with a stroke of any kind and 0.4% of patients had TIA. Among cases of stroke within 30 days, 48.9% strokes occurred within the first day and 68.4% within 3 days after TAVI. The median time to stroke events was 2 days after TAVI. The occurrence of a stroke was associated with a significant increase in 30-day mortality, with 16.7% of patients in the stroke group dying compared to 3.7% in the no-stroke group (p<.001). Patients with 30-day stroke had a higher proportion of previous stroke, previous TIA, peripheral arterial disease, hypertension, porcelain aorta, and carotid stenosis — which proves the clinical significance of these variables in the calculation of the STS-PROM [12].

Neuroprotection with Emphasis on Cerebral Embolic Protection Devices

Neurological symptoms that appear as consequences of TAVI remain a major challenge for providers to deal with on a daily basis. Even in the absence of clinical

symptoms, most patients (68–93%) have some evidence of microembolism in the pre-operative period, which can be visualized on magnetic resonance imagining (MRI) [13]. Serious thrombosis events are in most cases caused by plaque or debris dislodged from blood vessels or heart valves during surgery. To prevent this, a new branch of medical devices has been developed — the Cerebral Embolic Protection Devices (CEPDs). The purpose of these devices is to capture or deflect embolic debris that may become during the TAVI procedure. They are typically deployed in the aortic arch or carotid arteries to intercept particles before they reach the brain — the mechanism of action may resemble a fishing net [14].

The Sentinel Cerebral Protection System is the best-known example and the first to receive the Food and Drug Administration (FDA) approval for use during TAVI. The mechanism of action of such a system is to cover the brachiocephalic trunk (innominate artery) and the left common carotid artery [14]. In addition, there are TMCA systems (derived from the three main cerebral arteries), such as TriGuard, which covers the three main branches of the aortic arch (brachiocephalic trunk, left common carotid artery and subclavian artery) that supply the brain [15].

Levi et al. performed a cohort study aimed to investinate the outcome of patients, who underwent TAVI with additional CEPD or without it (with CEPD+; without CEPD–). In 18 725 TAVI procedures, 2.2% had an ischemic stroke within 72 hours. Rates of disabling stroke (modified Rankin Score >1 at 30 days) were 47.3% vs. 42.5% (p=0.62), and 6-month mortality was 31.3% vs. 23.3% (p=0.61) in the CEPD– and CEPD+ groups, respectively [16].

Kapadia et al. demonstrated that the use of CEPD has no significant effect on the prevention of periprocedural neurological complications, defined as the occurrence of stroke, TIA, or delirium diagnosed by a neurologist before hospital discharge or within 72 hours. Mean STS-PROM for both groups was 3.3% for the CEPD+ group and 3.4% for the CEPD– group. The incidence of neurological complications was not significantly different between the CEPD+ and CEPD– groups (2.3% vs. 2.9%) (p=0.30), and death occurred in 0.5% and 0.3% of patients, respectively. The trial did not conclusively demonstrate benefits of CEPD in all patients undergoing TAVI. Nevertheless, CEPD proved safe and may be a reasonable choice for some patients [17].

Wang et al. performed a meta-analysis of different types of CEPDs to demonstrate their clinical relevance. Based on the CEPD design types of the included studies, there were two subgroups: The Innominate & Left Common Carotid Artery (I&LCCA) group mainly used the Sentinel CEPD and the TMCA group mainly used the TriGuard CEPD. Both of those systems were compared to CEPD– group of patients who underwent TAVI. The researchers found that there was no significant difference in the risk of stroke within 30 days between the use of CEPD during TAVI and the control group (p=0.14). However, when subgroup analysis was performed according to the device used, the risk of stroke was lower in the I&LCCA-type CEPD group: p=0.03. There was no significant difference in the risk of stroke when using the TMCA-type CEPD compared to the CEPD group p=0.60 [13].

Pharmacological Prevention of Thromboembolic Incidents Associated to TAVI

The POPular TAVI trial is an investigator-initiated, parallel-group, randomized, open-label study conducted at 17 European sites. Patients enrolled in this study were already on adequate doses of oral anticoagulants (without distinction between VKA and DOAC) due to prior indication. The study measured the effect of adding antiplatelet agent (clopidogrel 75 mg daily for 3 months post procedure) after TAVI procedure as part of anticoagulation therapy. At 12 months, bleeding of any type occurred in 21.7% of patients receiving oral anticoagulation alone and in 34.6% of patients receiving oral anticoagulation+clopidogrel (p=0.01). Death from cardiovascular causes, ischemic stroke, or myocardial infarction occurred in 21 patients (13.4%) receiving oral anticoagulation alone and in 27 patients (17.3%) receiving oral anticoagulation+clopidogrel. In conclusion, the incidence of major bleeding over a 1-year period was lower with oral anticoagulation alone than with oral anticoagulation+clopidogrel, and anticoagulation alone was non-inferior to anticoagulation+clopidogrel in preventing bleeding [18].

Another study was conducted to determine the optimal anticoagulation therapy for patients referred for TAVI but who have no other indications. Brouwer et al. in the POPular TAVI trial evaluated the outcomes of patients treated with aspirin 80–100 mg daily or a combination of aspirin 80–100 mg and clopidogrel 75 mg for 3 months after TAVI. At 12 months, 15.1% of patients receiving aspirin alone and 26.6% of patients receiving aspirin+clopidogrel experienced any bleeding (p=0.001). These results showed that aspirin alone was non-inferior to the combined therapy [19,20]. Thromboembolic events, including death from cardiovascular causes, ischemic stroke or myocardial infarction occurred in 9.7% of patients receiving aspirin alone and in 9.9% of patients who received aspirin+clopidogrel. These results showed that aspirin alone was non-inferior to the combined therapy [20]. The POPular TAVI trial has provided important clarification for the routine management of antithrombotic therapy

after TAVI. Single antiplatelet therapy in routine cases is preferred in groups without independent indications for anticoagulation. Questions remain regarding the use of DOACs vs. VKAs. Anticoagulation therapy alone is associated with lower bleeding rates and no worse effect in preventing of thromboembolic incidents in patients with independent indications for anticoagulation than therapy combined with clopidogrel [18].

Conclusions

Complications following TAVI remain a serious concern, although they are no more common than after surgical valve replacement. Depending on risk factor stratification groups, the prevalence of neurological complications may occur in 0.6% to 3.4% of patients undergoing the procedure, but non-symptomatic microembolization occurs in the majority of patients. In other words, TAVI is safe and an efficient therapeutic procedure in the treatment of aortic stenosis, non-inferior to SAVR in terms of complication rates. Patients should be provided with anti-embolic prevention to minimize the risk of ischemic stroke after TAVI.

Mono-antiplatelet therapy has been shown to be superior to dual antiplatelet therapy in patients with no other indication for anticoagulation. In groups with such indications, DOACs have been shown to be non-inferior in the efficacy of preventing ischemic attacks and superior in safety than combined therapy DOACs +clopidogrel.

Implications for Nursing Practice

Neurological thromboembolic events associated with TAVI should be managed no differently than other ischemic events, according to international or national guidelines, available resources, and the clinical experience of specialists. Moreover, it is recommended to perform a complete neurologic exam as soon as possible after surgery and consider a fast-track anesthesia protocol to help quickly identify signs of a stroke after surgery [21].

References

[1] Vahanian A., Beyersdorf F., Praz F. et al. 2021 ESC/EACTS Guidelines for the management of valvular heart disease. *Eur Heart J*. 2022;43(7):561–632.

[2] Steiner J.M., Cooper S., Kirkpatrick J.N. Palliative care in end-stage valvular heart disease. *Heart*. 2017;103(16):1233–1237.

[3] Mack M.J., Leon M.B., Thourani V.H. et al. Transcatheter Aortic-Valve Replacement in Low-Risk Patients at Five Years. *N Engl J Med*. 2023;389(21):1949–1960.

[4] Svensson L.G., Adams D.H., Bonow R.O. et al. Aortic valve and ascending aorta guidelines for management and quality measures: executive summary. *Ann Thorac Surg*. 2013;95(4):1491–1505.

[5] Mack M.J., Leon M.B., Thourani V.H. et al. Transcatheter Aortic-Valve Replacement with a Balloon-Expandable Valve in Low-Risk Patients. *N Engl J Med*. 2019;380(18):1695–1705.

[6] Popma J.J., Deeb G.M., Yakubov S.J. et al. Transcatheter Aortic-Valve Replacement with a Self-Expanding Valve in Low-Risk Patients. *N Engl J Med*. 2019;380(18):1706–1715.

[7] Forrest J.K., Deeb G.M., Yakubov S.J. et al. 2-Year Outcomes After Transcatheter Versus Surgical Aortic Valve Replacement in Low-Risk Patients. *J Am Coll Cardiol*. 2022;79(9):882–896.

[8] Leon M.B., Smith C.R., Mack M.J. et al. Transcatheter or Surgical Aortic-Valve Replacement in Intermediate-Risk Patients. *N Engl J Med*. 2016;374(17):1609–1620.

[9] Durko A.P., Reardon M.J., Kleiman N.S. et al. Neurological Complications After Transcatheter Versus Surgical Aortic Valve Replacement in Intermediate-Risk Patients. *J Am Coll Cardiol*. 2018;72(18):2109–2119.

[10] Smith C.R., Leon M.B., Mack M.J. et al. Transcatheter versus surgical aortic-valve replacement in high-risk patients. *N Engl J Med*. 2011;364(23):2187–2198.

[11] Adams D.H., Popma J.J., Reardon M.J. et al. Transcatheter aortic-valve replacement with a self-expanding prosthesis. *N Engl J Med*. 2014;370(19):1790–1798.

[12] Huded C.P., Tuzcu E.M., Krishnaswamy A. et al. Association Between Transcatheter Aortic Valve Replacement and Early Postprocedural Stroke. *JAMA*. 2019;321(23):2306–2315.

[13] Wang C., Han J., Lu L., Qiu J., Fu Y., Zheng J. The efficacy of different types of cerebral embolic protection device during transcatheter aortic valve implantation: a meta-analysis. *Front Cardiovasc Med*. 2024;11:1205943.

[14] Kapadia S.R., Kodali S., Makkar R. et al. Protection Against Cerebral Embolism During Transcatheter Aortic Valve Replacement. *J Am Coll Cardiol*. 2017;69(4):367–377.

[15] Nazif T.M., Moses J., Sharma R. et al. Randomized Evaluation of TriGuard 3 Cerebral Embolic Protection After Transcatheter Aortic Valve Replacement: REFLECT II. *JACC Cardiovasc Interv*. 2021;14(5):515–527.

[16] Levi A., Linder M., Seiffert M. et al. The Impact of Cerebral Embolic Protection Devices on Characteristics and Outcomes of Stroke Complicating TAVR. *JACC Cardiovasc Interv*. 2024;17(5):666–677.

[17] Kapadia S.R., Makkar R., Leon M. et al. Cerebral Embolic Protection during Transcatheter Aortic-Valve Replacement. *N Engl J Med*. 2022;387(14):1253–1263.

[18] Nijenhuis V.J., Brouwer J., Delewi R. et al. Anticoagulation with or without Clopidogrel after Transcatheter Aortic-Valve Implantation. *N Engl J Med*. 2020;382(18):1696–1707.

[19] Guedeney P., Roule V., Mesnier J. et al. Antithrombotic therapy and cardiovascular outcomes after transcatheter aortic valve implantation in patients without indications for chronic oral anticoagulation: a systematic review and

network meta-analysis of randomized controlled trials. *Eur Heart J Cardiovasc Pharmacother*. 2023;9(3):251–261.
[20] Brouwer J., Nijenhuis V.J., Delewi R. et al. Aspirin with or without Clopidogrel after Transcatheter Aortic-Valve Implantation. *N Engl J Med*. 2020;383(15):1447–1457.
[21] Benesch C., Glance L.G., Derdeyn C.P. et al. Perioperative Neurological Evaluation and Management to Lower the Risk of Acute Stroke in Patients Undergoing Noncardiac, Nonneurological Surgery: A Scientific Statement From the American Heart Association/American Stroke Association. *Circulation*. 2021;143(19):e923–e946.

Corresponding Author:
Daniel Rogowicz
Department of Cardiac Surgery,
The Ludwik Rydygier Collegium Medicum in Bydgoszcz,
The Nicolaus Copernicus University Toruń
Łukasiewicza 1 street, 85-821 Bydgoszcz, Poland
e-mail: rogowicz.d@gmail.com

Conflict of Interest: None
Funding: None
Author Contributions: Daniel Rogowicz[A–C, E, F, H], Karina Motolko[A–C, E, F, H], Radomir Skowronek[B, E, F, H], Damian Świątkowski[B, E, F, H], Katarzyna Zaborowska[B, F–H], Jakub Piotrowski[B, F–H], Aleksandra Wojnicz[B, F–H], Wojciech Pawliszak[G, H, J]

A — Concept and design of research, B — Collection and/or compilation of data, C — Analysis and interpretation of data, E — Writing an article, F — Search of the literature, G — Critical article analysis, H — Approval of the final version of the article, J — Supervising all stages of manuscript preparation

Received: 4.02.2024
Accepted: 22.03.2024