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Modern methods of researching autonomic functions in children with syncope: A literature review

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Abstract. The research of autonomic functions in children with non-cardiogenic syncope allows improving differential diagnosis and treatment tactics in children depending on the pathogenetic mechanisms of syncope development. The purpose of the research was to analyse modern scientific achievements in the field of autonomic functions in children with different types of syncope. The review used the full texts of English-language studies published between January 2018 and December 2022 and published in the PubMed Medline and Scopus databases. It has been established that the active orthostasis test, tilt test, circadian blood pressure rhythms and heart rate variability are the most commonly used functional autonomic tests in paediatric practice. They allow evaluating the spectrum of pathological cardiovascular reactions in a standing position; identifying types of orthostatic hypotension and causes of orthostatic intolerance; diagnosing orthostatic hypertension, postural orthostatic tachycardia syndrome, presyncope or syncope; to differentiating between sympathetic and parasympathetic autonomic dysfunctions and psychogenic transient syncope and epilepsy; to recommend orthostatic training as a method of treatment of syncope with an orthostatic mechanism of development. Despite this, there is no consensus on the definition of autonomic disorders and the methodology for conducting functional autonomic tests in children of different ages, considering their gender, body mass index and time of assessment during the day. Thus, functional autonomic tests are additional methods of physical and instrumental examination of the patient that allow effective assessment of the autonomic nervous system and possible mechanisms of syncope development, differentiation of transient loss of consciousness, stratification of future risks and optimisation of treatment and preventive tactics of the child's management based on an individual patient-centred approach

Keywords: nervous system; autonomic dysfunction; functional tests; vasovagal syncope; syncope due to orthostatic hypotension; children

INTRODUCTION

Since the 2000s, significant progress has been made in understanding the various aspects of syncope diagnosis and management. A significant part of this progress has been in the development of clear criteria for the diagnosis of syncope, according to the European Society of Cardiology (ESC) 2018 revision [1]. These guidelines call attention to the importance of conducting functional autonomic tests in patients with syncope as a manifestation of dysautonomia, as they provide an objective and quantitative assessment of the integrity and reactivity of autonomic nerves, ganglia, and the central nervous system in general. Since the autonomic nervous system is not available for direct physiological testing, clinical autonomic tests usually allow evaluating of the response of an end organ to a specific physiological provocation. The search for new effective methods of assessing autonomic functions in children with syncope is one of the priority areas of modern medicine, which will allow expanding the understanding of the pathogenetic mechanisms of syncope development and evaluating the effectiveness of treatment measures in the long term.

It is well-known that the phenomenon of syncope is the result of transient global cerebral hypoperfusion, which, regardless of the initiating mechanism, occurs due to a decrease in the activity of vasoconstrictor neurons and an increase in the parasympathetic activity of cardio-motor neurons [2]. The complexity of these mechanisms

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determines the significance of assessing the autonomic nervous system in patients with syncope, which involves studying the reactivity of the heart and/or blood pressure (BP) in response to tests such as active orthostasis, tilt test, Valsalva test, hyperventilation test, analysis of circadian BP rhythms and heart rate variability, etc [3]. Functional autonomic tests can help determine autonomic dysfunction as the main cause of classical orthostatic hypotension, characterise cardiovascular sympathetic and parasympathetic autonomic function, and assess the severity of autonomic dysfunction [4].

A.P. Wang *et al.* [5], Y. Cui *et al.* [6], M.R. Khalilian *et al.* [7] substantiate the significance of the research, quantification and topical diagnosis of autonomic dysfunction in the verification of vasovagal syncope and syncope due to orthostatic hypotension in childhood. The research of B. Gu *et al.* [8], T. Kovalchuk *et al.* [9] demonstrated that sympathetic function is dominant in children with vasovagal syncope under non-provocative conditions. Changes in such parameters as heart rate variability, QT interval dispersion, P-wave dispersion, late ventricular potentials, and the ability to slow the heart rate (HR) may indicate autonomic nervous system dysfunction and provide a new therapeutic target in the treatment of noncardiogenic syncope [10]. The results of observations by M. Kisanuki *et al.* [11], F. Aghajani *et al.* [12] indicate that training in autonomic functions is an effective method of treating patients with syncope, provided that autonomic dysfunction is involved in the pathogenesis of transient loss of consciousness. Thus, the research on autonomic nervous function in patients with non-cardiogenic syncope is useful both from the standpoint of a better understanding of syncope mechanisms and their diagnosis and treatment.

The purpose of this work was to analyse the current scientific achievements in the research of autonomic functions in children with different pathogenetic mechanisms of syncope development – vasovagal syncope, syncope due to orthostatic hypotension and cardiogenic syncope. The review focuses on autonomic functional tests that are considered by experts to be scientifically valid, reliable and clinically useful.

To analyse the data, the PubMed Medline and Scopus databases were used, using the following search terms: "vasovagal syncope" and "autonomic functions"; "syncope due to orthostatic hypotension" and "autonomic functions"; "cardiogenic syncope" and "autonomic functions". The research includes full texts of studies published in English between January 2018 and December 2022. A total of 294 scientific publications were identified – 187 in PubMed Medline and 107 in Scopus. Due to duplicates, 155 sources were excluded from the research. After screening 139 publications, 104 scientific works were excluded from the search due to irrelevant research subjects, lack of full-text versions of articles and the results of own research. Thus, 35 scientific publications were checked for relevance to the subject of the search.

USING ACTIVE AND PASSIVE ORTHOSTASIS TESTS IN THE ASSESSMENT OF AUTONOMIC FUNCTIONS IN CHILDREN

The active orthostasis test is used to evaluate the spectrum of pathological cardiovascular reactions in the standing position, to establish the types of orthostatic hypotension and causes of orthostatic intolerance, to diagnose orthostatic hypertension, postural orthostatic tachycardia syndrome, presyncope or syncope, and to determine autonomic function and dysfunction [13]. The initial decrease in BP during the first 10 seconds of active orthostasis reflects the discrepancy between the increase in cardiac output due to the outflow of blood from the lower extremity muscles and its deposition in the abdomen and the instantaneous vasodilation of the leg vessels. Short-term mechanisms of the baroreflex are accompanied by a rapid increase in HR (within 1-3 s), cardiac contractility (within 3-8 s), peripheral arterial and venous vasoconstriction (within 10-30 s), which lead to the recovery of BP. In most healthy people, these compensatory mechanisms are characterised by the restoration of baseline BP values within 20-30 s [14].

The spectrum of pathological haemodynamic reactions that are most often identified during an active orthostasis test with continuous BP monitoring is as follows [14]: initial orthostatic hypotension – a decrease in systolic blood pressure (SBP) > 40 mm Hg and/or diastolic blood pressure (DBP) > 20 mm Hg within 15 s of standing in the absence of persistent orthostatic hypotension; late recovery – delayed or inability to restore BP to ≤ 20 mm Hg from baseline values after 30-40 s of active orthostasis in the absence of criteria for classical orthostatic hypotension; classical orthostatic hypotension – a persistent decrease in SBP ≥ 20 mm Hg or DBP ≥ 10 mm Hg, that occurs between 60 and 180 seconds of orthostasis; orthostatic hypertension – sustained increase in SBP ≥ 20 mm Hg or DBP ≥ 10 mm Hg after 60-180 seconds of orthostasis; postural orthostatic tachycardia syndrome – sustained tachycardia with a HR > 40 beats/min from baseline in children or > 120 beats/min in general without concomitant orthostatic hypotension.

It is generally accepted that the active orthostasis test with continuous BP monitoring is a more accurate method of diagnosing syncope compared with single BP measurements at the 1st, 3rd, 5th, 7th, and 10th minute in a standing position [15]. Therewith, H. Cai *et al.* [16] substantiated the effectiveness of the active orthostasis test in patients with postural orthostatic tachycardia syndrome, which was equivalent to the Tilt test. In any case, the active orthostasis test is the only tool for diagnosing syncope due to orthostatic hypotension, which is confirmed by a fall in SBP ≥ 20 mm Hg or DBP ≥ 10 mm Hg from baseline, or a fall in SBP < 90 mm Hg, accompanied by spontaneous reproduction of symptoms in orthostasis [1].

The tilt test (tilt table test, passive orthostasis test) is a useful diagnostic test in the diagnosis of syncope with an orthostatic component. The main purpose of the tilt test is to provoke an event with recognition of the complaint and demonstrate a pathophysiological correlate [17]. Both of these aspects are key: recognition can refer to subjective sensations reported by patients and visible aspects such as changes in facial colour or movements that the examiner judges to be spontaneous. Along with the demonstration of pathophysiological measurements, a clinical and pathophysiological correlate is obtained to confirm the cause of the transient loss of consciousness.

The Tilt test is a useful tool for the diagnosis of those forms of syncope that are accompanied by an orthostatic component, such as reflex syncope, syncope due to orthostatic hypotension, and postural orthostatic tachycardia syndrome [17]. In addition, the Tilt test has an important diagnostic value for provoking psychogenic transient syncope by excluding epilepsy, which is not usually provoked by orthostasis [18]. The Tilt test can help to differentiate between sympathetic or parasympathetic autonomic dysfunction and distinguish between neurogenic and non-neurogenic causes of classical orthostatic hypotension [19]. Thus, L. Norcliffe-Kaufmann *et al.* [20] demonstrated that the ratio of ΔHF/ΔBP from the supine position to the standing position within 3 minutes < 0.5 beats/min/mm Hg indicates neurogenic orthostatic hypotension (sensitivity 91%; specificity 88%; area under the curve (AUC) = 0.96).

G. Barón-Esquivias *et al.* [21] proved that the combined use of the European Society of Cardiology guidelines and the tilt test in 1 058 adult patients with syncope was accompanied by the diagnosis of syncope of unknown etiology in 19.5% of cases. To confirm vasovagal syncope in patients, the tilt test with drug provocation – intravenous administration of isoproterenol or sublingual administration of nitroglycerine is increasingly used [22]. Drug provocation increases the sensitivity of the tilt test, but slightly reduces its specificity [23]. Due to a large number of side effects, drug provocation in paediatric practice is limited and not standardised [24].

Although the tilt test has been used in clinical practice for more than 30 years, it lacks standardisation and therefore different protocols are used in different centres [25]. The sensitivity of the tilt test in the diagnosis of vasovagal syncope varies and ranges from 21 to 85%, depending on the specific protocol used [26]. The prevalence of asystole during tilt-induced vasovagal syncope may depend on the test methodology [27]. In addition, the European Society of Cardiology guidelines note that a positive tilt test occurs in 92% of patients with vasovagal syncope and 47% of patients with cardiogenic syncope, and the presence of a negative result does not refute the diagnosis of vasovagal syncope [1]. N. Kulkarni *et al.* [28] drew attention to the high frequency of false positive and false negative results of the body test, and suggested that the tilt table test should no longer be used to diagnose syncope.

Thus, active and passive orthostasis tests are important methods for assessing the functional state of the autonomic nervous system and diagnosing syncope with an orthostatic component. Therewith, there is no clear standardised protocol for conducting a tilt test, and therefore, the results of the test interpretation may differ significantly depending on the methodology.

THE VALUE OF THE VALSALVA TEST, HYPERVENTILATION TEST AND CAROTID SINUS MASSAGE IN THE RESEARCH OF AUTONOMIC FUNCTIONS

The Valsalva test – an exercise test characterised by changes in intrathoracic pressure and accompanied by a specific haemodynamic response. The latter can be divided into four separate phases: Phase I – an increase in mean arterial pressure at the beginning of exercise due to an increase in intrathoracic pressure; Phase IIa – a decrease in stroke volume due to a decrease in atrial filling pressure; Phase IIb – an increase in HR due to the activation of the arterial baroreflex to compensate for the reduced stroke volume; Phase III – a rapid decrease in mean arterial pressure due to a decrease in exercise; Phase IV – a rapid recovery and increase in mean arterial pressure as the restored cardiac output is released into the constricted arterial vessels [28]. Thus, the Valsalva test provides an autonomous analysis of BP and HR modifications during respiratory activity.

The parasympathetic activity of the autonomic nervous system is often assessed by calculating the Valsalva coefficient. According to the results of the study by U. Zafar *et al.* [29] there was no significant difference between the functioning of the parasympathetic and sympathetic systems in young men and women. An effective response of peripheral vascular resistance of end organs is crucial for controlling BP in the upright position and preventing syncope. The Valsalva test causes a decrease in BP, which causes baroreflex-mediated vasoconstriction. B.C.D. Hockin *et al*. [30] characterised the forearm vascular resistance responses to the Valsalva test in healthy subjects and explored their connection with orthostatic intolerance. The authors suggested that people with a reduced forearm vascular resistance response are more susceptible to syncope, regardless of gender.

Pathological changes in BP and HR during the Valsalva test are a marker of orthostatic intolerance. Thus, neurogenic orthostatic hypotension is characterised by a progressive decrease in BP in phase II and its slow recovery in phase IV [31]. J. Baker *et al.* [32] found that the Valsalva test, like other baroreflex-mediated tests, affects the function of the cerebellum, which plays an essential role in the vestibulo-sympathetic reflexes of BP changes in orthostasis. Nevertheless, the distinct haemodynamic patterns and associated baroreflex hypersensitivity in orthostatic intolerance are still understudied and controversial, and there are no clear protocols for interpreting Valsalva test results in children with transient syncope.

Whether hyperventilation is caused by rapid or deep breathing, it is common in stressful situations and may contribute to symptoms of presyncope or syncope. The effects of some previously tested interventions to prevent syncope, such as applied tension, may be associated with a reduction in hyperventilation. More targeted respiratory control techniques may be useful and promising additional methods to reduce vasovagal symptoms [33].

Hyperventilation in the upright position is observed in 25% of patients with postural orthostatic tachycardia syndrome as a manifestation of orthostatic intolerance with a high risk of syncope [33]. Hyperventilation in postural orthostatic tachycardia syndrome is characterised by hyperpnoea, in contrast to a panic attack, which causes tachypnoea. In orthostatic failure, hyperventilation decreases cardiac output, and peripheral resistance and BP increase. Such changes distinguish hyperventilation from arbitrary hyperventilation, when cardiac output increases, while resistance and BP decrease, and from a panic attack when all these parameters increase [34].

The hyperventilation test is one of the methods for assessing autonomic function in patients with syncope. Usually, the HR increases during inhalation and decreases during exhalation. The variability of HR during deep breathing (expiratory-inspiratory index) is ⩾ 15 beats/min in healthy individuals over the age of 50 [1]. There is convincing evidence that a decrease in this index is an indication of parasympathetic dysfunction [35]. The hyperventilation test can be used in the diagnosis of autonomic dysfunction in children, but there is no clear algorithm for performing this test and its interpretation in paediatric practice.

Carotid sinus massage is another diagnostic test used in patients over 40 years of age. A cardiac pause of > 3 s and/or a drop in SBP > 50 mm Hg is the result of carotid sinus hypersensitivity and may be the cause of syncope in older age [36]. Carotid sinus massage is an effective test of vagal stimulation in children with paroxysmal supraventricular tachycardia but has not been proven effective in assessing autonomic dysfunction in paediatrics [1].

The above is evidence of the effectiveness of using the Valsalva test and hyperventilation test in children with syncope to determine sympathicotonia or vagotonia in the functioning of the CVS. Further research is needed to explore the reference values and features of the interpretation of these tests in children of different ages.

EVALUATION OF CIRCADIAN BLOOD PRESSURE RHYTHMS AND HEART RATE VARIABILITY

Due to physiological circadian rhythms, human BP undergoes significant daily fluctuations. The research of circadian rhythms of BP using daily BP monitoring is a modern, effective and easily accessible method of evaluating the functioning of the autonomic nervous system in children [5]. Thus, the daytime period is characterised by sympathicotonia and increased plasma catecholamine concentrations, while the nighttime period is characterised by vagotonia and decreased blood catecholamine concentrations. Staying in the supine position during sleep is accompanied by a redistribution of systemic blood flow with blood accumulation in the lower extremities and causes increased blood flow to the trunk, increased central venous pressure and afferent impulses in baroreceptors, and increased inhibitory effects of afferent vasomotor centres in orthostasis. After that, the sympathetic arousal reflex is weakened, cardiac output decreases, peripheral vascular resistance decreases, general hypotension of the body muscles develops, and, as a result, BP levels decrease during the night [37].

Notably, there are no clear diagnostic criteria for daily BP monitoring in patients with suspected syncope. Several studies indicate specific patterns of circadian BP rhythms in this group of patients. G. Rivasi *et al.* [38] proved that patients with reflex syncope have significantly more frequent episodes of low SBP according to the results of daily BP monitoring compared with healthy subjects. The group of authors R. Zou *et al.* [39] identified a significantly higher percentage of insufficient (non-dipper) degree of nocturnal BP reduction among children with vasovagal syncope, which was associated with vitamin D deficiency. T. Kovalchuk & O. Boyarchuk [40] proved that the prevalence of the pathological profile of "non-dippers" of nocturnal SBP reduction is 47.7% and is the justification for the dysfunction of the autonomic nervous system in children with vasovagal syncope.

In patients with vasovagal syncope, a comparison of daily BP monitoring with an activity diary can establish correlations between hypotension episodes and their potential triggers [41]. In patients with neurogenic orthostatic hypotension, daily BP monitoring can detect nocturnal hypertension and hypotension associated with food, medication, or exercise, which, in turn, offers a window of opportunity for individualised treatment [42].

To evaluate the functioning of the autonomic nervous system, several cardiac electrophysiological parameters have been developed and implemented in clinical practice, such as HR variability, Q-T interval dispersion, P wave dispersion, late ventricular potentials, HR deceleration, etc. The implementation of these electrophysiological parameters of the cardiovascular system allows for the selection of individual treatment plans for children with different haemodynamic types of syncope [43]. However, there is still a lack of systematic multicentre long-term studies that would confirm or refute the diagnostic and prognostic value of these indicators in the group of patients with syncope.

H. Akizuki *et al.* [44] proved that in adults with vasovagal syncope, there is a depression of the sympathetic and parasympathetic autonomic nervous system, and the increase in HR after a syncope episode is due to parasympathetic inhibition rather than sympathetic reactivation. In addition, the authors proposed to use the coefficient of variation of the R-R interval as an effective clinical biomarker of syncope in the emergency department. However, S. Akıncı *et al.* [45] found no difference in HR variability parameters between tilt-positive and tilt-negative patients and concluded that basal autonomic functions do not affect the pathogenesis of vasovagal syncope.

The results of the research by Q. Zhang *et al.* [46] demonstrated that children with vasovagal syncope have a decrease in the parasympathetic tone of the cardiovascular system in the setting of vitamin D deficiency. While Y. Wang *et al.* [47] established that ULF (average spectral power value at a frequency of ≤ 0.003 Hz) and VLF (average spectral power value at a frequency of < 0.05 Hz) are higher in children with vasovagal syncope compared to postural orthostatic tachycardia syndrome and recommended using these indicators of HR variability for the differential diagnosis of these groups of patients.

Thus, the active orthostasis test, tilt test, and research of circadian BP rhythms and HR variability in children are the functional autonomic tests most often used in paediatric clinical practice and research. There is no doubt that most methods for assessing autonomic functions are restricted by limited experience in children and the lack of clear criteria for diagnosing autonomic disorders depending on age, gender, body mass index, and time of assessment during the day.

CONCLUSIONS

Assessment of the autonomic nervous system functioning can be performed non-invasively using autonomic tests based on determining the response of the cardiovascular system to applied stimuli or provocations. These include the active orthostasis test, tilt test, Valsalva test, hyperventilation test, assessment of daily BP rhythms and HR variability. Functional autonomic tests are additional methods of physical and instrumental examination of the patient, which allow effective assessment of the autonomic nervous system with an assessment of the dominance of sympathicotonia or vagotonia, establish the possible mechanisms of syncope development, including orthostatic intolerance, and differentiate between types of transient loss of consciousness. Orthostatic training improves the functioning of the autonomic nervous system and is an essential method of treating syncope with an orthostatic mechanism, although its effectiveness is still controversial. The results of studies of the autonomic nervous system will allow stratifying the risk of developing syncope in the future and making decisions about the specifics of treatment of a child in each case of syncope. Considering the significance of evaluating the autonomic nervous system in patients with syncope, notably, a significant number of functional autonomic tests are non-standardised and have limited use in paediatric patients due to the lack of criteria for autonomic disorders depending on age, gender, body mass index and time of assessment during the day. Given the wide variety of available methods and their variations, there is a need to develop a single consensus methodology for the assessment of autonomic nervous system functioning in children. Establishing commonly accepted standards for the assessment and classification of autonomic disorders will ensure homogeneity of results between studies and allow for more effective comparisons of data obtained in different clinical settings and patient groups.

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CONFLICT OF INTEREST
The author declares no conflict of interest.

REFERENCES
[1] Brignole M, Moya A, de Lange FJ, Deharo JC, Elliott PM, Fanciulli A, et al. 2018 ESC Guidelines for the diagnosis and management of syncope. Eur Heart J. 2018;39(21):1883–48. DOI: 10.1093/eurheartj/ehy037
[2] Li HX, Gao L, Yuan Y. Advance in the understanding of vasovagal syncope in children and adolescents. World J Pediatr. 2021;17(1):58–62. DOI: 10.1007/s12519-020-00367-z
[3] Nader-Kawachi J, Manrique-Mirón PC, Pino-Peña YC, Andrade-Magdaleno ML, López-Estrada J. Feasibility of a new free mobility procedure to evaluate the function of the autonomic nervous system in patients with syncope. Sci Rep. 2020;10:13994. DOI: 10.1038/s41598-020-70701-y
[4] Aponte-Becerra L, Novak P. Tilt test: A review. J Clin Neurophysiol. 2021;38(4):279–86. DOI: 10.1097/WNP.0000000000000625
[5] Wang AP, Zheng J, Wang C, Cai H, Mao DA, Lin P, et al. [Vasovagal syncope or postural orthostatic tachycardia syndrome in children with neurological symptoms at disease onset: A clinical analysis of 88 cases]. Zhongguo Dang Dai Er Ke Za Zhi. 2020;22(5):488–93. DOI: 10.7499/j.issn.1008-8830.1911080
[6] Cui Y, Liao Y, Zhang Q, Yan H, Liu P, Wang Y, et al. Spectrum of underlying diseases in syncope and treatment of neurally-mediated syncope in children and adolescents over the past 30 years: A single center study. Front Cardiovasc Med. 2022;9:1017505. DOI: 10.3389/fcvm.2022.1017505
[7] Khalilian MR, Ghasemi A, Khazaei N, Khoshkhou S, Mahmoudi E. Repolarization disparity as a predictor of response to Head up Tilt-table Test in pediatric syncope. Pacing Clin Electrophysiol. 2021;44(8):1397–3. DOI: 10.1111/pace.14305
[8] Gu B, Liu T, Yang L, Zhang H, Xin Y, Wang J. Head-up tilt test induces T-wave alternans in long QT syndrome with KCNQ1 gene mutation: Case report CARE-compliant article. Medicine (Baltimore). 2020;99(20):e19818. DOI: 10.1097/MD.0000000000019818
[9] Kovalchuk T, Boyarchuk O, Pavlyshyn H, Balatska N, Luchyshyn N. Analysis of heart rate variability in paediatric patients with vasovagal syncope. Pediatr Pol. 2019;94(6):357–67. DOI: 10.5114/polp.2019.92965
[10] Bilici M, Fidancı-Dedeoğlu Z, Demir F, Akın A, Türe M, Balık H, et al. Prolonged QT dispersion is associated with pediatric syncope. Turk J Pediatr. 2019;61(1):85–91. DOI: 10.24953/turkjped.2019.01.013
[11] Kisanuki M, Ikeda S, Kondo M, Odashiro K. A case of vasovagal syncope associated with carotid sinus hypersensitivity: Effectiveness of tilt training and subsequent squatting. J Cardiol Cases. 2022;26(6):423–25. DOI: 10.1016/j.jccase.2022.09.003
[12] Aghajani F, Tavolinejad H, Sadeghian S, Bozorgi A, Jalali A, Vasheghani-Farahani A, et al. Implementation of supervised physical training to reduce vasovagal syncope recurrence: A randomized controlled trial. J Cardiovasc Electrophysiol. 2022;33(8):1863–70. DOI: 10.1111/jce.15578
[13] Van Twist DJL, Dinh T, Bouwmans EME, Kroon AA. Initial orthostatic hypotension among patients with unexplained syncope: An overlooked diagnosis? Int J Cardiol. 2018;271:269–73. DOI: 10.1016/j.ijcard.2018.05.043
[14] Van Wijnen VK, Ten Hove D, Finucane C, Wieling W, Van Roon AM, Ter Maaten JC, Harms MPM. Hemodynamic mechanisms underlying initial orthostatic hypotension, delayed recovery and orthostatic hypotension. J Am Med Dir Assoc. 2018;19(9):786–92. DOI: 10.1016/j.jamda.2018.05.031
[15] Okamura S, Sairaku A, Tokuyama T, Okubo Y, Ikeuchi Y, Miyauchi S, et al. Peripheral arterial tone during active standing. Pflugers Arch. 2021;473(12):1939–46. DOI: 10.1007/s00424-021-02632-0
[16] Cai H, Wang S, Zou R, Liu P, Li F, Wang Y, Wang C. Comparison of the active sitting test and head-up tilt test for diagnosis of postural tachycardia syndrome in children and adolescents. Front Pediatr. 2021;9:691390. DOI: 10.3389/fped.2021.691390
[17] White L, Jones HT, Davies A. What is a tilt table test and why is it performed during the investigation of syncope? Br J Hosp Med (Lond). 2021;82(10):1–7. DOI: 10.12968/hmed.2020.0462

[18] Stewart JM, Boris JR, Chelimsky G, Fischer PR, Fortunato JE, Grubb BP, et al. Pediatric disorders of orthostatic intolerance. Pediatrics. 2018;141(1):e20171673. DOI: 10.1542/peds.2017-1673
[19] Cheshire WP, Goldstein DS. Autonomic uprising: The tilt table test in autonomic medicine. Clin Auton Res. 2019;29:215–30. DOI: 10.1007/s10286-019-00598-9
[20] Norcliffe-Kaufmann L, Kaufmann H, Palma JA, Shibao CA, Biaggioni I, Peltier AC, et al. Orthostatic heart rate changes in patients with autonomic failure caused by neurodegenerative synucleinopathies. Ann Neurol. 2018;83(3):522–31. DOI: 10.1002/ana.25168
[21] Barón-Esquivias G, Díaz Martín AJ, Marco Del Castillo Á, Quintanilla M, Barón-Solís C, Morillo CA. Head-up tilt test diagnostic yield in syncope diagnosis. J Electrocardiol. 2020;63:46–50. DOI: 10.1016/j.jelectrocard.2020.09.016
[22] Buszko K, Piątkowska A, Koźluk E, Fabiszak T, Opolski G. Hemodynamic response to tilt test in vasovagal syncope. Sci Rep. 2018;8:14554. DOI: 10.1038/s41598-018-32718-2
[23] García A, Bustillos-García GA, Rivera-Roodríguez L. Safety of pediatric head-up tilt test with pharmacological challenge. Arch Cardiol Mex. 2020;90(2):163–72. DOI: 10.24875/ACME.M20000111
[24] Duong H, Masarweh OM, Campbell G, Win TT, Joolhar F. Isoproterenol-induced coronary vasospasm and ST elevations during tilt table testing. J Investig Med High Impact Case Rep. 2020;8:2324709620966862. DOI: 10.1177/2324709620966862
[25] Van Dijk JG, Ghariq M, Kerkhof FI, Reijntjes R, van Houwelingen MJ, van Rossum IA, et al. Novel methods for quantification of vasodepression and cardioinhibition during tilt-induced vasovagal syncope. Circ Res. 2020;127(5):e126–e38. DOI: 10.1161/CIRCRESAHA.120.316662
[26] Xu L, Cao X, Wang R, Duan Y, Yang Y, Hou J, et al. Clinical features of patients undergoing the head-up tilt test and its safety and efficacy in diagnosing vasovagal syncope in 4,873 patients. Front Cardiovasc Med. 2022;8:781157. DOI: 10.3389/fcvm.2021.781157
[27] Russo V, Parente E, Groppelli A, Rivasi G, Tomaino M, Gargaro A, et al. Prevalence of asystole during tilt test-induced vasovagal syncope may depend on test methodology. EP Europace. 2023;25(2):263–69. DOI: 10.1093/europace/euac154
[28] Kulkarni N, Mody P, Levine BD. Abolish the tilt table test for the workup of syncope! Circulation. 2020;141(5):335–37. DOI: 10.1161/CIRCULATIONAHA.119.043259
[29] Zafar U, Rahman SU, Hamid N, Salman H. Assessment of gender differences in autonomic nervous control of the cardiovascular system. J Pak Med Assoc. 2020;70(9):1554–58. DOI: 10.5455/JPMA.27702
[30] Hockin BCD, Tang EZ, Lloyd MG, Claydon VE. Forearm vascular resistance responses to the Valsalva maneuver in healthy young and older adults. Clin Auton Res. 2021;31:737–53. DOI: 10.1007/s10286-021-00810-9
[31] Guaraldi P, Baschieri F, Barletta G, Cecere A, Cortelli P, Calandra-Buonaura G. Validation of the new index of baroreflex function to identify neurogenic orthostatic hypotension. Auton Neurosci. 2020;229:102744. DOI: 10.1016/j.autneu.2020.102744
[32] Baker J, Paturel JR, Kimpinski K. Cerebellar impairment during an orthostatic challenge in patients with neurogenic orthostatic hypotension. Clin Neurophysiol. 2019;130(1):189–95. DOI: 10.1016/j.clinph.2018.07.026
[33] Mennitto S, Harrison J, Ritz T, Robillard P, France CR, Ditto B. Respiration and applied tension strategies to reduce vasovagal reactions to blood donation: A randomized controlled trial. Transfusion. 2019;59(2):566–73. DOI: 10.1111/trf.15046
[34] Stewart JM, Pianosi P, Shaban MA, Terilli C, Svistunova M, Visintainer P, Medow MS. Hemodynamic characteristics of postural hyperventilation: POTS with hyperventilation versus panic versus voluntary hyperventilation. J Appl Physiol. 2018;125(5):1396–3. DOI: 10.1152/japplphysiol.00377.2018
[35] Lamotte G, Coon EA, Suarez MD, Sandroni P, Benarroch E, Cutsforth-Gregory JK, et al. Standardized autonomic testing in patients with probable radiation-induced afferent baroreflex failure. Hypertension. 2022;79(1):50–56. DOI: 10.1161/HYPERTENSIONAHA.121.17805
[36] Wu TC, Hachul DT, Darrieux FCC, Scanavacca MI. Carotid sinus massage in syncope evaluation: A nonspecific and dubious diagnostic method. Arq Bras Cardiol. 2018;111(1):84–91. DOI: 10.5935/abc.20180114
[37] Zhixiang Y, Cheng W, Jibing X, Bisheng G, Ming X, Deyu L. Ambulatory blood pressure monitoring in children suffering from orthostatic hypertension. BioMed Eng OnLine. 2018;17:129. DOI: 10.1186/s12938-018-0530-4
[38] Rivasi G, Groppelli A, Brignole M, Soranna D, Zambon A, Bilo G, et al. Association between hypotension during 24 h ambulatory blood pressure monitoring and reflex syncope: The SynABPM 1 study. Eur Heart J. 2022;43(38):3765–76. DOI: 10.1093/eurheartj/ehac347
[39] Zou R, Wang S, Cai H, Li F, Lin P, Wang Y, Wang C. Vitamin D deficiency in children with vasovagal syncope is associated with impaired circadian rhythm of blood pressure. Front Neurosci. 2021;15:712462. DOI: 10.3389/fnins.2021.712462
[40] Kovalchuk T, Boyarchuk O. The features of the circadian rhythm of blood pressure in children with vasovagal syncope. Actual Probl Pediatr Obstet Gynecol. 2020;(1):10–16. DOI: 10.11603/24116-4944.2020.1.11477
[41] Sharad B, Rivasi G, Hamrefors V, Johansson M, Ungar A, Sutton R, et al. Twenty-four-hour ambulatory blood pressure profile in patients with reflex syncope and matched controls. J Am Heart Assoc. 2023;1–8. DOI: 10.1161/JAHA.122.028704
[42] Li Y, Wang M, Liu XL, Ren YF, Zhang WB. Neurogenic orthostatic hypotension with Parkinson's disease as a cause of syncope: A case report. World J Clin Cases. 2021;9(21):6073–80. DOI: 10.12998/wjcc.v9.i21.6073

[43] Wang Y, Zhang C, Chen S, Liu P, Wang Y, Tang C, et al. Heart rate variability predicts therapeutic response to metoprolol in children with postural tachycardia syndrome. Front. Neurosci. 2019;13:1214. DOI: 10.3389/fnins.2019.01214
[44] Akizuki H, Hashiguchi N. Heart rate variability in patients presenting with neurally mediated syncope in an emergency department. Am J Emerg Med. 2020;38(2):211–16. DOI: 10.1016/j.ajem.2019.02.005
[45] Akıncı S, Çoner A, Balcıoğlu AS, Akbay E, Müderrisoğlu IH. Heart rate variability and heart rate turbulence in patients with vasovagal syncope. Kardiologiia. 2021;61(8):54–59. DOI: 10.18087/cardio.2021.8.n1523
[46] Zhang Q, Sun Y, Zhang C, Qi J, Du J. Vitamin D deficiency and vasovagal syncope in children and adolescents. Front. Pediatr. 2021;9:575923. DOI: 10.3389/fped.2021.575923
[47] Wang Y, Zhang C, Chen S, Li X, Jin H, Du J. Frequency domain indices of heart rate variability are useful for differentiating vasovagal syncope and postural tachycardia syndrome in children. J Pediatr. 2019;207:59–63. DOI: 10.1016/j.jpeds.2018.11.054

Сучасні методи дослідження вегетативних функцій у дітей із синкопе: огляд літератури

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Анотація. Вивчення вегетативних функцій у дітей із некардіогенними синкопе дозволяє покращити диференційну діагностику та лікувальну тактику у дітей залежно від патогенетичних механізмів розвитку непритомності. Метою дослідження був аналіз сучасних наукових досягнень у вивченні вегетативних функцій у дітей із різними видами синкопе. В огляді використані повні тексти англомовних статей, опубліковані у період з січня 2018 року по грудень 2022 року та розміщені у базах даних PubMed Medline і Scopus. Встановлено, що тест активного ортостазу, тілт-тест, дослідження циркадних ритмів артеріального тиску та варіабельності серцевого ритму є найбільш застосованими функціональними вегетативними тестами у педіатричній практиці. Вони дозволяють оцінити спектр патологічних серцево-судинних реакцій у положенні стоячи; ідентифікувати типи ортостатичної гіпотензії та причини ортостатичної непереносимості; діагностувати ортостатичну гіпертензію, синдром постуральної ортостатичної тахікардії, пресинкопе або синкопе; диференціювати симпатичну і парасимпатичну вегетативні дисфункції та психогенні транзиторні втрати свідомості і епілепсію; рекомендувати ортостатичні тренування, як метод лікування синкопе з ортостатичним механізмом розвитку. Попри це, не існує консенсусного підходу щодо визначення вегетативних розладів і методології проведення функціональних вегетативних тестів у дітей різного віку із врахуванням їх статі, індексу маси тіла та часу оцінки впродовж доби. Таким чином, функціональні вегетативні тести є додатковими методами фізикального та інструментального обстеження пацієнта, які дозволяють ефективно оцінити стан вегетативної нервової системи та ймовірні механізми розвитку синкопе, диференціювати транзиторні втрати свідомості, стратифікувати майбутні ризики та оптимізувати лікувально-профілактичну тактику ведення дитини, базуючись на індивідуальному пацієнт-центрованому підході

Ключові слова: нервова система; вегетативна дисфункція; функціональні тести; вазовагальне синкопе; синкопе внаслідок ортостатичної гіпотензії; діти