THE NEW ARMENIAN MEDICAL JOURNAL
Volume17 (2023), Issue 2 p.72-77

DOI: https://doi.org/10.56936/18290825-2023.17.2-72

GRAVITY FACTOR IN DETERMINATION OF HEMODYNAMICS REGULATORY SETTING IN HUMAN (RHEOGRAPHIC STUDY)

Dilenyan L.R., Belkaniya G.S., Fedotova A.S., Bocharin I.V,. Martusevich A.K. *

Laboratory of medical biophysics, Privolzhsky Research Medical University, Nizhny Novgorod, Russia

Received 15.11.2022; accepted for printing 10.01.2023

Abstract

The purpose of this study was to show the dynamics of the ratio of arterial hypo- and hypercirculation in postanal ontogenesis. The ratio of opposite hemodynamic phenomena, such as circulatory insufficiency in arterial blood circulation (arterial hypocirculation) and adaptive arterial hypercirculation, reflects the direction of the regulatory setting of the circulatory state of the cardiovascular system. In the regulatory setting of blood circulation in a person in the standing position prevails "anti-gravity stress", which eliminates the age component detected in the supine position. The defining characteristic of this voltage is the pressor unit for regulating the cardiovascular system, which is characterized by a systemic prevalence of vasoconstriction (hyperresistivity of arterial vessels), as well as signs of circulatory insufficiency. In the supine position, under the conditions of minimal impact of the gravitational factor, adaptive conditions prevail up to 35 years. After 35 years the transition and disadaptive states were registered rottenly. Changes are mainly detected in the standing position in the pelvis-hip and leg block, and after 35 years are fixed in the lying position.

Keywords: *hemodynamics, orthostatic types, regulatory standing, gravity*

Introduction

The study of the problems of human evolution is necessary to understand the biological foundations of various pathologies [*Folkow B, Nile E, 1996; Rasmer R, 2001; Zampieri P, 2009*]. Moreover, in humans, unlike other animals, the cardiovascular system (CVS) is vulnerable [*Sahni M et al., 2005; Guyton AG, Hall DE, 2008; Belkaniya GS et al, 2014; Sayenko DG et al, 2015*]. Unlike all four-legged animals, in a person who is upright (standing, sitting, walking), a person's vertical axis coincides with the gravitational vertical [*Sahni M, Lowenthal DT, Meuleman J, 2005; Masuki S et al., 2007; Belkaniya GS et al, 2014; Sayenko DG et al., 2015; Dilenyan LR et al., 2018*]. Under these conditions, the maximum effect of the gravitational (hydrostatic) factor in the functioning of the cardiovascular system occurs [*Arbeille P et al., 2008; Fedorowski A et al, 2009; Fan XH et al., 2010; Rose KM et al., 2010; Jones CD et al., 2012*].

At all stages of postnatal ontogenesis, one of the permanent and characteristic species factors of hydrostatic «perturbation» of the circulatory state of CVS is a stereotypical change in the position of the body associated with the diurnal rhythm of the postural conditions of life characteristic only for a person [*Sahni M et al., 2005; Jones CD et al., 2012; Belkaniya GD et al, 2014; Dilenyan LR et al, 2019*]. Outwardly, this is a daily stereotypical change in the position of the body, and for blood

Cite This Article as:

***Dilenyan L.R., Belkaniya G.S., Fedotova A.S., Bocharin I.V,. Martusevich A.K.,* (2023).** Gravity factor in determination of hemodynamics regulatory setting in human (rheographic study); The New Armenian Medical Journal. 17(2): 72-77; DOI: https://doi.org/10.56936/18290825-2023.17.2-72

Address for Correspondence:

Andrew K. Martusevich, PhD
Privolzhsky Research Medical University
10/1 Minin square, Nizhny Novgorod, Russian Federation
tel. +7-909-144-92-82
e-mail: cryst-mart@yandex.ru

circulation, fundamentally different conditions for the manifestation of the hydrostatic (gravitational) factor of blood circulation [*Zampieri P, 2009; Belkaniya GS et al, 2014; Sung SH et al. 2014; Dilenyan LR et al., 2018*].

As conditions that destabilize the circulatory state of CVS, you should also keep in mind a wide range of somatic conditions – from fatigue to painful ones, which are cardiovascular diseases. At the same time, it should be borne in mind that against the background of any painful somatic condition,either excessive regulation stress on the gravitational factor of blood circulation or insufficient circulatory adaptation may occur [*Masuki S et al., 2007; Arbeille P et al., 2008; Rose KM et al., 2010; Jones CD et al., 2012; Belkaniya GS et al, 2014; Dilenyan LR et al., 2018*]. In this regard, it is important to evaluate the circulatory state not by functional and, especially, clinical consequences, but by the systemic characteristics of blood circulation. This approach can establish new hemodynamic predictors of the development of clinically significant disorders in CVS, which, in turn, will allow the prevention of such disorders. Based on this the most important is to study the ratios of different directions for arterial circulation

The **purpose of this study** was to show the dynamics of the ratio of arterial hypo- and hypercirculation in postanal ontogenesis.

Material and methods

Patients

The observation group consisted of 1,944 people (1,308 men and 636 women). Patients with acute conditions and exacerbations of chronic diseases were excluded from the examination. The samples are presented in tables and were formed in accordance with the classification of stages of ontogenetic adaptation to the Earth's gravity in the process of formation and life activity in typical human conditions of upright walking.

Methods characteristics

The study was carried out with program and apparatus device "ANTHROPOS-CAVASCREEN" is basing on rheography standing and after 15-20 minutes in standing and lying (supine) positions [*Belkaniya GS et al., 2013, 2014; Dilenyan LR et al, 2019*]. When going beyond the lower limit of the AP indicator, a decrease in arterial blood flow and arterial circulatory insufficiency syndrome (AC2) are identified, and an in case of beyond the upper limit of this parameters is fixed an increase in blood flow and arterial hypercirculation syndrome (AC1).

Each of the age samples can be represented by AC1 and AC2 [*Belkaniya GS et al., 2013, 2014; Dilenyan LR et al, 2019*]. Hence, the group characteristic of arterial circulation is estimated by the ratio (% of the sample) of opposite-directed syndromes (AC1 / AC2) by blood circulation units (Table 1, upper half). Assessment states for AC1 / AC2 are color-coded as follows: circulatory stable - white (AC1 = 0 / AC2 = 0); adaptive state - green (AC1 > AC2); transition state - yellow (AC1 ≈ AC2); disadaptive state - red (AC1 < AC2). Reliably (P≤0.05 and less) prevailing shares (in absolute value) of syndromes in estimated ratios are marked in bold.

Statistics

The data were analyzed using standard parametric and nonparametric methods of statistical analysis [*Gubler EV, Genkin AA, 2003*].

Results and Discussion

The data is presented in the form of analytical matrices that reflect the direction of differences in the analyzed relationships.

Outside of the active "anti-gravity" stress of the circulatory state of the CCC in the supine position along the arterial circulation (AC1/AC2) during the pre-definitive stage of postnatal ontogenesis and during the period of the greatest stabilization of the circulatory state, the CCC at the age of 22-35 years is characterized by an adaptive state in which hypercirculatory syndromes prevail in both men and women. In table 1, the corresponding matrix cells are marked in green. At the same time, for the vast majority of AD cells (in total for men and women), there were no circulatory insufficiency syndromes (AC2) for the designated age period out of 40 positions for 35 (P<0.01) (.../0) or their manifestation was low (... /1-2%). Transition states are not found in any cell.

Starting from the 2nd reproductive age (older than 35 years), a permanent increase in the absolute value of the proportion of syndromes is detected (table. 1 and 2) circulatory insufficiency in arterial blood flow, which reflects the systemic na-

TABLE 1

Arterial circulation in men by the ratio of circulatory syndromes manifestation (in %) in the lying and standing positions

Circulatory blocks	Age intervals (years, n) < 8 (n=44)	9-14 (n=37)	15-21 (n=129)	22-35 (n=209)	36-60 (n=467)	До 70 (n=271)	70> (n=151)
Arterial hypercirculation / insufficiency in the lying position (AC1/AC2)							
Lungs	**61**/0	**65**/0	**39**/1	**23**/4	3/4	**4**/0	**5**/1
Head	**86**/0	**73**/0	**47**/0	**47**/0	**30**/2	**18**/6	**30**/7
Abdomen	**39**/0	**32**/3	**28**/1	**24**/0	**18**/6	**27**/0	**30**/0
Pelvis	**57**/0	**57**/0	**14**/0	**6**/0	**18**/5	18/**31**	25/35
Leg	**45**/0	**62**/0	**29**/1	**25**/0	19/13	16/**30**	10/**43**
Arterial hypercirculation / insufficiency in the standing position (AC1/AC2)							
Lungs	**20**/0	**46**/0	**16**/0	**13**/2	**9**/4	**11**/2	**8**/1
Head	27/16	**54**16	**29**/8	**25**/9	23/13	**21**/7	**35**/4
Abdomen	**11**/0	**27**/0	**5**/0	0/0	8/7	7/5	**8**/4
Pelvis	9/14	8/**46**	1/**17**	1/**19**	3/**29**	9/**49**	7/**60**
Leg	11/16	**11**/5	0/**14**	2/**8**	6/**26**	13/**39**	6/**54**

NOTES: *Assessment states for AC1 / AC2 are color-coded as follows: circulatory stable - white (AC1 = 0 / AC2 = 0); adaptive state - green (AC1 > AC2); transition state - yellow (AC1 ≈ AC2); dis-adaptive state - red (AC1 < AC2).*

ture of age-related changes. Both men and women showed transient and adaptive maladaptive states (table 1 and 2, yellow and red matrix cells). Age-related changes in transient and disadaptive states before and after 35 were statistically significant ($P<0.01$). Basically, these changes were localized in the regions of the pelvis-hip and lower leg (in total, men and women in 9 cells out of 12, $P<0.05$).

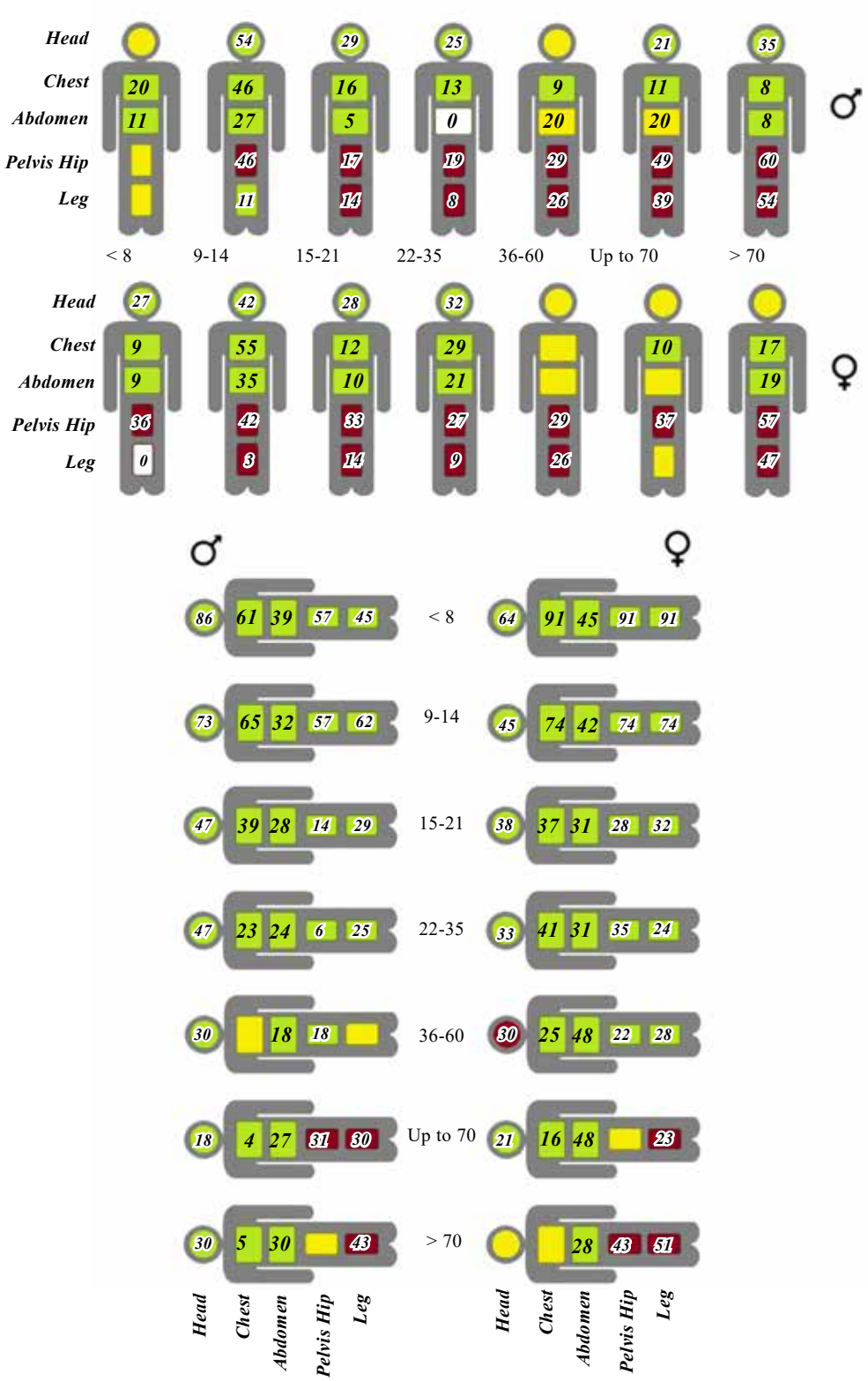
In the standing position, the ratio of AC1/AC2 syndromes in arterial circulation changes significantly due to the regulation of blood circulation by the gravitational (hydrostatic) factor. Regardless of gender (in men and women) and almost throughout postnatal ontogenesis, dysadaptive states are reliably detected by the prevalence of circulatory insufficiency syndromes (AC2) in the blood circu-

TABLE 2.

Arterial circulation in women by the ratio of manifestation of circulatory syndromes (in %) in the lying and standing positions

Circulatory blocks	Age intervals (years, n) < 8 (n=11)	9-14 (n=31)	15-21 (n=97)	22-35 (n=117)	36-55 (n=191)	До 70 (n=142)	70 > (n=47)
Arterial hypercirculation / insufficiency in the lying position (AC1/AC2)							
Lungs	**91**/0	**74**/0	**37**/0	**41**/0	**25**/3	**16**/1	4/2
Head	**64**/0	**45**/0	**38**/0	**33**/3	16/**30**	**21**/6	17/11
Abdomen	**45**/0	**42**/3	**31**/2	**31**/1	**48**/0	**48**/2	**28**/0
Pelvis	**91**/0	**74**/0	**28**/0	**35**/3	**22**/5	25/15	17/**43**
Leg	**91**/0	**74**/0	**32**/1	**24**/1	**28**/10	8/**23**	2/**51**
Arterial hypercirculation / insufficiency in the standing position (AC1/AC2)							
Lungs	**9**/0	**55**/0	**12**/0	**29**/0	11/9	**10**/5	**17**/2
Head	**27**/13	**42**/10	**28**/10	**32**/12	14/16	22/19	23/15
Abdomen	**18**/0	**35**/0	**10**/3	**21**/3	6/7	11/7	**19**/4
Pelvis	0/**25**	0/**42**	1/**33**	6/**27**	6/**29**	2/**37**	2/**57**
Leg	**9**/0	0/**3**	1/**14**	3/**9**	4/**22**	17/24	6/**47**

NOTES: Assessment states for AC1 / AC2 are color-coded as follows: circulatory stable - white (AC1 = 0 / AC2 = 0); adaptive state - green (AC1 > AC2); transition state - yellow (AC1 ≈ AC2); disadaptive state - red (AC1 < AC2).



Figype 1. *Prevailing arterial circulation syndromes "hypercirculation - insufficiency" (AC1 / AC2) in men and women in different age in a standing and lying position*
Assessment states for AC1 / AC2 are color-coded as follows: circulatory stable - white (AC1 = 0 / AC2 = 0); adaptive state - green (AC1 > AC2); transition state - yellow (AC1 ≈ AC2); disadaptive state - red (AC1 < AC2).
The digital data specified in human figures are given in the following order by region: head, chest, abdomen, pelvis+hip, and lower leg.

lation of the pelvis and lower extremities (red matrix cells, in men and women 12 out of 14, P<0.05). While the age dynamics was similar to the lying position in the abdomen and blocks located at or above the heart (lungs and head). It was in these departments that the age component was manifested, although less pronounced in comparison with the supine position, which in samples older than 35 years, especially in women, was reflected by an increase in with a parity ratio of circulatory syndromes of adaptive orientation (AC1) and circulatory insufficiency (AC2).

The described ratios for arterial circulation, their sex differences in the age dynamics of the CVS state, as well as between standing and lying positions are particularly clearly visible in Figure 1. On the silhouettes of the figures, the contour segments correspond to the considered blood circulation blocks, which are marked with a color background in accordance with the estimated states. Figures indicate the prevailing proportion of the ratio of syndromes of the opposite direction in arterial circulation (AC1/AC2).

In figure 1, in both men and women, the age component in the supine position is clearly traced by the transition from a predominantly adaptive regulatory state (marked in green) for absolutely all blood circulation blocks in the age period up to 35 years to the subsequent manifestation of transitional (yellow) and non-adaptive (red) States after 35 years.

In contrast to the lying position, the standing age component of arterial circulation (fig. 1) is largely leveled.

This is manifested in a significant representation of transient and disadaptive states throughout the age dynamics, demonstrating the prevailing value in men and women of regulation by the gravitational (hydrostatic) factor of blood circulation. This picture shows a pressor installation in the regulation of the circulatory state of the CVS, which is associated with the regulation of blood circulation in the standing position. At the same time, this regulation determines the state of the CVS, leveling the manifestations of the age component in the standing position. Evidence of this is the manifestation of the age component in conditions of minimizing the gravitational (hydrostatic) factor of blood circulation in the supine position along the arterial circulation (fig. 1). The same can be noted with regard to sexual differences, which are leveled in the standing position-the conditions of the" anti-gravity " stress of the CVS.

The profile of the regulatory setup of the circulatory status of identified the most problematic departments of blood circulation on head and lower extremity (pelvis, tibia), and the sample 15-21 year – circulation of the abdomen. This is especially evident in the systemic pressor regulatory setting of arterial circulation (fig. 1). On the one hand, such an attitude is characteristic of the human CVS [*Folkow B, Nile E, 1996; Jones CD et al., 2012; Belkaniya GS et al., 2014; Sung SH et al. 2014; Sayenko DG et al., 2015*] and reflects its nature as an upright being. As a result, the "anti-gravity" stress of the CVS and possible circulatory consequences. On the other hand, it is the circulatory basis of clinically significant circulatory disorders and pathological conditions of CVS [*Masuki S et al., 2007; Belkaniya DG et al., 2014; Dilenyan LR et al., 2018*].

Conclusion

1. The ratio of opposite hemodynamic phenomena, such as circulatory insufficiency in arterial blood circulation (arterial hypocirculation) and adaptive arterial hypercirculation, reflects the direction of the regulatory setting of the circulatory state of the cardiovascular system. In the regulatory setting of blood circulation in a person in the standing position prevails «anti-gravity stress», which eliminates the age component detected in the supine position. The defining characteristic of this voltage is the pressor unit for regulating the cardiovascular system, which is characterized by a systemic prevalence of vasoconstriction (hyperresistivity of arterial vessels), as well as signs of circulatory insufficiency.

2. In the supine position, under the conditions of minimal impact of the gravitational factor, adaptive conditions prevail up to 35 years. After 35 years the transition and disadaptive states were registered rottenly.

3. Changes are mainly detected in the standing position in the pelvis-hip and leg block, and after 35 years are fixed in the lying position.

REFERENCES

1. *Arbeille P, Kerbeci P, Mattar L, Shoemaker JK, Hughsonet R.* Insufficient flow reduction during LBNP in both splanchnic and lower limb areas is associated with orthostatic intolerance after bedrest. Am. J. Physiol. Heart. Circ. Physiol. 2008; 295(5): H1846-H1854.
2. *Belkania GS, Dilenyan LR, Bagriy AS, Ryzhakov DI, Puchalska LG, Konkov DG*. Features of methodological support for anthropophysiological diagnostics of the cardiovascular system. Medical almanac. 2013; 6: 208-214.
3. *Belkaniya GS, Dilanyan LR, Bagriy AS, Ryzhakov DI, Kononets VV, Puchalska LG.* «Gravitational biology-anthropology» in the anthropogenetic justification of health and ill health. Modern Problems of Science and Education. 2014; 4.
4. *Belkaniya GS, Dilenyan LR, Konkov DG, Wsol A, Martusevich AK, Puchalska LG.* An anthropogenic model of cardiovascular system adaptation to the Earth's gravity as the conceptual basis of pathological anthropology. Journal of Physiological Anthropology. 2021; 40 (9): 15.
5. *Dilenyan LR, Belkaniya GS, Martusevich AK.* Role of Systemic Vasoconstruction in Regulatory Installation of Blood Circulation. Journal of Stress Physiology & Biochemistry. 2018; 14(4): 35-45.
6. *Dilenyan LR, Martusevich AK, Bocharin IV, Belkaniya GS.* Typological structure of hemodynamics in age scale. Archiv Euromedica. 2019; 9(2): 65-67.
7. *Fan XH, Wang Y, Sun K. Zhang W, Wang H. et al.* Disorders of orthostatic blood pressure response are associated with cardiovascular disease and target organ damage in hypertensive patients. Am. J. Hypertens. 2010; 23(8): 829-837.
8. *Fedorowski A, Burri P, Melander O.* Orthostatic hypotension in genetically related hypertensive and normotensive individuals. J Hypertens. 2009; 27: 976-982,.
9. *Folkow B, Nile E,* Blood Circulation [Published in Russian]. Moscow: Medicine. 1996, 464
10. *Gubler EV, Genkin AA,* Application of nonparametric statistical criteria in biomedical research, Saint-Petersburg. 2003:141.
11. *Guyton AG, Hall DE.* Medical physiology [Published in Russian]. Moscow: Logosphere. 2008. 296.
12. *Jones CD, Loehr L, Franceschini N. Rosamond WD, Chang PP. et al.* Orthostatic hypotension as a risk factor for incident heart failure. The atherosclerosis risk in communities study. Hypertension. 2012; 59(5): 913-918.
13. *Masuki S, Eisenach JH, Johnson CP, Dietz NM, Benrud-Larson LM. et al.* Excessive heart rate response to orthostatic stress in postural tachycardia syndrome is not caused by anxiety. J Appl Physiology, 2007; 102: 896-903.
14. *Rasmer R.* 2001. Dynamics of the cardiovascular system. Eds. Moscow: Medicine, 600 p.
15. *Rose KM, Couper D, Eigenbrodt ML, Mosley TH. Sharrett AR. et al.* Orthostatic hypotension and cognitive function: the Atherosclerosis Risk in Communities Study. Neuroepidemiology. 2010; 34; 1-7.
16. *Sahni M, Lowenthal DT, Meuleman J,* A clinical physiology and pharmacology evaluation of orthostatic hypotension in elderly. International Urology and Nephrology. 37; 2005; 669-674.
17. *Sayenko DG, Artamonov AA, Kozlovskaya IB.* Characteristics of postural corrective responses before and after long-term spaceflights. Human Physiol. 2015; 37(5); 91-99.
18. *Sung SH, Chen ZY, Tseng TW, Lu DY, Yu WC. et al.* Wave reflections, arterial stiffness, and orthostatic hypotension. Am. J. Hypertens. 2014; 27(12); 1446-1455.
19. *Zampieri P.* Medicine, Evolution, and Natural Selection: an historical overview. The Quarterly Review of Biology, 2009; 4; 333-355.

THE NEW ARMENIAN MEDICAL JOURNAL
Volume17 (2023). Issue 2

CONTENTS

THE NEW ARMENIAN MEDICAL JOURNAL

Volume17 (2023). Issue 2

The Journal is founded by
Yerevan State Medical
University after M. Heratsi.

Rector of YSMU

Armen A. Muradyan

Address for correspondence:

Yerevan State Medical University
2 Koryun Street, Yerevan 0025,
Republic of Armenia

Phones:

(+37410) 582532 YSMU
(+37493 588697 Editor-in-Chief
Fax: (+37410) 582532
E-mail:namj.ysmu@gmail.com, ysmiu@mail.ru
URL:http//www.ysmu.am

Our journal is registered in the databases of Scopus, EBSCO and Thomson Reuters (in the registration process)

SCOPUS *EBSCO*
REUTERS

Copy editor: Tatevik R. Movsisyan

Printed in "LAS Print" LLC
Director: Suren A. Simonyan
Armenia, 0023,Yerevan,
Acharyan St. 44 Bulding,
Phone: (+374 10) 62 76 12,
E-mail: las.print@yahoo.com