ДРУЖЕСТВО НА КАРДИОЛОЗИТЕ В БЪЛГАРИЯ
Българска кардиология
том XXIX, 2023, № 3
ОБЗОРИ
REVIEWS
doi: 10.3897/bgcardio.29.e110316

PRACTICAL SIGNIFICANCE OF INDIVIDUAL BLOOD PRESSURE TRAJECTORIES

T. Yaneva-Sirakova, Ivan Gruev[1], Arman Postadzhiyan[2]

[1]National Transport Hospital "Tzar Boris III" – Sofia, Bulgaria
[2]University Multyprofile Hospital for Active Treatment "Sveta Anna" – Sofia, Bulgaria

ПРАКТИЧЕСКО ЗНАЧЕНИЕ НА ИНДИВИДУАЛНИТЕ ТРАЕКТОРИИ НА АРТЕРИАЛНОТО НАЛЯГАНЕ

Т. Янева-Сиракова, И. Груев[1], А. Постаджиян[2]

[1]Национална транспортна болница „Цар Борис III" – София, България
[2]УМБАЛ „Света Анна" – София, България

Abstract. Individual blood pressure values tend to be close to a certain population pattern (because of environmental and socio-economic factors), without fully following it (because of specific individual genetic predisposition). These population "patterns" or "trajectories' can be followed back to prenatal period and across the whole lifespan. Some of them are correlated with higher risk for development of arterial hypertension. There are also several "cornerstones" in these patterns, where the individual may be at an increased risk for movement to a higher-risk group. They can explain why certain individuals are more prone to target organ damage than others and why we, as clinicians, should have an individualized approach when we translate population-based guidelines to the single patient. Proper definition and practical knowledge of the significance of these blood pressure trajectories could be important for everyday prophylaxis and practice.

Key words: blood pressure trajectories/population, childhood, prenatal, target organ damage

Address for correspondence: Teodora Yaneva-Sirakova, e-mail: teodora.yaneva@gmail.com

Резюме. Индивидуалните стойности на артериалното налягане се доближават до определен популационен модел (поради екологични и социално-икономически фактори), без да го следват напълно (поради специфична индивидуална генетична предразположеност). Тези популационни „модели" или „траектории" могат да бъдат проследени до пренаталния период и през целия живот на индивида. Някои от тях са свързани с по-висок риск от развитие на артериална хипертония. Има и няколко ключови (високорискови) моменти в тези модели, при които индивидът може да бъде застрашен от преминаване към група с по-висок сърдечно-съдов риск. Тези траектории на артериалното налягане и високорискови преходни моменти могат да обяснят защо някои хора са по-склонни към увреждане на целевите органи от други. Клиницистите трябва да подхождат индивидуализирано при приложението на насоките на база популационни модели върху конкретен пациент. Правилното дефиниране и практическото познаване на значението на тези траектории на артериалното налягане може да бъде важно за ежедневната профилактика и практика.

Ключови думи: траектории на кръвното налягане/популация, детство, пренатално, увреждане на целевите органи

Адрес за кореспонденция: д-р Теодора Янева-Сиракова, e-mail: teodora.yaneva@gmail.com

Introduction

According to the current concepts there are three main groups of pathogenetic factors, that play the leading role for the development of essential hypertension [1]: 1) genetic predisposition [2], 2) environmental factors [3], and 3) aging [4, 5]. Neither of these groups of factors is self-sufficient to cause arterial hypertension and ultimately – target organ damage. Their interaction leads to the classical cascade for increased arterial stiffness and local low-grade inflammation followed by target organ damage and necessity for perfusion maintenance, resulting in elevation of blood pressure (BP) and consecutive closure of the vicious circle [6]. However, it should be noted that vascular changes caused by aging, may occur independently from the hypertension induced vascular damage [7]. We should

consider two major points of view when facing the "hypertension problem": 1) Population, and 2) Individual. The environmental factors in terms of salt consumption, air pollution, exercise habits, chemicals, food exposure, etc. lead to a significant change (rise) in blood pressure, beginning from the earliest age, even prenatally [8, 9]. From the above, naturally follows that the different populations may have different predisposition to arterial hypertension. If the genetic predisposition is taken into consideration, there might be different population-based blood pressure trajectories. Individual values may be close to a given trajectory that is one of several possible for the given population. The practical significance of this issue is that the individual treatment – time and threshold values of initiation, continuation, target values, may vary according to this trajectory and not only according to the specific blood pressure values. Knowing the problem may help the clinicians in their decision-making when to screen and when to intervene, in order to achieve timely control of arterial hypertension.

Main document

Evidence for blood pressure trajectories across lifespan

The understanding that blood pressure (BP) rises with the advancing age was objected in several trials and the environmental factors were considered in the pathogenesis of arterial hypertension [10, 11].

Current concept postulates that aging is not enough to cause arterial hypertension and socioeconomic and environmental factors play a significant role [12-15]. A study of Liu et al followed 30 384 Chinese adults for 4 years and distinguished five BP phenotypic variants and assessed their relation to brachial-ankle pulse wave velocity (PWV): low-stable, moderate-stable, elevated-stable, elevated-increasing, elevated-decreasing [16]. There was a correlation between BP life trajectories and both initial and consecutive PWV. However, the study was of limited duration to lead to a definite conclusion for the adult lifespan.

In a study of Zhang et al, there were 5 systolic blood pressure (SBP) trajectories and 4 diastolic blood pressure (DBP) among normotensive young adults [17]. They tried to find the modifiable predicting factors for the development of hypertension among Asian population. Physical activity and low salt intake were found to be protective for the development of arterial hypertension. Such studies are a need in other parts of the world as the environmental factors may differ in the context of different socio-economic factors.

Several studies point out the origin of these BP trajectories from childhood or even prenatally [18]. They stem from factors such as: body mass index, skinfold thickness, waist circumference from ages 3 to 8, abdominal adipose tissue at 4.5 years, triglyceride levels. Insulin resistance at the age of 6, maternal BP during pregnancy and infant weight gain in the first 2 years of life. However, there is not a single study which encompasses the whole period – from the prenatal to the advanced age with the transitions of BP at times of excessive growth and hormonal changes.

As a conclusion: the current studies offer different points of view on a single problem – the significance of BP trajectories, with neither a clear definition, nor proper delineation of risk factors and the clinical significance of these trajectories.

Critical periods in the lifespan

There are three critical BP life-time periods which may become a turning point for the development of arterial hypertension and transition between the BP trajectories: adolescence; peripartum; advanced age/menopause [19].

Shen et al. showed that the puberty period was very important for the development of advanced-life hypertension [20]. Four major trajectories were defined from this point of development towards midlife: low-stable; elevated-stable; moderate-increasing; elevated-increasing. The finding was true for both genders and for various races. However, the pre-puberty BP values were negatively correlated with the adult hypertensive pattern – with a steeper slope of rise of BP. Thus, the hypothesis of hypertension as a "growth-related" disorder was introduced, with the explanation for a "regression to the mean" on population level [21].

The second critical period – the peripartal one, a female-specific period, may have a significant implication for the following – life BP values in two totally different directions: a stable rise or a stable fall in blood pressure, being a continuation of the rise (pathological) or fall of blood pressure during the peripartal period [19, 22]. The explanation of the first phenomenon is the continual rise of blood pressure in sensitive women and the understanding that this life-period unmasks an underlying problem, which might be just a matter of time to be clinically manifested. This thesis is proven in a meta-analysis of BP data from four community-based trials ARIC, [23]. CARDIA, [24]. MESA, [25]. FHS [26]. in which blood pressure rise in women is steeper than in men and the major rise comes in the third and fourth decade [27]. This is proven also in preeclampsia studies – once hypertensive during pregnancy – always hypertensive [28]. The second phenomenon was seen in the HUNT Study [29]. It comprises 125 000 Norwegian people with three population – based surveys (HUNT1, 2 and 3) and a significant relatively open access biobank, the results of the more than 20 years of follow

up showed that hormonally (progesterone) mediated decline of BP during pregnancy is perpetuated and postpartum with the net effect that parous women had lower BP values [30].

The third risk period for the clinical manifestation of hypertension is older adulthood. The pathogenesis of this process is well known and lies within the combination of the progression of atherosclerosis and arterial stiffness (or vice-versa) and the environmental factors – salt intake, sedentary lifestyle, obesity, glycemic control, that accelerate normal aging [31]. It should be noted that in later life BP values and arterial stiffness may go in opposite directions – with the rise of arterial stiffness BP falls because of frailty or autonomic dysfunction. The sex difference in BP during this period is nonsignificant [27]. However, women start at a relatively lower values and the consecutive postmenopausal rise should be interpreted as a steeper rise in BP than in men [32]. The maximal BP sex difference was observed around 26 years of age with the difference explained with various hormonal and epigenetic factors [33].

Several large cohort and prospective trials show that BP decreases 14-18 years before the end of life, due to dementia, heart failure, frailty, or simply as harbinger of the natural end of life [34].

Blood pressure trajectories and target-organ damage

Some of the BP trajectories can easily transform into overt hypertension. But if we consider the significance of the central aortic pressure – a clear delineation between certain borderline profiles and hypertension is clinically difficult [35]. Thus, we can confer that some of the BP trajectories may be associated with a significant unrecognized risk for target organ damage above the age-related one.

Liu et al, followed 4625 adults for the life-span period between 18-60 years. [36]. They recognized four BP trajectories: normotensive-stable, prehypertension-stable, stage I hypertension-increasing, stage II hypertension – increasing. The last two groups were associated with elevated risk of developing diabetes mellitus. The common pathway discussed was endothelial dysfunction [37]. And oxidative stress, resultant from arterial hypertension and impaired beta-cells [38, 39].

A 23-year follow-up of children to early adulthood with around 16 measurements showed that among the 683 participants, three major BP trajectories were found (low-increasing, moderate-increasing, high-increasing), which were independently associated with target organ damage – increased intima-media thickness and left ventricular mass index [40]. A Korean epidemiological study proved that elevated mid-life BP trajectories provoked cardiac atrial size changes [41]. Similar were the results from the Cardia Study, which proved an association between the BP trajectories of the highest profile in young ages and consecutive coronary artery calcification [42].

A follow-up of 30 years was conducted as part of the CARDIA study and the patients were divided in five distinct types of global BP tendencies: low-stable; moderate-stable; high-stable; moderate – increasing and high-increasing [43]. The last two – with continually rising mean values of SBP, DBP and PP, were associated with the most prominent myocardial remodeling in terms of impaired systolic and diastolic function in later life.

BP patterns in normotensives may predict the development of renal disease in later life [44]. Among 2430 people with moderate-stable, high- stable and moderate increasing groups 228 developed subclinical kidney injury for a follow-up of 30 years.

As a result, it naturally raises the problem of finding the different BP trajectories in populations of different cardio-vascular risk. Some studies define four, others – five or three types. Thus, we need a standardization to make better predictions and primary prevention especially in a high-risk population as the Bulgarian one [45].

Gaps in evidence and further studies

There is no proper and unified definition of what BP trajectory is, rather – an intuitive understanding of the problem is used. In different papers a different word is used to mark this blood pressure curve over the lifespan. We have chosen “trajectory”, and not “profile” or “pattern”, to stress on the fact that we have a process of progression and not a static depiction. However, BP “trajectory” is quite different from “overt” hypertension, and there should be a clarification when we diagnose “hypertensive” patients in the lowest BP trajectories, when to intervene to reduce the cardio-vascular burden. For this purpose, we must have a better knowledge of birth and childhood status. There might also be population differences in the threshold values, explained by the different ethnic and environmental factors. However, there are several patterns of time-changes in BP across life which are discussed in literature, such as the gradual rise in early life and the gradual fall near the end of life. Here we should mention another problem, that has been recently discussed in literature – the variability of a certain factor and whether we can consider these “BP variations over lifetime” an example of the pathological variability [46]. Future efforts should be made to clearly define these patterns, with variables’ thresholds in accordance with the specific local epigenic factors.

Conclusion

Based on the above trials and conceptions there are several major problems to be discussed: 1. the need for timely and continuous follow-up of people in the risky transitional lifetime points – from childhood into early adulthood, and then with advancing age to the most elderly people; 2. the timely start of treatment in high -risk groups. 3. the timely reduction of treatment in frail groups at advanced age; 4. the definition of specific population BP trajectories; 5. conduction of targeted treatment initiation trials according to the specific BP risk profiles.

No conflict of interest was declared

References

1. Mancia G, Keutz R, Brunstrom M, et al. 2023 ESH Guidelines for the management of arterial hypertension. The Task Force for the management of arterial hypertension of the European Society of Hypertension. Endorsed by the European Renal Association (ERA) and the International Society of Hypertension (ISH). Journal of Hypertension 2023; 41: 000-000.
2. Kelly T, Sunx, He K, et al Insights from a large-scale whole-genome sequencing study of systolic blood pressure, diastolic blood pressure and hypertension. Hypertension 2022; 79: 1656-67.
3. Titze J, Luft F. Speculations on salt and the genesis of arterial hypertension. Kidney Int. 2017; 91: 1324-35.
4. Nilsson P. Early vascular aging in hypertension. Front Cardiovasc Med. 2020; 7: doi.org/10.3389/fcvm.2020.00006.
5. Harvey A, Montezano A, Touyz Rh, et al. Vascular biology of aging – implications in hypertension. Journal of Molecular and Cellular Cardiology. 2015; 83: 112-21.
6. Ma J, Chen X. Advances in pathogenesis and treatment of essential hypertension. Front Cardiovasc Med. 2022; 9: 1003852.
7. Falkner B. Hypertension in children and adolescents: epidemiology and natural history. Pediatr. Nephrol; 2010; 25(7): 1219-24.
8. Brook R, Rajagopalan S. Inhaling Hypertension. Hypertension. 2020; 76: 32-4.
9. Warembourg Ch, Maitre L, Tamayo-Uria I, et al. Early – life environmental exposures and blood pressure in children: an exposome approach. J Am Coll Cardiol. 2019; 74(10): 1317-28.
10. Singh J, Nguyen T, Kerndt C, Dhamoon A. Physiology, blood pressure age related change. [Updated 2022 Sep 11]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK537297/
11. Gurven M, Blackwell A, Rodriguez D, Stieglitz J, Kaplan H. Does blood pressure inevitably rise with age? Longitudinal evidence among forager-horiculturalists. Hypertension. 2012; 60: 25-33.
12. Stevenson D. Blood pressure and age in cross-cultural perspective. Human Biology. 1999; 71: 529.
13. Steffen P, Smith T, Larson M, Butler L. Acculturation to Western society as a risk factor for high blood pressure: a meta-analytic review. Psychosom Med. 2006; 68: 386-97.
14. Gurven M, Kaplan H, Winking J, et al. Inflammation and infection do not promote arterial aging and cardiovascular disease among lean Tsimane forager-horticulturalists. PLoS One. 2009; 4: e6590.
15. Waldron I, Nowotarski M, Freimer M, et al. Cross-cultural variation in blood pressure: a quantitative analysis of the relationships of blood pressure to cultural characteristics, salt consumption and body weight. Soc Sci Med. 1982: 16: 419-30.
16. Liu R, Li D, Yang Y, et al. Systolic blood pressure trajectories and the progression of arterial stiffness in Chinese adults. International Journal of Environmental Research and Public Health.
17. Zhang X, Ouyang Y, Huang F, et al. Modifiable factors of 20-year blood pressure trajectories among normotensives and their associations with hypertension: a prospective study. British Journal of Nutrition. 2022; 128(2): 252-62.
18. Yan W, Kramer M, Michael N, et al. Trajectories of systolic blood pressure in children: risk factors and cardiometabolic correlates. The Journal of Pediatrics: 2021; 236: 86-94.
19. Allen N, Khan S. Blood pressure trajectories across the life course. Am J Hypertens. 2021; 34(3): 234-41.
20. Shen W, Zhang T, Li Sh, Zhang H et al. Race and gender differences of long-term blood pressure profiles from childhood and adult hypertension: The Bogalusa Heart Study. Hypertension. 2017; 70(1): 66-74.
21. Barnett A, van der Pols, Dobson A. Regression to the mean: what it is and how to deal with it. International Journal of Epidemiology; 2005; 34(1): 215-20.
22. Mehta L, Beckie T, DeVon H, et al. American Heart Association Cardiovascular Disease in women and special populations committee of Council on Clinical Cardiology, Council on Epidemiology and Prevention, Council on Cardiovascular and Stroke Nursing, and Council on Quality of care and Outcomes Research. Acute myocardial infarction in women: a scientific statement from the American Heart Association. Circulation. 2016: 133(9): 916-47.
23. The ARIC investigators. The Atherosclerosis Risk in Communities (ARIC) Study: design and objectives. Am J Epidemopl. 1989; 129(4): 687-702.
24. Yano Y, Reis J, Tedla Y, et al. Racial differences in associations of blood pressure components in young adulthood with incident cardiovascular disease by middle age: Coronary Artery Risk Development in Young Adults (Cardia) Study. JAMA Cardiol. 2017; 2(4): 381-9.
25. Bild D, Bluemke D, Burke G, et al. Multi-Ethnic Study of Atherosclerosis: objectives and design. Am J Epidemiol. 2002; 156(9): 871-81.
26. Cheng S, Xanthakis V, Sullivan L, Vasan R. Blood pressure tracking ove the adult life course: patterns and correlates in the Framingham heart study. Hypertension. 2012; 60(6): 1393-9.
27. Hongwei J, Kim A, Ebinger J, et al. Sex differences in blood pressure trajectories over the life course. JAMA Cardiol. 2020; 5(3): 1926.
28. Benschop L, Brouwers L, Zoet g, et al. Early onset of coronary artery calcification in women with previous preeclampsia. Reprod Sci. 2019; 26: 76A.
29. Krokstad S, Langhammer A, Hveem K, et al. Cohort profile: The HUNT study, Norway. International Journal of Epidemiology. 2013; 42(4): 968-77.
30. Haug E, Horn J, Markovitz A, et al The impact of parity on life course blood pressure trajectories: the HUNT study in Norway. Eur J Epidemiol. 2018; 33(8): 751-61.
31. Safar M, Asmar R, Benetos A, et al. Interaction between hypertension and arterial stiffness. An Expert Reappraisal. Hypertension. 2018; 72: 796-805.
32. Wills A, Lawloe D, Matthews F, et al. Life course trajectories of systolic blood pressure using longitudinal data from eight UK cohorts. PLoS Med. 2011; 8(6)P e1999440.
33. Arnold A, Cassis L, Eghbaali M, et al. Sex hormones and sex chromosomes cause sex differences in the development of cardiovascular diseases. Arterioscler Thromb Vasc Biol. 2017: 37(5): 746-56.
34. Delgado J, Bowman K, Ble A, et al. Blood pressure trajectories in the 20 years before death. JAMA Intern Med. 2018; 178(1): 93-9

35. Weber Th, Protogerou A, Agharazii M, et al. Twenty-four-hour central (aortic) systolic blood pressure: reference values and dipping patterns in untreated individuals. Hypertensio; 2022; 79: 251-60.

36. Liu Y, Chen X, Li Ch, et al. Life-course blood pressure trajectories and incident diabetes: A longitudinal cohort in a Chinese population. Front Endocrinol. 2022;/doi.org/10.3389/fendo.2022.1035890

37. Meigs J, Hu F, Rafai N, Manson J. Biomarkers of endothelial dysfunction and risk of type 2 diabetes mellitus. Jama. 2004; 291: 1978-86.

38. Ceriello A, Motz E. Is oxidative stress the pathogenic mechanism underlying insulin resistance, diabetes, and cardiovascular disease? The common soil hypothesis revisited. Arterioscler Thromb Vasc Biol. 2004; 24: 816-23.

39. Pinkney J, Stehouwer C, Coppack S. Yudkin J. Endothelial dysfunction: cause of insulin resistance syndrome. Diabetes. 1997; 46(Suppl 2); S9-13.

40. Hao G, Wang X, Treiber F, et al. Blood pressure trajectories from childhood to young adulthood associated with cardiovascular risk. Results from the 23-year longitudinal Georgia Stress and Heart Study. Hypertension. 2017. 69: 435-42.

41. Kim S, Lee J, Lee S, et al. Blood pressure trajectories for 16 years and the development of left ventricular hypertrophy and increased left atrial size: the Korean Genome and Epidemiology Study. International Journal of Hypertension. 2022; doi.org/101155/2022/6750317.

42. Allen N, Siddique J, Wilkins J, et al. Blood pressure trajectories in early adulthood and subclinical atherosclerosis in middle age. JAMA. 2014; 311: 490-7.

43. Zhou H, Zhang H, Zhan Q, et al. Blood pressure trajectories in early adulthood and myocardial structure and function in later life. ESC Heart Failure; 2022; 9(2): 1258-68.

44. Zheng W, Jianjun M, Chao Ch, et al. Association of Blood pressure trajectories in early life with subclinical renal damage in middle age. Journal of the American Society of Nephrology. 2018; 29(12): 2835-46.

45. Yotov Y, Torbova Sv, Naydenov S, et al. Risk factors for cardio-vascular diseases in urban population with arterial hypertension – have they change in five years in Bulgaria? European Heart Journal. 2013; 34(1): P3237.

46. Messerli F, Hofstetter L, Rimoldi S, et al. Risk factor variability and cardiovascular outcome: JACC Review Topic of the Week. J Am Coll Cardiol. 2019; 73(20): 2596-603.