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Central blood pressure and pulse wave velocity in patients with resistant hypertension

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ABSTRACT

Background. The measurement of brachial pressure (BP) has passed been on for ages, but the central pressure detection could only be possible with invasive techniques, until recently non-invasive and modern technology was introduced into the clinical setting. Studies described that the increase in central blood pressure (CBP) is an indicator of future cardiovascular or target organ damage. Compared with the general population, cardiorenal morbidity is much higher in patients with resistant hypertension (RH). We investigated for the first time the value of CBP and pulse wave velocity (PWV) in a group of RH patients.

Materials and Methods. Data from 80 patients with RH (resistance to 3 or more drugs, one is diuretic) without chronic kidney disease, at University hospital Merkur, Zagreb from the period of June 2017 to January 2018 were analysed. The pulse wave velocity (PWV), mean arterial pressure (MAP), vessels age (older than biological age), pulse pressure (PP), central blood pressure (CBP), brachial pressure (BP) were evaluated using the noninvasive Agedio B900 device (Germany).

Results. The median age was 58.75 (SD-15.3). 27 (35%) of patients were male (avg 53.9 y). BP and CBP were elevated in all RH patients (53 F/27M). The difference between the median value of BP (145.9/90.52mmHg, F=146.4/89.5, M=145/92) and CBP (132.16/91.78mmHg, F=132/90, M 131/94) was statistically significant for systolic BP ($p<0.01$). The mean value of the total measured PWV value was higher than reference for age in all RH and was 8.84 m/s. The mean value of PP and MAP was higher than reference (60.11 and 123,87 mmHg). The difference between sex was statistically significant higher for PWV in females than males (M/F= 8.1/9.2m/s, $p<0.01$). The difference between MAP median concentration (M/F=125.83/123) and PP (M/F=56/62mmHg) was not statistically significant ($p>0.01$).

Conclusion. Currently no gold standard technique is available to measure the CBP. Future studies should address that the cuff method could be a promising device in every day practice for this high risk population.

Key words: resistant hypertension, central blood pressure

INTRODUCTION

Despite measuring the blood pressure with a cuff and sphygmomanometer in the brachial artery, we have been accepting it as an important marker for the prediction of future cardiovascular, cerebrovascular and renal disease risk1. The brachial pressure (BP) values vary numerously in individuals from that of the central (aortic) blood pressure2. Many studies described that the increase in central blood pressure (CBP) is an indicator of future cardiovascular or other target organ damage3. The brachial and central pressures respond differently to different drugs, with central pressure being more accurate and specific than the brachial one4. The measurement of brachial pressure has been passed on for ages, but the central pressure detection could only be possible with invasive techniques, until recently non-invasive and modern technology was introduced into the clinics5. The systolic pressure amplification phenomenon occurs due to the increase in the arterial stiffness shifting way from the heart. As the pressure waves travel from highly elastic central arteries to that of stiffened brachial arteries, the upper portion of the wave narrows, followed by the increase in the systolic blood pressure6. The peripheral arteries are muscular and not distensible whereas the central arteries are made of elastin fibres. The arterial walls of the large arteries permit blood filling during systole distending and push blood flow in a steady flow during diastole as the artery recoils. As a result the thoracic and ascending aorta is less stiff and distal arteries like the tibial are stiffer7.

Arterial stiffness rapidly increases in the limb vessels as the move away from the heart, this leads to a larger wave with greater systolic blood pressure. This results in making the brachial systolic BP and pulse pressure greater than the central pressure in young individuals, whereas the diastolic BP is in the normal range. The pulse pressure (PP) is the difference between the systolic and diastolic pressure of the respective artery measured.

Pulse wave velocity (PWV) is the speed at which the pressure waveform travels along the aorta and large arteries, during each cardiac cycle8. PWV is considered the gold standard for measuring the arterial stiffness. Compared with the general population, cardiorenal morbidity is much higher in patients with resistant hypertension (RH). We investigated the value of CBP and pulse wave velocity in a group of RH patients.

The primary objective of this study was to determine the value of PWV in resistant hypertension using for the first time a non-invasive measurement. The secondary goal was quantification and comparison of PWV according to sex.

PATIENTS AND METHODS

The study included 80 patients with resistant hypertension (RH) without acute heart failure, acute coronary disease and without chronic kidney disease (eGFR <60ml/min/1.73m2). The study population consisted of patients enrolled in Registar of RH and is an ongoing prospective single-center cohort study at the University hospital Merkur, Zagreb. The study included only patients from June 2017 to January 2018. All RH patients gave their written informed consent. The study was approved by the ethics committee.

Resistant hypertension is defined as failure to diminish blood pressure values to <140/90 mmHg (<140/85mmHg for diabetic patients) with a lifestyle method and prescription of at least three antihypertensive drugs in optimal doses, including a diuretic, or when patients use four or more antihypertensive drugs regardless of blood pressure control9. The following classes of medications were used: in all patients angiotensin-converting enzyme (ACE) inhibitors or angiotensin II receptor blockers (ARBs), calcium channel blockers (CCBs) and diuretics (we prefere combinations like ACEI+CCB+diuretic). In 75 % beta blockers, in 40% sympatholytics, and potassium sparing diuretic in 30 %.

The measurement of the central blood pressure detection was evaluated with new non-invasive techniques10. We used brachial pressure waveforms of superficial arteries (almost identical to those obtained intra-arterially) 11. This arm cuff based method makes use of a transfer function-like method with the ARCSolver algorithm built in the Mobil-o-graph10. An appropriate cuff-size we used to avoid poor blood pressure measurement after rest of 5 minutes. In all patients, we measured central blood pressure and PWV several times in an ideal environment (patients sat calmly and quietly). The pulse wave velocity (PWV, m/s), mean arterial pressure (MAP, mmHg, normal value <105), age of vessels (older than biological age or same as the biological age, years), pulse pressure (PP, mmHg, normal value <60), central blood pressure (CBP, normal value<130/90 mmHg), and brachial pressure (BP, normal value <140/90 mmHg) were evaluated using the noninvasive Agedio B900 device (IEM, Stolberg, Germany) 10,11.

The statistical analysis was made using the statistical program Statistics (version 13.1). Descriptive data analysis was performed for all attributes.

RESULTS

The median age of patients with RH was 58.75 years (SD-15.3). A minority of patients, 27, (35%) were male and were younger than their female counterparts (53.9 years). BP and CBP were elevated in all RH patients (53 F/27M). The difference between median concentration of BP (145.9/90.52mmHg, F =146.4/89.5, M=145/92) and CBP (132.16/91.78mmHg, F=132/90, M 131/94) was statistically significant for systolic BP ($p<0.01$). The mean value of the total measured PWV value was higher than reference for age in all RH and was 8.84 m/s. The mean value of PP and MAP was higher than reference (60.11 and 123.87 mmHg). The difference between sex was statistically significant for PWV (M/F= 8.1/9.2m/s, $p<0.01$). In all patients age of vessels was older than biological age for >6 years. The difference between MAP median concentration (M/F=125.83/123) and PP (M/F=56/62mmHg) was not statistically significant ($p>0.01$).

All data are in tables.

Table 1. The value of brachial, central blood pressure, pulse wave velocity, pulse pressure, mean arterial pressure and age of vessels in total (80) patients with resistant hypertension

Age (y)	BP-syst	BP-dias	CBP-sys	CBP-dias	PWV	Age of vessels	PP	MAP
Avg- 57.75	145.9	90.52	132.16	91.78	8.84	6.11	60.11	123.87
SD-15.3	21.29	12.85	19.6	13.43	2.25	2.53	21.81	11.84

BP syst=systolic brachial pressure (mmHg), BP dias=diastolic brachial pressure (mmHg), CBP syst= systolic central blood pressure (mmHg), CBP dias= diastolic central blood pressure (mmHg), PWV=pulse wave velocity (m/s). PP= pulse pressure (mmHg), MAP= mean arterial pressure (mmHg)

Table 2. The value of brachial, central blood pressure, pulse wave velocity, pulse pressure, mean arterial pressure and age of vessels in male (N=27) patients with resistant hypertension

Age (years)	BP-syst	BP-dias	CBP-sys	CBP-dias	PWV	Age of vessels	PP	MAP
Avg-53.29	145	92.66	131.11	94.33	8.12	6.17	56.41	125.83
SD-14.53	24.25	14.35	20.5	15.49	1.97	2.38	24.51	12.64

BP syst=systolic brachial pressure (mmHg), BP dias=diastolic brachial pressure (mmHg), CBP syst= systolic central blood pressure (mmHg), CBP dias= diastolic central blood pressure (mmHg), PWV=pulse wave velocity (m/s). PP= pulse pressure (mmHg), MAP= mean arterial pressure (mmHg)

Table 3. The value of brachial, central blood pressure, pulse wave velocity, pulse pressure, mean arterial pressure and age of vessels in female (N=53) patients with resistant hypertension

Age	BP-syst	BP-dias	CBP-sys	CBP-dias	PWV	Age of vessels	Pulse pressure	MAP
AVG-60.01	146.41	89.49	132.69	90.49	9.20	6.08	62.1	123
SD-15.27	19.84	12.072	18.91	12.20	2.31	2.62	20.19	11.60

BP syst=systolic brachial pressure (mmHg), BP dias=diastolic brachial pressure (mmHg), CBP syst= systolic central blood pressure (mmHg), CBP dias= diastolic central blood pressure (mmHg), PWV=pulse wave velocity (m/s). PP= pulse pressure (mmHg), MAP= mean arterial pressure (mmHg)

DISCUSSION

Patients with resistant hypertension are presented with a long-standing history of poorly controlled hypertension9. Inaccurate blood pressure measurement is not uncommon; it occurs when patients are not instructed to sit calmly and quietly, and when the cuff is too small12. In this study an appropriate cuff-size was used to avoid poor blood pressure measurement. In accordance with the new original article from the Netherlands, that in hypertensive patients presence of controlled (BP<140/90mmHg) or uncontrolled (BP>140/90mmHg) resistant hypertension is related to an increased risk of cardiovascular mortality and all-cause mortality13, we measured PWV. We have proved for the first time that RH patients have higher PWV (than according to age), and this research confirmed the difference between sex. In female patients, menopause status influences arterial stiffness, but mechanisms are undefined. We have confirmed that a measurement finding is not random because we measured PWV and CBP several times. Due to higher cardiovascular risk, resistant hypertension is serious and requires special diagnosis and treatment by a multidisciplinary team14. It is of high importance that the evaluation of a patient with RH includes on the first visit not only 24-hours ambulatory monitoring of blood pressure (AMBP) but also measurement of CBP and PWV. This cuff-based device is usable without specific training and is adapted to ambulatory use.

CONCLUSION

Currently no gold standard technique is available to measure the central blood pressure. The non invasive cuff method is more promising and needs further evaluation. Future studies should address that the cuff method could be a promising device in every day practice for this high risk population RH. Targeting PWV from a therapeutic perspective might slow the progression of cardiovascular remodeling.

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Conflict of Interest: None to declare.

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