

## Clinical Study : Open Access

## Pulse wave analysis in hypertension treated with Unani herbal formulation UNIM 904 in comparison with standard drug amlodipine: A clinical study

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### Abstract

The aim of the study is to relate pulse wave analysis (PWA) with hypertension (zaghtuddam qawi) and to evaluate the clinical findings for Unani formulation UNIM-904 and control drug, amlodipine on the parameters of PWA. Literature is collected from Unani classical books, and authentic and reputed sources such as PubMed, Google scholar. The present study is to assess the pulse wave analysis (PWA), an application of tonometry, SphygmoCor, used in hypertension. SphygmoCor measures the central and peripheral blood pressure, the augmentation index which relates the vascular stiffness which occurs in case of atherosclerosis and cardiovascular disorders. This study was a part of a multicentric clinical trial conducted to evaluate the efficacy of UNIM 904 in comparison to amlodipine in the management of hypertension. Statistical analysis was carried out using paired t-test in both the test drug, *i.e.*, UNIM 904 and control drug, amlodipine which showed significant results in normalizing blood pressure and improving the quality of life.

### 1. Introduction

Sphygmology is the most important diagnostic method in clinical practice. Its history goes back to long years when physicians were not aware of the effect of blood pressure on the body's mechanism and its relation to diseases. Egyptians explained the relationship between heartbeat and pulse. Avicenna (Ibn e sina), persian physician who had made a great contribution in sphygmology, wrote a book entitled, Canon of Medicine (Al Qanoon fil Tib) (Zarshenas *et al.*, 2013). The 1<sup>st</sup> and 3<sup>rd</sup> volume of his book describes cardiology and blood pressure. The detailed explanation about pulse, *i.e.*, examination of pulse, factors affecting parameters, single and compound pulse is present in his book. He told about the variation of pulse in sex, age wise, in different seasons and in different physiological and pathological conditions (Zarshenas *et al.*, 2013; Ibn e Sina, 1998; Hamdani, 1980; Majusi, 2010).

Pulse wave analysis (PWA) is the analysis of pulse pressure waveform which provides information about the state of ventricular ejection and the (elastic and geometric) properties of the arterial tree. For the 1<sup>st</sup> time, PWA was done in the middle of the 19th

century after the invention of sphygmography by Vierodt, it estimates systolic arterial pressure. It was modified by Marey making it portable, more accurate, and it records the pressure waveform on smoked paper. Mohamed contributed in the advancement of sphygmograph which characterise radial hypertensive pulse (Proença *et al.*, 2019). He differentiates and diagnoses several cardiovascular diseases such as dilated left ventricular hypertrophy, rheumatic carditis, arterial ageing (Gurovich and Braith, 2011). At the end of the 19th century, Riva-Rocci invented the sphygmomanometer which allows the measurement of systolic pressure. The diastolic pressure was assessed for the 1<sup>st</sup> time in 1905, when Korotkov used a stethoscope with a sphygmomanometer. Towards the beginning of the 1960s, the use of arterial catheters in clinics started increasing significantly, which assesses the pressure waveform (Proença *et al.*, 2019). However, it took almost a century to understand the hydro and hemodynamic mechanisms involved in pressure wave reflection characteristics. In the late 20<sup>th</sup> century, the relationship between central aortic pressure and pulse wave analysis was established (Gurovich and Braith, 2011). PWA provides a complete picture of a patient's cardiovascular parameters, central arterial stiffness, aortic pulse wave velocity, hypertension development.

According to ACC (American College of Cardiology) and AHA (American Heart Association), revised in 2018, arterial or systemic hypertension is clinically divided into stage 1 and stage 2

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hypertension. Persistent elevation of SBP of  $>130$  mmHg or DBP of  $>80$  mmHg is grouped into stage 1 (if the SBP is 130-139 mmHg or DBP is 80-89 mmHg) and if SBP is  $\geq 140$  mmHg and DBP is  $\geq 90$  mmHg it is grouped into stage 2. Hypertension is a common and major health problem and accounts for 6% of death worldwide (Mohan, 2019). It was estimated to have caused 7.6 million premature deaths and contributed 92 million disability-adjusted life years (DALYs) worldwide in 2001 (Bhat and Malik, 2020).

In classical Unani literature, hypertension (zaght al-dam qawi) is not described in detail, hypertension is a type of vascular congestion which may be due to increased volume of blood (Razi, 1991) or due to narrowing of blood vessels and some factors that are responsible are lack of exercise, faulty eating habits like overeating, weakness of digestive and expulsive faculty (zaf-i quwwat hazima o dafia), strong retentive faculty (qawi quwwat masika) of the body (Ibn e Sina, 1998) and psychological factors (Khan, 1906). Clinical symptoms are the features of a humoral disease (imtilā ba hasbal-awiyya) (Siddiqui *et al.*, 2021), *i.e.*, redness of face, warm body, heaviness of head, temporal region, eyes, drowsiness and confusion in case of vascular congestion. In severe conditions, there may be bleeding, apoplexy and sudden death (Razi, 1991; Anonymous, 2016; Parveen *et al.*, 2020). Further to mention, it is widely reported that herbal based drugs or drug products are more efficacious and have lesser or no adverse drug reactions (Sekeroglu, 2019, Khan, 2020, Rasheed *et al.*, 2012 and 2013). In this study an effort was made to relate PWA with hypertension and to evaluate the effect of

Unani herbal formulation UNIM-904 with control drug as amlodipine on the parameters of PWA.

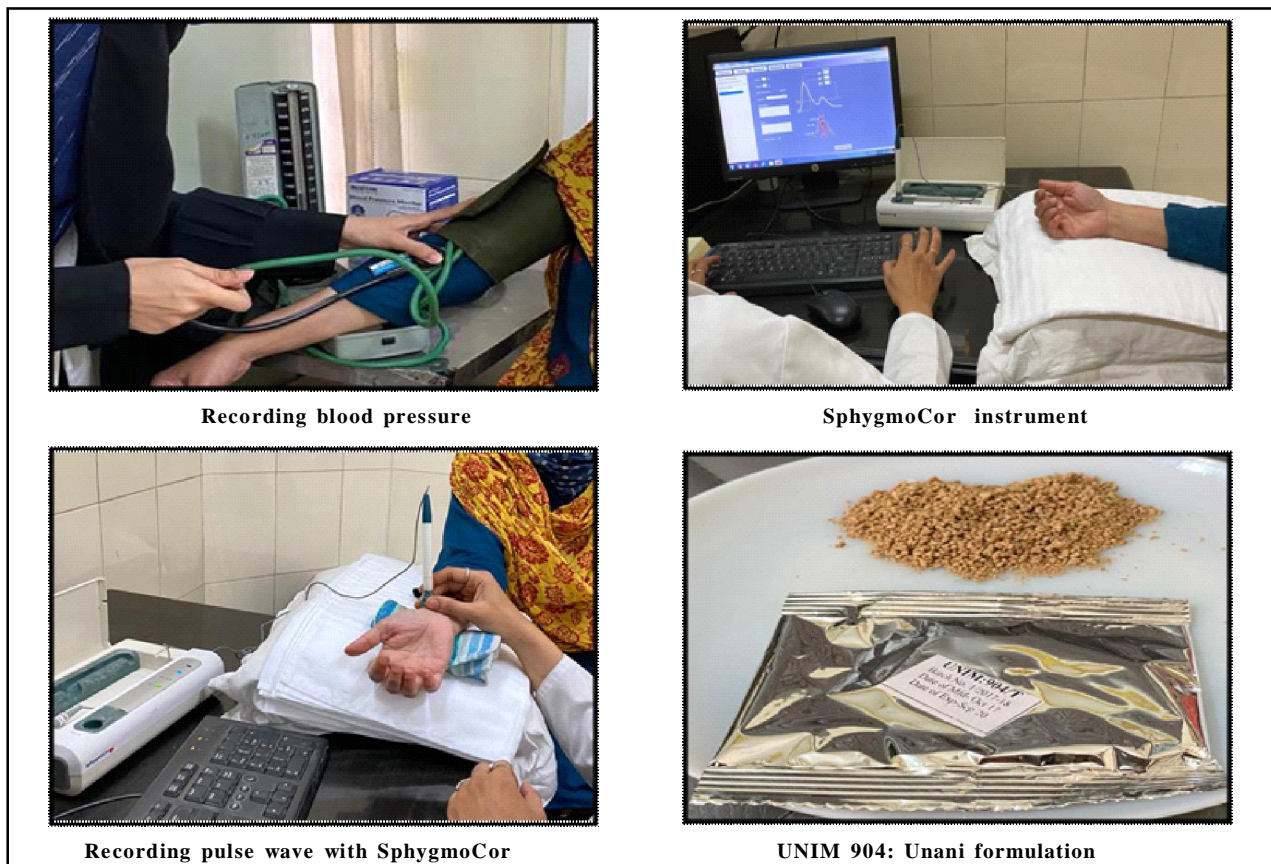
## 2. Material and Methods

### 2.1 Study design

The study was conducted in the OPD of National Research Institute of Unani Medicine for Skin Disorders (formerly Central Research Institute of Unani Medicine), Hyderabad, India in April 2013 under the aegis of Central Council for Research in Unani Medicine, New Delhi. The study was a multicentric, randomized, open label, comparative, controlled trial. The subjects were enrolled in the trial based on inclusion and exclusion criteria to evaluate the efficacy and safety of Unani coded herbal formulation UNIM 904 in comparison with amlodipine in the management of hypertension. This research project was registered in Clinical Trial Registry India on 23/Oct/2013. CTRI number-CTRI/2013/10/004091. At the study centre, the pulse wave analysis of the subjects was done with the help of SphygmoCor machine at baseline and at each follow up.

### 2.2 Sphygmocor

SphygmoCor is a non-invasive technique that measures central aortic pressure waveform which is a determinant of pulse pressure recorded at peripheral site of the subjects (Butlin and Qasem, 2016). The SphygmoCor device requires brachial cuff (Figure 1) to measure systolic blood pressure (SBP) and diastolic blood pressure (DBP), it also calibrates arithmetic mean and DBP of peripheral waveform and central SBP and DBP (O'Rourke, 2017).



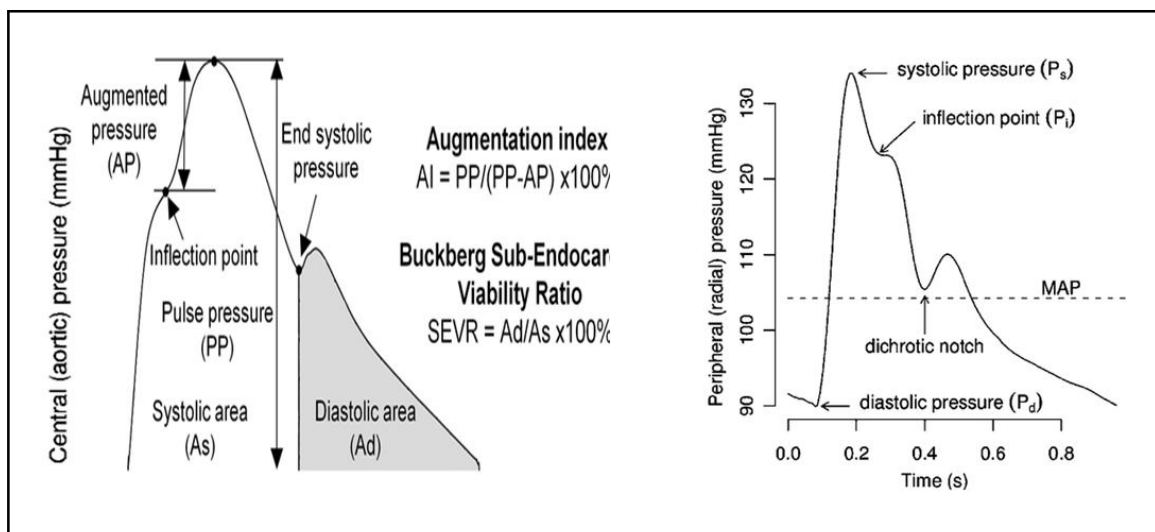
**Figure 1:** Photographs of UNIM 904 Unani formulation, SphygmoCor instrument, Pulse wave and BP recording with the patient.

The values of SBP and DBP are the maximum and minimum points of the pressure curve obtained in a peripheral location, usually the upper arm. As the arteries get hardened with age, PWA is the standard technique for assessing arterial stiffness. The stiffness is due to decreased content of elastin fibres and accumulation of collagen in arterial walls, which increases the risk of hypertension and

cardiovascular diseases. PWA assesses the age of the arteries, if the arterial reference age is less than the chronological age of the patient, better is the arterial compliance (Mozos *et al.*, 2020; Dumor *et al.*, 2018). The pulse wave selected parameters for the assessments (Proença *et al.*, 2019) that relate with hypertension are described in Table 1.

**Table 1: Selected pulse wave parameters for assessment**

Parameters	Acronym	Description
Systolic blood pressure (mmHg)	SBP	The maximal blood pressure value over one heartbeat
Diastolic blood pressure (mmHg)	DBP	The minimal blood pressure value over one heartbeat
Blood pressure at time of reflection (mmHg)	$P_r$	Blood pressure value at the onset of the backward reflected wave
Augmentation pressure (mmHg)	$AP = (SBP - P_r) \times x$	The increase in blood pressure induced by the early arrival of the reflected wave, with $x = -1$ if $P_r$ occurs after SBP, and $x = 1$ otherwise
Pulse pressure (mmHg)	$PP = SBP - DBP$	The maximal peak-to-peak amplitude of the pressure wave over one heartbeat
Augmentation index (%)	$AIx = 100(AP / PP)$	The increase in blood pressure induced by the early arrival of the reflected wave, relative to the peak-to-peak amplitude of the pressure wave
Augmentation index corrected for a heart rate of 75 bpm (%)	$AIx_{@75} = 0.39(HR - 75) + AIx$	Augmentation index corrected for its dependency on heart rate (HR)
Mean arterial pressure (mmHg)	MAP	The average blood pressure value over one heartbeat
Mean systolic pressure (mmHg)	MSBP	The average blood pressure value during systole
Mean diastolic pressure (mmHg)	MDBP	The average blood pressure value during diastole
End systolic pressure (mmHg)	ESP	The blood pressure value at end of systole, when the aortic valve closes
Ejection duration (s)	LVET	Duration of systole
Diastolic time (s)	DT	Duration of diastole
Systolic pressure time index (mmHg s)	$SPTI = MSBP \cdot LVET$	Area under the systolic part of the pressure wave, representing an index of myocardial oxygen demand
Diastolic pressure time index (mmHg s)	$DPTI = MDBP \cdot DT$	Area under the diastolic part of the pressure wave, representing an index of coronary blood supply
Sub endocardial viability ratio	$SEVR = DPTI / SPTI$	Index of sub-endocardial oxygen supply and demand



**Figure 2: Graph obtained by SphygmoCor for central (aortic) pressure and peripheral (radial) pressure.**

### 2.3 Randomization

Selected subjects are randomized into two arms using block randomization technique with a variable block size and the randomization is center specific so that equal distribution between two arms is maintained.

### 2.4 Subjects

Inclusion criteria for the study were subjects from either sex of 18-65 years of age with SBP of 160-179 mmHg and DBP of 90-100 mmHg. Subjects are also included on the presence of following signs and symptoms, headache (suda), giddiness (duwar), palpitation (khafqan), laziness (kasal), anxiety (qalak), shortness of breath (usr-al-tanaffus), diminished alertness (takaddur fil hawas), subconjunctival hemorrhage (jiryan al-dam zer multahima), epistaxis (nakseer), pulsus plenus (nabz mumtali). The subjects were excluded in the study if the SBP  $>180$  mmHg and DBP  $>100$  mmHg, having history of secondary hypertension, sinus bradycardia, diabetes mellitus, malignancy, epilepsy, coronary artery disease, chronic kidney disease, pregnant, lactating women and females using oral contraceptive pills, patients on NSAIDs, SGPT  $>105$  IU, BMI  $>30$ , drug addicts and alcoholics.

### 2.5 Drug, dose and mode of administration

Both the trial and controlled drugs were for oral administration. UNIM-904 was in the form of sachets that has 5 g of granules, advised to be taken twice daily before lunch and dinner and amlodipine 5 mg was in tablet form, given once daily for 12 weeks.

### 2.6 Monitoring and follow up

Clinical monitors were present during the course of study to verify the acceptability of facilities, compliance with the investigational plan and relevant Indian GCP and ICMR guidelines and to maintain complete records. Patients who meet the inclusion and exclusion criteria are enrolled in the trial after obtaining the informed consent

and baseline scores for SBP, DBP and PWA were recorded. The duration of treatment was fixed for 12 weeks with schedules of 8 follow-ups. After completion of 2 weeks of treatment with weakly follow-up patients are subjected with investigations of safety profiles and continued treatment up to 4 weeks. After 4 weeks up to 12 weeks, the follow-up was scheduled every fortnight till the completion of treatment (12 weeks). During these visits, the baseline symptoms of hypertension, PWA along with Unani classical signs and symptoms which includes observation of Nabz and naked examination of urine (qaroora) was done and the findings were recorded. Efficacy of the treatment was evaluated by analysing, before and post-treatment scores for both test and control groups statistically.

### 2.7 Assessment of efficacy and safety

To assess the efficacy of drug, patients were examined clinically for reduction in systolic and diastolic blood pressure and improvement in the signs and symptoms of hypertension. To assess the safety of the drug, necessary haematological and biochemical investigations were done at baseline and at the end of the study. Participants were instructed to report any adverse events that they experience during the trial period.

### 2.8 Statistical methods for data analysis

Paired *t* test was applied before treatment and after treatment. Significance level fixed was *p* value less than 0.05.

## 3. Results

Assessment of safety and efficacy of test drug, UNIM 904 and controlled drug amlodipine was described by Afza *et al.* (2021). In this study, an effort was made to represent the assessment of both the drugs and its effect on selected parameters of pulse wave analysis. Biochemical and haematological studies showed no significant changes thus confirming the safety of drugs as presented in Table 2.

**Table 2: Assessment of safety investigational pathology and biochemistry parameters**

Parameters	UNIM 904 (test drug)		Amlodipine (control drug)	
	Before	After	Before	After
Hb%	13.7 ± 1.86	13.66 ± 1.78	13.3 ± 1.7	13.2 ± 01.9
RBC	4.64 ± 0.60	4.76 ± 0.5	4.67 ± 0.42	4.72 ± 0.46
PLT	2.42 ± 0.43	2.33 ± 0.6	2.73 ± 0.7	2.75 ± 0.07
Neutrophils	58.13 ± 7.74	58.93 ± 9.21	60.73 ± 5.9	60.35 ± 07.3
Lymphocytes	32.8 ± 7.05	30.8 ± 6.96	31.2 ± 5.98	30.9 ± 6.46
Eosinophils	4.73 ± 1.33	4.93 ± 1.86	4.6 ± 1.12	5.07 ± 01.9
Monocytes	4.33 ± 2.19	4 ± 1.88	3.33 ± 1.44	3.64 ± 01.4
ESR 1 <sup>st</sup> hour	26.4 ± 19.40	19.9 ± 17.01	26.1 ± 22.6	30.2 ± 0.15
ESR 2 <sup>nd</sup> hour	49.5 ± 29.59	40.8 ± 31.37	50.2 ± 44.1	61.8 ± 32.9
SGOT	23.2 ± 8.83	21.3 ± 6.65	19.86 ± 6.2	22.5 ± 6.2
SGPT	23.2 ± 10.70	20.13 ± 5.7	17.7 ± 5.36	22.2 ± 10.5
S Creatinine	1.03 ± 0.14	1.11 ± 0.15	1.01 ± 0.2	0.94 ± 0.2
BUN	22.4 ± 6.85	24.5 ± 7.87	21.03 ± 9.2	20.9 ± 9.02
S Uric acid	5.74 ± 1.25	5.4 ± 0.97	5.53 ± 1.1	7.37 ± 10.7
Total cholesterol	208.7 ± 58.0	214.4 ± 48.6	187.9 ± 33.5	201.6 ± 38.4
HDL	42.1 ± 6.37	43.2 ± 7.15	43.1 ± 9	43.6 ± 8.47
ALP	84.86 ± 14.80	83.7 ± 19.9	90.5 ± 32.3	78.3 ± 42.1
RBS	110.1 ± 31.50	106.2 ± 21.18	90.7 ± 14.2	93.2 ± 9.23
WBC	7520 ± 1611	7600 ± 1744	6846 ± 1089	7078 ± 1431

### 3.1 Effect on parameters of pulse wave analysis

The results show that the average heart rate reduced by 9.3% in test group and 3.2% in control group. Peripheral augmentation index reduced significantly by 34.9% and 19.8%, mean systolic pressure by 11.3% and 6.8%, central systolic pressure by 12.4% and 14.5%, radial systolic pressure by 22.5% and 25%, radial diastolic pressure by 15% and 16% , pulse pressure (aortic) by 26.06% and 18.3%, pulse pressure (radial) by 24.3% and 16.3%,

reference age by 25.8% and 17.5%, viability ratio increased by 7.7% and 2.9% (hence, improves the arterial compliance) of UNIM 904 and amlodipine, respectively.

Thus, few assayed parameters are found clinically significant, whereas some parameters are found as statistically significant as presented in Table 3 which shows reduction in heart rate and palpitation along with normalization of blood pressure (mean systolic pressure).

**Table 3: Some of the clinical parameters analyzed statistically**

Parameters	UNIM 904		p value	Amlodipine		p value
	before	after		before	after	
BMI	29 ± 5.2	29 ± 5.3	p > 0.05	28.6 ± 5.0	28.1 ± 5.0	p > 0.05
Heart rate	81.6 ± 15	74 ± 10	p > 0.05	88 ± 11.4	85.2 ± 8.5	p > 0.05
Ejection duration	276 ± 25	280 ± 20	p > 0.05	275 ± 19.4	276 ± 17.3	p > 0.05
Augmentation pressure (mmHg)	11.0 ± 7.8	8.0 ± 4.0	p > 0.05	5.7 ± 4.2	4.6 ± 3.7	p > 0.05
Aortic augmentation index	26.5 ± 11.5	25.5 ± 9.0	p > 0.05	19 ± 10.8	17.2 ± 11.0	p > 0.05
Peripheral augmentation index	212 ± 180.0	138.5 ± 19.0	p < 0.01**	126 ± 17.5	101 ± 17.0	p < 0.05*
Augmentation index @ HR %	14 ± 7.2	10 ± 7.0	p < 0.05*	12.4 ± 9.5	8 ± 7.0	p < 0.05*
Viability ratio	155 ± 27.0	167 ± 22.16	p > 0.05	136 ± 22.0	140 ± 12.0	p > 0.05
PTI systolic	2582 ± 382.0	2197 ± 500.0	p > 0.05	2583 ± 276.0	2341 ± 243.0	p > 0.05
PTI diastolic	3582 ± 545.0	3639 ± 315.0	p > 0.05	3450 ± 364.0	3287 ± 357.0	p > 0.05
End systolic pressure	121 ± 13.0	107 ± 8.31	p > 0.05	108.3 ± 8.0	101 ± 10.0	p > 0.05
Mean systolic pressure	118.4 ± 12.0	105 ± 8.0	p < 0.05*	107.3 ± 7.0	100 ± 10.0	p > 0.05
Mean diastolic pressure	102 ± 10.0	93 ± 7.5	p > 0.05	95.6 ± 6.0	90 ± 9.0	p > 0.05
Central systolic pressure	129 ± 16.25	113 ± 9.0	p < 0.05*	125.2 ± 9.0	107 ± 11.0	p < 0.05*
Radial systolic pressure	157.5 ± 10.7	122 ± 9.4	p < 0.05*	156.6 ± 13.9	117.5 ± 8.6	p < 0.05*
Central diastolic pressure	92 ± 9.0	85 ± 7.2	p > 0.05	87 ± 6.0	80 ± 9.0	p > 0.05
Radial diastolic pressure	97 ± 4.4	82 ± 6.7	p < 0.05*	97.6 ± 6.7	82.33 ± 6.2	p < 0.05*
Mean pressure (Aortic)	108.2 ± 10.0	97 ± 7.5	p > 0.05	100 ± 6.3	94 ± 9.0	p > 0.05
Mean pressure (Radial)	108 ± 10.0	97.6 ± 7.5	p > 0.05	100 ± 6.4	95 ± 9.0	p > 0.05
Pulse pressure (Aortic)	37.33 ± 14.0	27.6 ± 6.5	p < 0.05*	30 ± 7.0	24.5 ± 8.3	p < 0.05*
Pulse pressure (Radial)	49.3 ± 13.4	37.3 ± 7.0	p < 0.05*	39.46 ± 8.2	33 ± 10.0	p < 0.05*
Reference age in years	55.3 ± 14.7	41 ± 13.7	p < 0.05*	48 ± 14.0	39.6 ± 10.4	p < 0.05*

p > 0.05 = Statistically not significant

\*=The value is statistically significant

\*\*=The value is highly statistically significant

t= test has been applied to the above parameters

## 4. Discussion

Reduction in heart rate with trial drug showing better result than the control which could be the reason for relieving anxiety or stress in a way that there is an impact on cardiac performance. Peripheral augmentation index was reduced highly significantly which denotes the reduction in arterial stiffness and hypercholesterolemia (Sebely *et al.*, 2019). The augmentation index @HR75, a composite marker of wave reflection and stiffness in the arteries, is significantly reduced. Viability ratio increased indicating improved myocardial oxygen supply (Ondigi *et al.*, 2021) reducing the risk of ischemia. Significant decrease in mean systolic pressure, radial systolic, radial diastolic, pulse pressure (aortic and radial) indicates that the drug will be able

to decrease the risk of cerebral strokes, heart diseases, chronic kidney diseases. There is emerging evidence suggesting that central pressure is better related to future cardiovascular events than the brachial pressure (Carmel *et al.*, 2014). In this study, the central systolic pressure was significantly decreased as well as reference age reduced significantly improving the arterial compliance establishing the potentiality of Unani herbal formulation in improving heart health.

## 5. Conclusion

The pulse wave analysis in hypertension with the test drug as Unani herbal formulation UNIM 904 showed the improvement in the clinical sign and symptoms proving the efficacy of drug in comparison with the control drug amlodipine. No significant changes had been observed in the laboratory parameter which indicates that the drug UNIM 904 is safe to use for clinical purpose as it showed no nephrotoxicity and hepatotoxicity. The significant reduction in central and peripheral blood pressure, augmentation index, mean

pressure and pulse pressure parameters shows that the study drug UNIM 904 is equivalence to that of the effect of control drug amlodipine. The drug UNIM 904 is safe as herbal formulation, having no side effect as inferences from the study results in the patients did not report any adverse drug reactions such as headache, nausea, vomiting, dizziness, abdominal discomfort, *etc.* Hence, Unani herbal formulation UNIM 904 can be recommended effectively in the treatment of hypertension through unani system of medicine.

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### Conflict of interest

The authors declare no conflicts of interest relevant to this article.

### References

- Afza, S.; Khan, P.; Rehman, S.; Ayub, S.; Singh, R.; Verma, R.S.; Akhtar, J. and Khan, A.A. (2021). Comparative study of efficacy and safety of Unani coded drug UNIM-904 with allopathic drug amlodipine in the treatment of essential hypertension. *International Journal of Unani and Integrative Medicine*, 5(1):01-08.
- Anonymous, (2016). Standard unani treatment guidelines for common diseases, CCRUM, New Delhi, Vol. 2, pp:48.
- Bhat, M.D.A. and Malik, S.A. (2020). Efficacy of *Nardostachys jatamansi* (D.Don) DC in essential hypertension: A randomized controlled study. *Complement Ther. Med.*, 53:102532. doi: 10.1016/j.ctim.2020.102532. Epub 2020 Aug 14. PMID: 33066862.
- Butlin, M. and Qasem, A. (2016). Large Artery Stiffness Assessment Using SphygmoCor Technology. *Pulse*, 4:180-192. doi: 10.1159/000452448.
- Dumor, K.; Shoemaker-Moyle, M.; Nistala, R. and Whaley-Connell, A. (2018). Arterial stiffness in hypertension: An Update. *Current Hypertension Reports*, 20:72.
- Gurovich, A.N. and Braith, R.W. (2011). Pulse wave analysis and pulse wave velocity techniques: Are they ready for the clinic? *Hypertension Research*, 34:166-169. doi: 10.1038/hr.2010.217
- Hamdani, K.H. (1980). *Usool-e-tib*, Aligarh, pp:222.
- Ibn e Sina. (1998). *Al-Qanoon*. Idara Kitab shifa, New Delhi, pp:140.
- Khan, A.A. (2020). Role of Unani medicine in empowering national healthcare. *Ann. Phytomed.*, 9(2):1-5. <http://dx.doi.org/10.21276/ap.2020.9.2.1>

- Khan, M.A. (1906). *Iksir-e Azam*, Matba Nami Munshi Naval Kishore, Lucknow, Vol. 2, pp:266-312.
- Majusi, A. (2010). *Kamil sanat* (Urdu Translation), Idara Kitab shifa, New Delhi, pp:351.
- Mohan, H. (2019). *Text book of Pathology*, 8<sup>th</sup> ed., Jaypee Brothers, New Delhi; pp:718.
- Mozos, I.; Gug, C.; Mozos, C.; Stoian, D.; Pricop, M. and Jianu, D. (2020). Associations between intrinsic heartrate, P Wave and QT interval durations and pulse wave analysis in patients with hypertension and high normal blood pressure. *International Journal of Environmental Research and Public Health*; 17:4350. doi:10.3390/ijerph17124350.
- O'Rourke, M.F. (2017). Calibration of SphygmoCor. *Journal of Hypertension*, 35:645-652. doi: 10.1097/HJH. 0000000000001207
- Ondigi, O.; Bilchick, K.C.; Stafford, P.; Selinksi, C.; Harrison, K.; Jalenak, J.; Strickling, J.; Shah, K.P.; Blazek, O.; Mwansa, H.; Brethett, K.; Johnson, A.; Mehta, N.; Kwon, Y.; Sodhi, N. and Mazimba S. (2021). Abstract 11969: endocardial viability ratio is associated with survival in advanced heart failure patients. *Circulation*, 144:A11969. [https://www.ahajournals.org/doi/abs/10.1161/circ.144.suppl\\_1.11969](https://www.ahajournals.org/doi/abs/10.1161/circ.144.suppl_1.11969) DOI: 10.1161/circ.144.suppl\_1.11969.
- Parveen, B.; Parveen, A.; Parveen, R.; Ahmad, S.; Ahmad, M. and Iqbal, M. (2020). Challenges and opportunities for traditional herbal medicine today with special reference to its status in India. *Ann. Phytomed.*, 9(2):97-112. <http://dx.doi.org/10.21276/ap.2020.9.2.8>
- Proença, M.; Renevey, P.; Braun, F.; Bonnier, G.; Delgado-Gonzalo, R.; Lemkaddem, A.; Verjus, C.; Ferrario, D. and Lemay, M. (2019). Pulse wave analysis techniques. The handbook of cuffless blood pressure monitoring. (Solà J, Delgado-Gonzalo R. eds.) Springer Nature Switzerland AG, pp. 107-138.
- Rasheed, N.M.A.; Nagaiah, K. and Waheed, M.A. (2013). Recent analytical techniques in quality control of indigenous system of medicine. *Ann. Phytomed.*, 2(1):44-58.
- Rasheed, N.M.A.; Nagaiah, K.; Goud, P.R. and Sharma, U.V.M. (2012). Chemical marker compounds and their essential role in quality control of herbal medicines. *Ann. Phytomed.*, 1(1):1-8.
- Razi, Z. (1991). *Kitab al Mansuri* (Urdu Translation), CCRUM, New Delhi. pp:160-163.
- Sekeroglu, N. (2019). Some customary edible plants of incredible medicinal worth. *Ann. Phytomed.*, 8(2):1-6.
- Siddiqui, M.A.; Itrat, M.; Mobeen, A. and Khan, M.I. (2021). Efficacy of Khār-i-khasak (*Tribulus terrestris* Linn.) in prehypertension: A randomized, double-blind, placebo-controlled trial. *J. Complement Integr. Med.*, 18(4):783-789. doi: 10.1515/jcim-2020-0322. PMID: 33793146.
- Zarshenas, M.; Abolhassanzadeh, Z.; Faridi, P. and Mohagheghzadeh, A. (2013). sphygmology of *Ibn Sina*, a message for future. *Heart Views*, 14. doi: 10.4103/1995-705X.1259.

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