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A Comparison of Modern Cardiovascular Parameters in Patients with and Without Blood Stasis Syndrome

Xiaoqin Hu[1, 2, *], Wei Zhao[2], Xuewen Zeng[1], Xiao Wang[1], Hongxing Yang[1], Xuefei Ding[2], Yumei Meng[2], Edward Barin[3], Alberto Avolio[3]

[1]Jinhua Advanced Research Institute, Jinhua, China
[2]Faculty of Pharmacy, Guangxi University of Chinese Medicine, Nanning, China
[3]Faculty of Medicine and Health Sciences, Macquarie University, Sydney, Australia

Email address:

hxqok6905@163.com (Xiaoqin Hu), 1972320967@qq.com (Wei Zhao), 109829069@qq.com (Xuewen Zeng), wangxiao20190605@163.com (Xiao Wang), Hongxingyangbucm@163.com (Hongxing Yang), 3036363808@qq.com (Xuefei Ding), 1124060767@qq.com (Yumei Meng), edward.barin@gmail.com (Edward Barin), alberto.avolio@mq.edu.au (Alberto Avolio)

[*]Corresponding author

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Abstract: Objective: To study the relation between cardiovascular parameters and blood stasis syndrome (BSS) by investigating the conventional cardiovascular parameters of BSS, furthermore, finding out the objective evidence for TCM syndrome differentiation. Methods: A total of 66 patients with a mean age of 60±18 years were evaluated. Out of these, 30 had BSS and 36 did not (control group). All patients underwent an evaluation of brachial mean arterial pressure (MAP), brachial diastolic pressure (DP), brachial systolic pressure (SP), aortic systolic pressure (SP), aortic MAP, and aortic DP in the seated and supine positions using a SphygmoCor XCEL. Pulse wave velocity (PWV), aortic augmentation index (Aix), ejection duration, and heart rate (HR) in the seated and supine positions determining by electrocardiogram examination. Results: There were no significant differences in the age, height, weight, gender, or race ($P>0.05$) of the two groups. A significant difference was observed in the brachial SP, brachial MAP, brachial DP, aortic SP, aortic MAP, aortic DP, and HR of the two patient groups in the supine position ($P<0.05$ or $P<0.01$). Ejection duration and Aix were reduced and PWV examined in the supine position increased in the BS group, compared with the control group, although the differences were not significant ($P>0.05$). Seated patients with BSS had a lower MAP and aortic MAP than control patients ($P<0.05$). All other parameters in the two groups examined in the seated position were not significantly different ($P>0.05$). Conclusion: Changes in modern medical cardiovascular parameters were found in patients with BSS. These preliminary findings may be used to evaluate and treat patients with the disorder. Further controlled studies are needed to confirm these findings.

Keywords: Pulse Wave Analysis, Blood Stasis, Cardiovascular Parameters, TCM, Comparative Analysis

1. Introduction

Blood stasis syndrome (BSS) is associated with reduced tissue perfusion [1]. Clinical findings in patients with BSS include a purple tongue, blood stasis spots on the tongue, sublingual varices, persistent pain, angina, abdominal pain, a tumor, cyanotic lips and digits, dysmenorrhea with dark blood clots, amenorrhea, a purple-black face or purple-black color around the eyes, an irregular or intermittent pulse, abnormalities in the skin and nails, numbness, and paralysis [2]. Pathological findings include obstruction of microcirculation, abnormal hemodynamics, increased blood viscosity, decreased tissue perfusion, and formation of microthrombus in BSS [3-6]. Abnormal blood flow is found in many cardiovascular diseases that have changes in blood components, blood hemodynamics, or blood viscosity [7]. These abnormalities in BBS can affect the major organ systems of the body [8]. An investigation of these findings includes hemodynamic studies and echocardiography [9-10].

This pilot study was performed to determine whether BSS was associated with abnormalities in the conventional cardiovascular parameters, such as those seen during pulse wave analysis of brachial arteries and aorta.

2. Methods

2.1. Device

The SphygmoCor XCEL is the main device in this study (Table 1).

Table 1. *List of the device and software used in this part of the study.*

Manufacturer and device	Hardware module
AtCor SphygmoCor, XCEL	EM4 version 1.2.28

2.2. Participants

Sixty-six subjects (mean age: 60±18 years, 30 female) were evaluated. Recruitment and measurements were conducted at Macquarie University Clinic, Sydney, Australia. Ethics approval was received from the Macquarie University Human Research Ethics Committee. This study obtained the written consent of the participants.

2.3. Traditional Chinese Medicine (TCM) Diagnosis of BSS

BSS diagnostic criteria was defined at the second session of the Chinese Blood Circulation Research Conference in November, 1986. A TCM diagnosis of BSS was made by a qualified traditional Chinese Medicine doctor after obtaining a history related symptoms, palpitation of the pulse on the wrist, and examination of the tongue.

2.4. Blood Pressure Measurement

A SphygmoCor XCEL (SphygmoCor Vx, AtCor Medical, Sydney, New South Wales, Australia) was used to evaluate the central aortic waveform by recording the brachial cuff volume displacement waveform at a pressure of 10 mmHg under diastolic blood pressure and applying a validated transfer function to that waveform. Brachial blood pressure and derived aortic blood pressure was obtained in all subjects. Subjects were seated for 5 minutes before measuring blood pressure. All measurements were taken with the appropriate brachial cuff size according to the manufacturer's fitting guide. Two blood pressure measurements were made, one in the seated position and the other in the supine position. Measurements were repeated twice in every same body position.

2.5. Measurement of Pulse Wave Velocity

Pulse wave analysis was performed for all blood pressure waveforms. Carotid-femoral pulse wave velocity (cfPWV) was determined noninvasively using the SphygmoCor system (SphygmoCor Vx, AtCor Medical, Sydney, New South Wales, Australia) in the supine position. A high-fidelity applanation tonometer was used to measure pressure pulse waveforms sequentially in 2 peripheral artery sites. cfPWV was obtained from measurements of common carotid and femoral artery waveforms, as previously described. The transit time was calculated using the R-wave on the surface ECG as a common reference. cfPWV was automatically calculated from measurements of pulse transit time and distance between the 2 peripheral artery sites according to the formula: cfPWV (m/s) = distance (m)/transit time (s). The path length was calculated by subtracting the distance between the carotid artery measurement site and the suprasternal notch from the distance between the femoral artery measurement site and the suprasternal notch. Distance measurements were made using a caliper.

2.6. Measurement of Heart Rate, Aortic Augmentation Index, and Ejection Duration

An electrocardiogram examination was performed on all subjects and used to calculate the heart rate, aortic augmentation index (Aix), and ejection duration.

2.7. Statistical Analysis

All data were analyzed using SPSS. The results were expressed as mean ± standard deviation (mean ± SD). Test groups were compared using a paired t-test or a chi-square test, as appropriate. Results were considered significant with a P value <0.05 or <0.01.

3. Results

3.1. Results of TCM Diagnosis

A qualified traditional Chinese Medicine practitioner diagnosed 30 with BSS and 36 having no BSS (control group) of the 66 test subjects.

3.2. Comparison of the Demographic Characteristics of the BSS and Control Groups

Tables 2–4 present a comparison of basic clinical data found in the BSS and control groups. There was no significant difference in age, height, weight, gender, or race of the two clinical groups (P>0.05 for all comparisons).

Table 2. *Comparison of age, height and weight of blood stasis group and control group.*

Variable	N	age	height	weight
BS	30	64.03±19.581	167.90±12.626	72.20±21.285
Non-BS	36	56.19±16.232	165.92±9.581	69.92±17.038

All data were expressed as mean ± standard deviation,*P<0.05, **P<0.01 versus control group.

Table 3. *Comparison of gender between the BS group and Non-BS group.*

gender	BS		Non-BS	
	N	Percentage (%)	N	Percentage (%)
male	16	53.3	20	55.6
female	14	46.7	16	44.4
total	30	100	36	100

χ^2=0.033, P>0.05

Table 4. *Comparison of race between the BS group and Non-BS group.*

race	BS		Non-BS	
	N	Percentage (%)	N	Percentage (%)
NE Asian	9	30.0	12	33.3
SE Asian	4	13.3	6	16.7
Caucasian	17	56.7	14	38.9
Middle Eastern	0	0	3	8.3
Aboriginal	0	0	1	2.8
total	30	100	36	100

χ^2=4.612, P>0.05

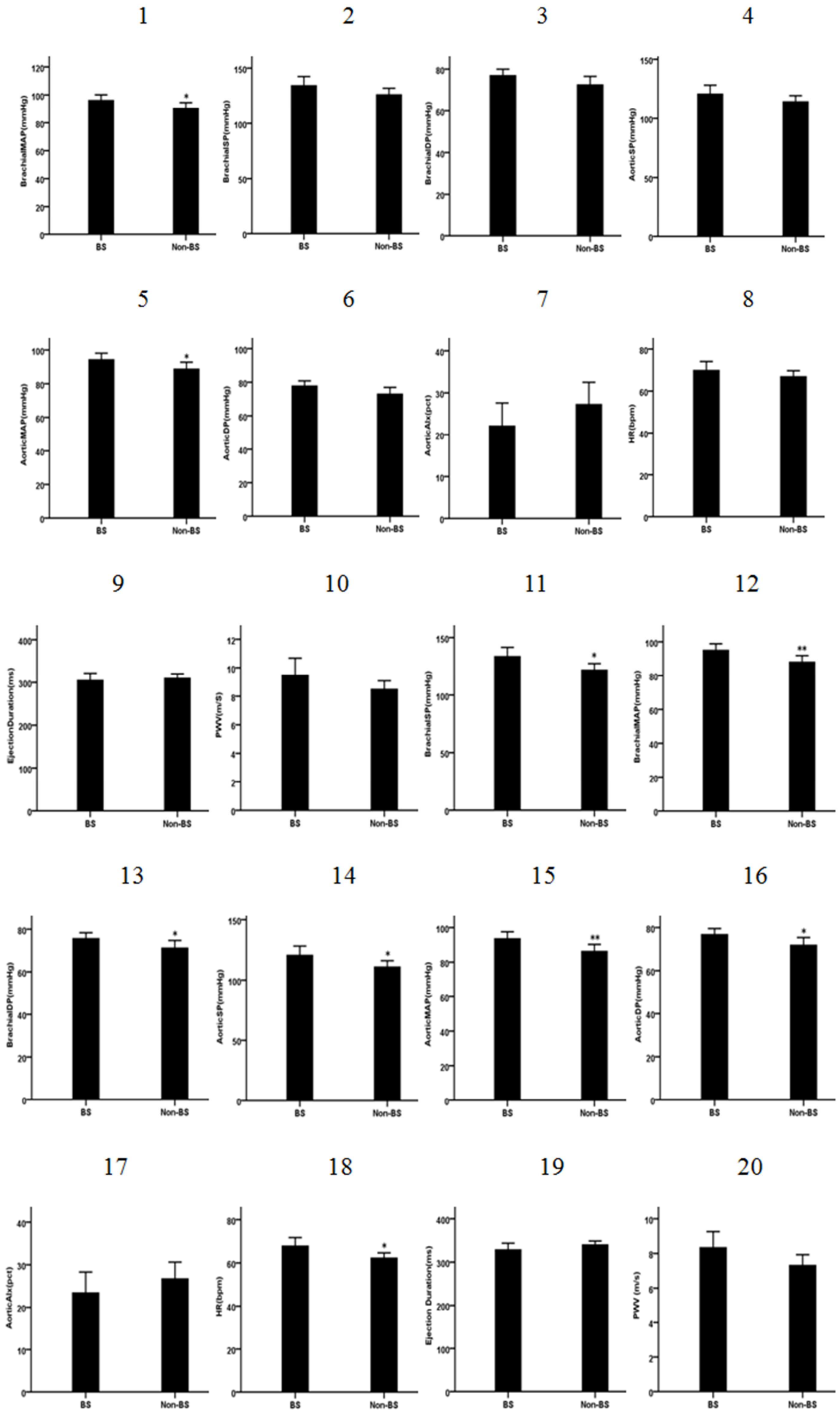

Figure 1. *Cardiovascular parameters in the BSS and control groups. Charts 1–10 present brachial SP, brachial MAP, brachial DP, aortic SP, aortic MAP, aortic DP, aortic Aix, HR, ejection duration, and PWV measured in the seated position. Charts 11–20 present the same parameters measured in the supine position.*P<0.05, **P<0.01 versus the control group.*

3.3. Evaluation of Cardiovascular Parameters in the BSS and Control Groups

Figure 1 presents the cardiovascular findings of the BSS and control patients in the sitting and supine positions. A significant difference was observed in the brachial systolic pressure (SP), brachial mean arterial pressure (MAP), brachial diastolic pressure (DP), aortic SP, aortic MAP, aortic DP and heart rate (HR) of the two patient groups in the supine position ($P<0.05$ or $P<0.01$). Ejection duration and Aix were reduced and pulse-wave velocity (PWV) increased in the BSS group, compared to the control group, although the differences were not significant ($P>0.05$).

Seated patients with BSS had a lower MAP and aortic MAP than seated control patients ($P<0.05$). All other parameters examined in the seated position were not significantly different ($P>0.05$).

4. Discussion

Hemorheology studies the fluidity and deformability of blood, blood cells, and plasma, and the effects of these characteristics on blood circulation, organ function, and metabolism. Abnormalities in hemorheology are similar to findings observed with BSS in TCM. Both propose that abnormalities in the pulse compromise blood flow and alter the normal hemodynamic state [11]. Like hemorheology, blood stasis is thought to alter blood vessel hemodynamics, the physical and chemical properties of blood, and the integrity of blood vessel walls [12]. In terms of modern medicine [13-16], patients with BSS have enhanced blood viscosity and platelet aggregation, decreased erythrocyte deformability, and a vasculopathy manifested as an increased pressure strain elastic coefficient, hardening parameter beta and pulse wave velocity, and decreased arterial compliance.

The maintenance of blood pressure is critical for preventing cardiovascular diseases and stroke [17]. Arterial elasticity is an indicator of arterial endothelial function, with PWV being related to it. Aix is the most common clinical parameter used to diagnose arteriosclerosis [18-19]. Increased heart rate is associated with sympathetic excitability and arterial, cardiac, or other organ injury [20-21]. We evaluated the brachial arterial pressure, aortic pressure, aortic Aix, and HR. Central aortic pressure is an indicator of end organ damage and is associated with changes in organ perfusion pressure. Current data suggest that aortic pressure is a better predictor of damage to target organs and clinical outcomes than brachial pressure [22-23]. We evaluated the changes in these parameters in order to determine their relationship with BSS [24].

Invasive measurements of CBP are limited in clinical application and noninvasive measurements of central aortic pressure are increasing in use [25]. We used the SphygmoCor XCEL, a noninvasive measure of central arterial pressure, to determine brachial and central aortic blood parameters including pulse wave velocity and aortic stiffness. The use of this device has been validated in over 600 studies. While noninvasive measurements of brachial artery pressure are not equal to ascending aortic pressure, they can reflect changing trends in their values found with hypertension and antihypertensive treatment regimens [25]. CBP is an important measure of cardiovascular disease and the patient's clinical prognosis [26-28].

Hypertension and coronary artery disease can lead to cardiovascular diseases with decreased blood perfusion to the body, compensatory cardiac acceleration, diastolic shortening, and decreased peripheral blood flow. These findings result in the aortic retention of blood at end-diastole, and increased diastolic and systolic blood pressure. The increasing arterial pressure leads to an increase in systolic ventricular pressure and shortening of the cardiac sphygmic period.

Patients with BSS we examined had a significantly higher brachial SP, brachial MAP, brachial DP, aortic SP, aortic MAP, aortic DP, and HR in the supine position than control patients in the same position. In addition, they also had a reduced ejection duration and aortic Aix, with an increase in PWV. These findings may be due to abnormalities in the cardiovascular system found in BSS.

Patients with BSS we examined had a significantly higher brachial MAP and aortic MAP in the seated position than control patients in the seated position.

Altering the patient position had an effect on blood pressure measurements. Blood pressure measurements in the supine position were generally lower than those in the seated position, This finding may be due to decreased venous blood pooling in the supine position. Patients in the seated position are subject to more venous pooling in the lower extremities with BSS, causing a decreased return of blood to the heart, decreased cardiac output, and increased sympathetic stimulation. As a result of these changes, small blood vessels in the body contract and raise the blood pressure [29].

Changes in cardiovascular parameters were found in patients with BSS. These preliminary findings may be used to evaluate patients with BSS. Further controlled studies are needed to confirm these findings.

Abbreviations

BSS: blood stasis syndrome;
TCM: Traditional Chinese Medicine;
MAP: mean arterial pressure;
DP: diastolic pressure;
SP: systolic pressure;
PWV: Pulse wave velocity;
Aix: augmentation index;
HR: heart rate;
CBP: central blood pressure.

Declarations

Ethics Approval and Consent to Participate

All assessments were conducted at the Vascular Laboratory (Suite 202, Clinic Building, 2 Technology Place, Macquarie University) between February 2016 and August 2016. The Macquarie University Human Research Ethics Committee approved the study (5201500946), and written informed consent was obtained from all participants.

Consent for Publication

Not applicable.

Availability of Data and Materials

The datasets used /or analysed during the current study available from thecorresponding author on reasonable request.

Competing Interests

The authors declare that they have no competing interests.

Authors' Contributions

Xiaoqin Hu, Xiao Wang and Hongxing Yang performed TCM diagnosis of BSS, Measurement of cardiovascular parameters including blood pressure, pulse wave velocity heart rate, aortic augmentation index, and ejection duration, data analysis and wrote the first draft of the paper. EB performed recruitment of clinical patients; YM contributed to data analysis, AA, Wei Zhao and Xuefei Ding revised the manuscript. Xuewen Zeng is in charge of statistics. All authors read and approved the final manuscript.

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