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Exploring the Diagnostic Value of Blood Tests Combined with Electrocardiogram and 24-Hour Ambulatory Blood Pressure Monitoring in Primary Hypertension with Myocardial Ischemia

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Abstract: *Objective*: To evaluate the diagnostic value of blood tests combined with dynamic electrocardiogram (DCG) and 24-hour ambulatory blood pressure monitoring (ABPM) for patients with primary hypertension and myocardial ischemia. *Methods*: 55 patients with primary hypertension and myocardial ischemia who visited our hospital from September 2021 to September 2023 were included in Group A, and 55 healthy individuals who underwent physical examination during the same period were included in Group B. Both groups received blood tests, DCG, and ABPM for diagnosis. *Results*: The blood test indicators, diurnal and nocturnal blood pressure, diurnal and nocturnal heart rate, ST segment depression duration, and ST segment depression were all higher in Group A than in Group B ($P < 0.05$). *Conclusion*: The combination of blood tests, DCG, and ABPM can be used to diagnose primary hypertension with myocardial ischemia. Changes in blood indicators, blood pressure, and electrocardiogram indicators can provide insights into the condition of hypertension with myocardial ischemia, guiding clinical diagnosis.

Keywords: Myocardial ischemia; Primary hypertension; Blood tests; 24-hour ambulatory blood pressure monitoring; Dynamic electrocardiogram

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1. Introduction

Cardiovascular disease is currently the leading cause of death globally [1]. It is estimated that there are 245 million people with hypertension in China [2]. Compared to those with normal blood pressure, patients with hypertension have greater blood shear force on their vessel walls, making them more susceptible to damage and increasing the risk of vascular disease. In the early stages of myocardial ischemia, patients often have

no obvious symptoms due to the insidious onset of the disease. However, as the duration of injury increases, once patients experience symptoms such as chest tightness and pain, myocardial ischemia often progresses to angina pectoris, myocardial infarction, and other stages, posing a high risk of death. Therefore, early diagnosis of primary hypertension with myocardial ischemia is crucial. Coronary angiography is the gold standard for diagnosing myocardial ischemia and can screen for early asymptomatic patients. However, it is an invasive diagnostic method with high costs and risks, making it difficult to promote widely. Therefore, exploring noninvasive and efficient diagnostic techniques is essential. Examinations such as blood pressure monitoring and electrocardiogram are low-cost and easy to perform, providing an initial assessment of the patient's condition. DCG can overcome the limitation of short monitoring time in conventional electrocardiograms. Through continuous electrocardiogram monitoring, it can comprehensively reflect myocardial ischemia. ABPM provides information on diurnal and nocturnal changes in systolic and diastolic blood pressure, serving as a basis for physicians to evaluate patients' blood pressure fluctuations. Additionally, myocardial ischemia can cause myocardial damage in patients with primary hypertension, leading to changes in myocardial-specific indicators. Hence, blood tests can aid in the diagnosis of myocardial ischemia. This study aims to investigate the diagnostic value of DCG and ABPM using 55 patients with primary hypertension and myocardial ischemia and 55 healthy individuals as samples from September 2021 to September 2023.

2. Materials and methods

2.1. Materials

55 patients with primary hypertension accompanied by myocardial ischemia who visited between September 2021 and September 2023 were included in Group A; 55 healthy individuals who underwent physical examination during the same period were included in Group B. Baseline data of Group A were compared with those of Group B, with $P > 0.05$. See **Table 1**.

Table 1. Baseline data analysis

Group	*n*	Gender (%)		Age (years old)		Course of disease (years old)	
		Male	Female	Range	Mean	Range	Mean
Group A	55	30 (54.55)	25 (45.45)	40–74	56.25 ± 3.81	3–16	4.28 ± 1.09
Group B	55	31 (56.36)	24 (43.64)	41–75	56.29 ± 3.79	-	-
χ^2/t	-	0.0368		0.0552		-	
P	-	0.8479		0.9561		-	

2.2. Inclusion and exclusion criteria

Inclusion criteria: (1) Meet the hypertension criteria in the 2017 version of the "Chinese Expert Consensus on the Diagnosis and Treatment of Hypertension in the Elderly" [3]; (2) Informed consent; (3) Imaging examination suggests myocardial ischemia.

Exclusion criteria: (1) Severe myocardial infarction; (2) Angina pectoris; (3) Presence of a cardiac pacemaker in the body; (4) Secondary hypertension; (5) Abnormal vital signs.

2.3. Methods

Blood test: One day before the test, the subjects were fasted from food and water. The next day, 5 mL blood sample was taken on an empty stomach, centrifuged, and allowed to stand for 15 minutes. The supernatant was taken, and indicators such as CtnT, Mb, CK-MB, and RDW were tested using an automatic biochemical analyzer. During ABPM blood pressure monitoring, a matching cuff was prepared and fixed on the patient's left upper limb, with the lower edge of the cuff preferably 2 cm away from the elbow fossa. Patient comfort was evaluated, and the cuff tightness was adjusted appropriately, with 1–2 fingers inserted into the cuff as appropriate. Blood pressure was monitored every 30 minutes from 8 am to 10 pm, and every hour from 10 pm to 8 am. During DCG monitoring, ECG data were collected under the patient's daily living conditions and daily routine, and the data were summarized using matching software to obtain monitoring results.

2.4. Statistical analysis

SPSS 21.0 was used to process hypertension and myocardial ischemia data. Hypertension and myocardial ischemia count data were recorded as percentages (χ^2 test), and hypertension and myocardial ischemia measurement data were recorded as mean ± standard deviation (*t*-test). Comparisons were considered statistically significant at $P < 0.05$.

3. Results

3.1. Comparison of diurnal and nocturnal blood pressure and heart rate

Both diurnal and nocturnal blood pressure and heart rate were higher in Group A than in Group B, with $P < 0.05$. See **Table 2**.

Table 2. Analysis of diurnal and nocturnal blood pressure and heart rate in patients with hypertension and myocardial ischemia and healthy individuals (mean ± standard deviation, SD)

Group	SBP (mmHg)		DBP (mmHg)		HR (times/min)	
	Daytime	Nighttime	Daytime	Nighttime	Daytime	Nighttime
Group A(*n*=55)	137.52±2.41	126.88±1.89	102.44±1.98	93.11±1.48	78.41±2.11	69.25±1.36
Group B(*n*=55)	131.44±2.25	120.43±1.42	93.28±1.42	88.06±1.25	75.36±2.06	65.33±1.07
t	13.6760	20.2345	27.8805	19.3326	7.6706	16.7998
P	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

3.2. Comparison of blood test indicators

Blood test indicators such as CtnT, Mb, CK-MB, and RDW were higher in Group A than in Group B, with $P < 0.05$. See **Table 3.**

Table 3. Blood test indicators

Group	CtnT (ug/L)	Mb (ug/L)	CK-MB (IU/L)	RDW (%)
Group A (n = 36)	0.06 ± 0.02	64.11 ± 2.69	32.81 ± 1.96	20.53 ± 2.11
Group B (n = 36)	0.02 ± 0.01	32.26 ± 1.85	15.66 ± 1.21	14.61 ± 1.16
t	10.7331	58.5343	44.6729	14.7518
P	0.0000	0.0000	0.0000	0.0000

3.3. Comparison of ECG indicators

ST-segment depression duration and ST-segment depression were higher in Group A than in Group B, with $P < 0.05$. See **Table 4**.

Table 4. Analysis of ECG indicators in patients with hypertension and myocardial ischemia and healthy individuals (mean ± SD)

Group	ST-segment depression time (min)		ST-segment depression (mV)	
	Daytime	Nighttime	Daytime	Nighttime
Group A (n = 55)	2.88 ± 0.79	6.15 ± 1.22	0.22 ± 0.06	0.11 ± 0.03
Group B (n = 55)	1.05 ± 0.52	1.53 ± 1.03	0.11 ± 0.04	0.04 ± 0.01
t	14.3497	21.4592	11.3129	16.4165
P	0.0000	0.0000	0.0000	0.0000

4. Discussion

Hypertension is a common chronic disease among middle-aged and elderly people in China, and it carries a high risk of myocardial ischemia. However, myocardial ischemia often presents with nonspecific symptoms, making diagnosis difficult and potentially affecting patient prognosis. The inducing factors of myocardial ischemia secondary to primary hypertension can be summarized as follows [4]:

(1) Myocardial hypertrophy: Persistent elevation of blood pressure can lead to myocardial hypertrophy, increasing the myocardial demand for nutrients and oxygen. If blood perfusion is impeded, myocardial ischemia may occur.

(2) Coronary artery spasm: Excessively high blood pressure can stimulate spasmodic contraction of the coronary arteries, reducing local blood flow and inducing myocardial ischemia.

(3) Coronary atherosclerosis: As hypertension progresses, it can damage vascular endothelial cells, leading to the continuous deposition of lipids on the vessel walls. This can result in coronary atherosclerosis and even plaque formation, causing vascular blockage or stenosis, which in turn restricts myocardial blood perfusion.

(4) High blood viscosity: Abnormal blood pressure can lead to increased blood viscosity, affecting blood circulation and causing or exacerbating myocardial ischemia. Blood tests, including indicators such as CtnT, Mb, CK-MB, and RDW, can assist physicians in initially evaluating the state of myocardial ischemia and guide diagnosis by providing insights through fluctuations in these indicators.

Diagnostic techniques combining DCG and ABPM enable real-time, dynamic display of blood pressure

and heart rate fluctuations. This is beneficial for physicians to assess fluctuations in catecholamine levels in patients, thereby improving the accuracy of myocardial ischemia diagnosis. Additionally, real-time and dynamic monitoring of changes in patient blood pressure, heart rate, and other indicators through DCG and ABPM techniques can provide feedback on disease progression. Dynamic observation of electrocardiogram changes allows for early detection of heart rate abnormalities and arrhythmias. By observing changes in the ST-T segment, physicians can assess the condition of myocardial ischemia, serving as a basis for clinical diagnosis.

During routine electrocardiogram (ECG) examination, only a snapshot of the patient's condition at a specific time point can be obtained for those with primary hypertension and myocardial ischemia. This approach fails to provide a dynamic observation of changes in various indicators, posing a risk of missed diagnosis and limiting the diagnostic results. Changes in human ECG and blood pressure fluctuations exhibit rhythmic characteristics and can be influenced by physiological states, leading to potential deviations in test results at different times. Therefore, in clinical diagnosis, relying solely on data from a specific time point makes it difficult to accurately reflect changes in patients' heart rate and blood pressure. In this paper, we selected DCG+ABPM technology for diagnosis, which allows for the acquisition of 24-hour ECG changes and blood pressure pulsation information. By combining this data with other examination results for comprehensive analysis, it becomes possible to assess the magnitude of blood pressure fluctuations and the degree of myocardial ischemia in patients, which is beneficial for guiding clinical treatment. Additionally, ABPM technology provides a clear representation of diurnal blood pressure variations in patients with primary hypertension, revealing fluctuations that occur during nighttime.

Through DCG diagnosis, it has been found that patients often experience myocardial ischemia in the early morning hours, posing a risk of sudden death. Therefore, strengthening nighttime monitoring, early identification of abnormal heart rate and blood pressure events, and prompt treatment can ensure the safety of diagnosis and treatment for patients with hypertension and myocardial ischemia. Compared to routine clinical spot blood pressure measurements, ABPM offers the following advantages:

(1) Continuous 24-hour monitoring of blood pressure, capturing numerous blood pressure fluctuation data points and minimizing the influence of occasional factors on blood pressure readings.

(2) Analysis of monitoring results allows for the recording of average blood pressure values during both waking and sleeping states.

(3) Continuous dynamic monitoring aids physicians in accurately identifying masked hypertension and white-coat hypertension.

(4) Recording blood pressure fluctuations over a 24-hour period provides insight into real-life blood pressure changes in patients during their daily routines.

(5) Measuring nocturnal blood pressure accurately reflects issues such as excessive nocturnal blood pressure dips and nocturnal hypertension.

(6) Provides an honest representation of blood pressure fluctuation patterns at different times of the day.

(7) Dynamic evaluation of blood pressure changes not only reflects the effectiveness of antihypertensive treatment but also enables early identification of cardiovascular and cerebrovascular diseases.

Based on the data analysis in this article, Group A with hypertension and myocardial ischemia had higher diurnal and nocturnal blood pressure and heart rate compared to Group B, with $P<0.05$. The reason for this is that hypertension is an independent risk factor for cardiovascular complications. Utilizing ABPM technology for dynamic observation of blood pressure pulsations can facilitate early detection of abnormal blood pressure. It

can also serve as a basis for physicians to analyze diurnal fluctuations in SBP and DBP indicators, maintaining a steady decline in blood pressure indicators, thereby enhancing blood pressure management effects, reducing the degree of cardiac function impairment, and facilitating the prevention of adverse cardiovascular events [5]. Additionally, during medication treatment for patients with primary hypertension, inappropriate medication regimens or dosages can trigger hypotensive events and increase the risk of cerebrovascular disease. Therefore, dynamic monitoring with ABPM technology can evaluate the antihypertensive effect and predict the risk of myocardial ischemia. Some patients with myocardial ischemia may not have obvious symptoms but experience elevated blood pressure during the night. Dynamic blood pressure monitoring can assist physicians in identifying myocardial ischemia and guiding clinical treatment. HR fluctuations can also provide feedback on the condition of primary hypertension, enabling assessment of target organ damage and disease progression. If elevated HR levels are detected in hypertensive patients, it may be related to increased catecholamine levels activating the sympathetic nervous system. Therefore, monitoring changes in HR levels can evaluate hypertension progression. During diagnosis with DCG+ABPM technology, analyzing HR fluctuations and types of arrhythmias can provide feedback on blood pressure fluctuations, resulting in high diagnostic sensitivity [6,7].

Furthermore, continuous dynamic monitoring with ABPM can assist physicians in accurately identifying occult hypertension and white coat hypertension. It can also record blood pressure fluctuations within 24 hours, capturing real blood pressure changes in patients' daily lives. Additionally, it can measure nocturnal blood pressure, accurately reflecting issues such as excessive nocturnal blood pressure dips and nocturnal hypertension. Another set of data indicates that blood test indicators such as CtnT, Mb, CK-MB, and RDW were higher in Group A compared to Group B, with $P < 0.05$. The reason for this is that after myocardial ischemia, myocardial metabolism becomes disordered, disrupting cell membrane integrity. As a result, cytosolic free CtnT enters the bloodstream, and the degree of ischemia is directly proportional to the rate of CtnT output from degenerated cardiomyocytes. Within 1-3 hours of myocardial ischemia, Mb rapidly enters the bloodstream through damaged cells, also directly proportional to the degree of ischemia. CK-MB originates from the outer sarcoplasmic layer of cardiomyocytes and rapidly increases within 4-6 hours of myocardial ischemia. RDW is associated with oxidative stress and inflammatory responses, and its elevated levels can affect the heterogeneity of peripheral blood erythrocytes, impacting overall health.

The final set of data shows that ST-segment depression duration and ST-segment depression indicators were higher in Group A patients with hypertension and myocardial ischemia compared to Group B, with $P < 0.05$. This suggests that diagnosis with DCG+ABPM technology can capture transient electrocardiographic changes, reducing the likelihood of missed diagnoses. The reason for this is that fluctuations in electrocardiographic indicators in patients with primary hypertension and myocardial ischemia are related to excessive secretion of catecholamines and corticosteroids in the body. This leads to platelet aggregation, which in turn inhibits fibrinolytic activity and anticoagulant function, resulting in the progression of myocardial ischemia. Diagnosis with DCG + ABPM technology can quickly identify transient myocardial ischemia signals and is highly sensitive to myocardial ischemia symptoms. It can accurately reflect fluctuations in electrocardiographic indicators and diurnal variations in blood pressure, facilitating the prevention and control of myocardial ischemia [8,9]. Additionally, the combined diagnosis of blood tests, DCG, and ABPM, simultaneously monitoring blood pressure, heart rate, and blood indicator fluctuations, can precisely predict and identify patient condition fluctuations [10].

5. Conclusion

In summary, the diagnosis of primary hypertension with myocardial ischemia using blood tests, DCG, and ABPM technology, combined with observation of diurnal and nocturnal blood pressure, heart rate changes, and electrocardiographic indicator fluctuations, reveals significant differences compared to healthy individuals. This approach can serve as a basis for physicians to diagnose the disease. It is affordable and can be performed in hospitals at various levels, making it valuable for widespread implementation.

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Disclosure statement

The authors declare no conflict of interest.

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