

# The Assessment of Blood Pressure in Atrial Fibrillation

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## Abstract

*For the first time the principles of evaluation of the blood pressure levels in atrial fibrillation have been suggested. They reflect absolutely precisely the degree of haemodynamic disturbances in atrial fibrillation and they can be used as the criteria for assessment of these patients treatment effectiveness. A new non-invasive modified method of blood pressure measurement in atrial fibrillation is suggested and it can estimate all the spectrum of fluctuation blood pressure in cardiac arrhythmia. The accuracy of this method is equal to the invasive direct method. The simplicity of modified method allows us to recommend it to the physicians for measuring the blood pressure in patients with atrial fibrillation. Nowadays the modified auscultative method of blood pressure measurement represents itself as exclusive and the most informative method. The described principle of blood pressure measurement in atrial fibrillation should serve the basis for computerized systems.*

## 1. Introduction

The original Korotkoff method and all its modern automated and computerized systems of measuring the blood pressure (BP) are always presenting own results only by one figure for both the systolic and the diastolic BP. However, the similar designation of blood pressure by one figure for both the systolic and the diastolic of BP can only be adequate and exact when all the pulse waves will be equal during all process of measurement.

In case of atrial fibrillation (AF) the chaos and randomness of fluctuations of the stroke volumes lead to the large fluctuations of the levels of both the systolic and diastolic BP.

The World Health Organization experts and all the fundamental scientific studies do not suggest the precise recommendations how to estimate all the range of fluctuations of both the systolic and the diastolic BP levels in AF [4, 6, 8]. It is quite strange, but we have not been advanced anyway in understanding the strategy of the rating of BP levels in AF, and as a result, we could not manage the patients with this hard

syndrome up till now. This circumstance is the main reason why physicians do not have an adequate method of measuring BP at this severe syndrome [1, 2, 7]. In addition, it explains why the researchers have so low interest in the studying of the influence the cardiac arrhythmia on the pressure regime in the cardiovascular system.

The standard Korotkoff method and all its modifications (including the computerized devices) can only constitute a rough estimate the blood pressure in AF because of their inability to estimate all spectrums of fluctuations of the BP levels [5, 6]. Therefore, there are no acceptable and accurate methods of measuring BP in cardiac arrhythmia today.

Despite of it all the doctors and researchers continue to use the usual Korotkoff method for physical examination the patients with the cardiac arrhythmia, make the diagnostic conclusions, prescribe the medicine and estimate the effectiveness of the treatment until now.

In our studies we pursued the following purposes: 1) to develop the principles of assessment of the levels of BP in AF, which can really reflect the circulatory disturbances at this syndrome and 2) to offer an accurate noninvasive method for measuring BP in AF.

## 2. Methods

38 patients with tachysystolic form of AF have been examined. 23 patients were examined twice: before and after the adequate treatment when the normosystolic form of AF was established.

The BP was determined by the Korotkoff method with meticulous observance of the unified recommendations [5].

Next, the BP was measured manually by the modified auscultative method of measuring BP [3]. The pressure in sphygmomanometer cuff was elevated up to the level exceeding 10 mm Hg the established systolic BP. Keeping it constantly at this level, the number of Korotkoff tones was counted up within 10 seconds (s) by auscultation. Next, the cuff pressure was decreasing step by step by 10 mm Hg and the number of Korotkoff tones during 10 s was counting on each step of cuff pressure until full disappearance of tones.

To avoid any subjective errors in the modified

auscultative method, the synchronous recording of the ECG, the Korotkoff tones and the pulse waves on the right hand have been made along with the registration of invasive BP by means of puncture of the radial artery of left hand at 16 patients

### 3. Results

All patients had the tachysystolic form of AF (heart rate -110.4 beats /min), the pulse deficit (pulse rate - 88.6 /min) and the symptoms of congestive heart failure III-IV (NYHA). The parameters of BP received by different methods of measuring BP are listed in the table.

Parameters	Form of atrial fibrillation	
	tachy-	normo-
Heart rate, beats/min	110.4 ± 3.1	71.9 ± 2.5**
Pulse rate, /min	88.6 ± 1.6	71.9 ± 2.5**
Pulse deficit, /min	1.8 ± 1.0	-
Korotkoff method,	mm Hg	mm Hg
Systolic BP	121.5 ± 3.4	116.7 ± 2.6
Diastolic BP	73.1 ± 2.3	66.7 ± 1.8**
Pulse BP	48.4 ± 1.4	50.0 ± 1.1
Modified method,	mm Hg	mm Hg
Systolic BP:		
- maximal	123.9 ± 2.5	118.0 ± 2.0
- effective	99.2 ± 2.0	107.6 ± 2.2*
- fluctuation	24.7 ± 1.3	10.4 ± 1.0**
Diastolic BP:		
- upper limit	91.9 ± 1.8	73.5 ± 2.7**
- lower limit	72.6 ± 2.0	63.3 ± 2.6*
- fluctuation	19.3 ± 1.0	10.2 ± 0.7**
Pulse BP:		
- maximal	51.3 ± 1.1	54.7 ± 1.0
- minimal	7.3 ± 0.9	34.1 ± 2.4**
	* p<0.01	** p<0.001

Both the systolic and the diastolic BP, obtained by the Korotkoff method in those severe ill patients with tachyarrhythmia, were formally normal - 121.5 / 73.1 mm Hg. Naturally, the pulse BP was normal, as well - 48.4 mm Hg. These data demonstrate an impressive contrast between «normal» BP and gravity of haemodynamic disturbances in these severe patients. It is clear that the usual Korotkoff method cannot characterize the status of haemodynamic disturbances in patients with AF, even if this method is applied accurately.

Furthermore, the designation of both the systolic and the diastolic BP in AF by one numeral for each parameter is absolutely incorrect. Obviously, the usual principle of the Korotkoff method does not come up for measuring BP in cardiac arrhythmia.

Applying the modified method, we detected that the

first Korotkoff tone during 10 s registration was captured at pressure in rubber cuff equal to 123.9 mm Hg. We have called this level of pressure as MAXIMAL SYSTOLIC BP (Figure 1).

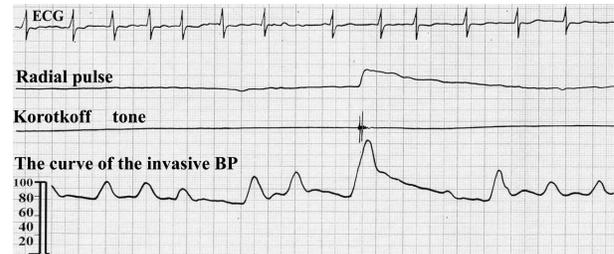


Figure 1. ECG, radial pulse and Korotkoff tone synchronously recorded when the cuff pressure was equal to the maximal systolic BP. The curve below is the invasive BP.

According to the results obtained by invasive measuring of BP in the radial artery, the first Korotkoff tone was caused by the pulse wave with the greatest level of systolic pressure.

During the subsequent step decompression the number of Korotkoff tones was continually augmenting on each step of cuff pressure.

At the pressure in the cuff of 99.2 mm Hg the number of Korotkoff tones for the first time was the biggest (on the average, 13 tones per 10 s of auscultation). We have called the cuff pressure at which the number of tones for the first time became the greatest as EFFECTIVE SYSTOLIC BP.

It is important that the effective systolic BP coincided with the systolic BP of smallest and weakest pulse waves at direct measuring BP in radial artery (Figure 2).

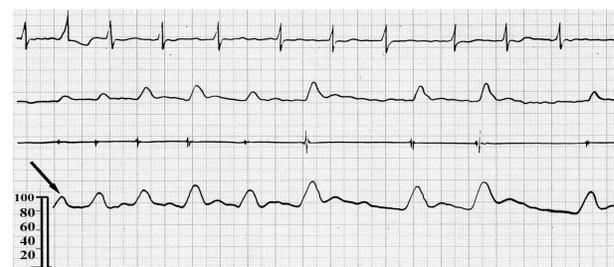


Figure 2. ECG, radial pulse and Korotkoff tones synchronously recorded when the cuff pressure was equal to the effective systolic BP. The curve below is the invasive BP.

It is clear that these weakest and frequent pulse waves bring the significant contribution to cardiac output and by that determine the entire efficiency of the heart during the tachyarrhythmia.

The amplitude of fluctuations of systolic pressure in these patients was significant - 24.7 mm Hg.

The subsequent step decompression led to the progressive decreasing the number of Korotkoff tones during 10 s of auscultation on each step of cuff pressure.

From the level of cuff pressure of 91.9 mm Hg the subsequent step decompression has led to the continual decreasing the number of Korotkoff tones during 10 s of auscultation on each step of cuff pressure.

The level of cuff pressure, from which the subsequent step decompression for the first time has led to decreasing the number of tones, is designated as the UPPER LIMIT OF DIASTOLIC BP (Figure 3).

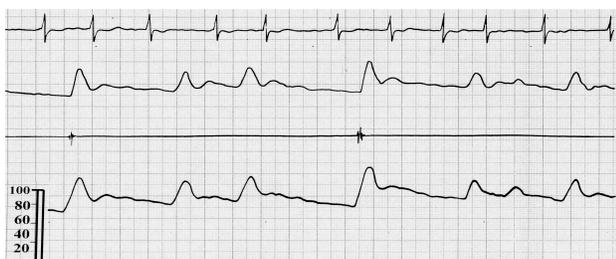


Figure 3. ECG, radial pulse and Korotkoff tone synchronously recorded when the cuff pressure was 10 mm Hg below the upper limit of the diastolic BP. The curve below is the invasive BP.

Eventually, at the cuff pressure of 72.6 mm Hg we heard only 1 Korotkoff tone during 10 s of auscultation. This lowest level of cuff pressure, when only 1 Korotkoff tone could be found during 10 s is marked as the LOWER LIMIT OF DIASTOLIC BP (Figure 4).

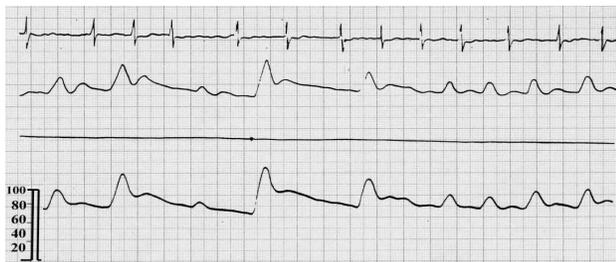


Figure 4. ECG, radial pulse and Korotkoff tone synchronously recorded when the cuff pressure was equal to the lower limit of the diastolic BP. The curve below is the invasive BP.

The difference between two limits of diastolic BP was 19.3 mm Hg and it reflected the range of the fluctuation in diastolic BP in AF.

The MAXIMAL PULSE PRESSURE, defined as a difference between the maximal systolic and the lower limit of diastolic BP, was equal 5.3 mm Hg and it did

not differ from the pulse pressure measured by usual Korotkoff method. It is important that the maximal pulse pressure has coincided with the pulse pressure of the strongest pulse waves on the curve of pressure in the artery.

The MINIMAL PULSE PRESSURE, defined as a difference between the effective systolic and the upper limit of diastolic BP, was only 7.3 mm Hg. As well as it was necessary to expect, the pulse pressure of the weakest wave on the curve of BP, obtained by direct recording in the radial artery, was only approximately 7-10 mm Hg (Figure 5).

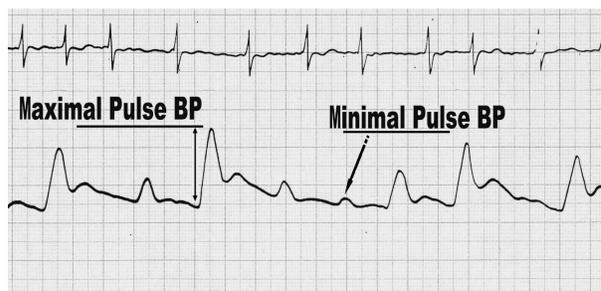


Figure 5. The maximal and minimal pulse BP: ECG and the curve of the invasive BP.

These weakest stroke volumes created the minimal pulse BP and, naturally, were reflecting the minimal degree of effectiveness of the mechanical efforts of the heart. For this reason, this parameter is capable to give additional and very valuable information about the circulatory status in the patients with tachysystolic form of AF.

Thus, using a modified non-invasive method of measuring BP in AF, for the first time we have obtained the possibility to estimate the pressure of the weakest pulse waves.

The establishing the normoarrhythmia in patients after the treatment was accompanied by a significant decreasing of clinical manifestations of congestive heart failure. However, this positive effect of treatment has not been reflected on the BP levels measured by the Korotkoff method. The BP levels, obtained by Korotkoff method, were practically equal as up to treatment, and after.

Therefore, the usual Korotkoff method cannot be used for evaluation the effectiveness of treatment in patients with AF.

According to the data acquired by the modified method, the levels of maximal systolic BP were almost equal as up to treatment, and after. There were no significant changes in the lower limits of diastolic BP as up to treatment, and after, as well.

At the same time the effective systolic BP has been

increased from 99.2 to 107.6 mm Hg and the upper limit of diastolic BP has been considerably decreased from 91.9 to 73.5 mm Hg. As a result, the minimal pulse BP has been grown almost in 5 times.

The minimal pulse pressures of all the "weakest" waves, obtained by direct recording in the radial artery, were significantly increased and they were almost equal to the pulse pressures of the "strongest" waves. This circumstance characterizes the increase of stroke volumes of the "weakest" waves and, as the result, the increasing of the effectiveness of heart work (Figure 6).

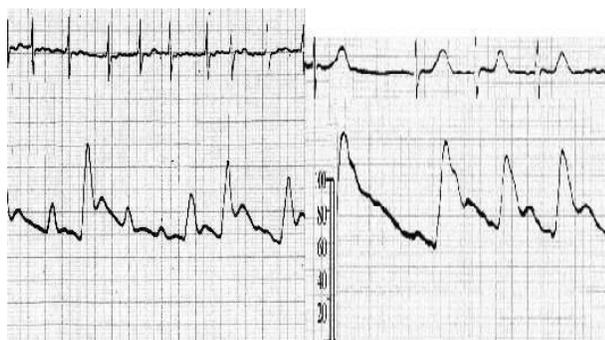


Figure 6. The varieties of the minimal pulse pressure in patient before (left) and after treatment (right). The curve below is the invasive BP.

The ranges of fluctuation of both the systolic and diastolic pressures were insignificant.

Obviously, these changes of BP levels, caused by moderation the rate of arrhythmia after the treatment, were definitely associated with the increasing and aligning the amplitudes of the weakest pulse waves.

In patients with AF all identified BP levels are indispensable patterns and they will always be found at each measurement of BP by the modified method.

#### 4. Discussion and conclusions

Two levels of systolic pressure (maximal and effective), two levels of diastolic pressure (upper and lower limits) and two parameters of pulse pressure (maximal and minimal) ought to be determined in atrial fibrillation.

The effective systolic, upper limit of diastolic and especially the minimal pulse BP levels should be accepted as the objective criteria of haemodynamic disturbances in patients with atrial fibrillation. These parameters of blood pressure precisely reflect the gravity of haemodynamic disturbances.

In patients with cardiac arrhythmia should be used the modified auscultative method of the measuring the blood pressure. Its principle is based on the step decompression with the counting the number of Korotkoff sounds for the 10 seconds on each step of cuff pressure.

Nowadays this non-invasive modified (auscultative) method of blood pressure measurement in atrial fibrillation is unique and its accuracy is equal to the direct invasive method. Its accuracy and simplicity allow us to recommend the modified auscultative method to physicians for measuring and monitoring blood pressure in patients with atrial fibrillation. This method requires only the usual sphygmomanometer, stethoscope and the wristwatch with a seconds-hand.

The described algorithm of blood pressure measurement in atrial fibrillation should serve by the basis for the automated and computerized systems of investigations the patients with cardiac arrhythmia.

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