Original Research Article

Determining the Association between 24-hour blood pressure variability and major adverse cardiac events (MACE) in hospitalized patients with acute myocardial infarction: a prospective study

Abstract :

Acute myocardial infarction (AMI) is a challenging cardiovascular disease leading to a high rate of mortality. Some cardiomyocytes in AMI were affected by ischemia and necrosis, resulting in a decrease in myocardial contractility, an acute proinflammatory response, and an increase in sympathetic tone. In the meantime, proinflammation and endothelial dysfunction are induced by high blood pressure variability (BPV), which increases left ventricular workload, heart rate, and myocardial oxygen demand. As a result, a high BPV and the pathological effects it causes are likely to affect the onset of acute cardiac complications in AMI and the physiological function of the heart[1]. Patients Pulse changeability (BPV) has been fundamentally concentrated on through the crystal of congestive cardiovascular breakdown (CHF) and hypertension, yet not in that frame of mind of an intense coronary condition (ACS). This study means to explore the relationship between transient BPV and major unfavorable heart occasions (MACE) in AMI patients. The following order can be used to define MACEs: Death > shock > cerebrovascular stroke > heart failure > hypertensive crisis > life-threatening arrhythmias .This prospective study used the weighted standard deviation of 24-hour ambulatory blood pressure monitoring readings to include 74 patients who were hospitalized in the cardiology department at ARRAZI hospital MOHAMED VI, MARRAKECH between September 2022 and February 2023.

Results :

The average systolic BPV value which was estimated as standard deviation (SD) and average real variability (ARV) was more significant in the MACE group than in the non-MACE group. Systolic SD and systolic ARV in the MACE group were 12,78 mmHg and 11,61 mmHg respectively. In the non-MACE group, systolic SD and systolic ARV were 10.45 mmHg and 7,23 mmHg respectively. There was no significant association between BPV and MACE. However, there were significant differences between systolic ARV in patients with hypertension who experienced MACE and patients without hypertension who experienced MACE, unlike patients who didn't experienced MACE for whom the ARV was nearly the same for patient with and without HBP.

Conclusion:

MACE was higher in the group BPV of AMI patients than that of non-MACE AMI patients. There was no significant association between BPV and MACE during the acute phase of AMI, however the BPV was significantly more important for HBP patient who experienced MACE, which leads us to think that the screening of BPV in HBP patient may by a predictive factor for the development of MACEs.

Keywords: Acute myocardial infarction, ambulatory BP monitoring, blood pressure variability, major adverse cardiac events (MACE)

Introduction :

“Hypertension and its effects on target organ damage are well established in clinical practice. Overall, the risk of fatal coronary events and stroke doubles for every 20 mmHg increase in systolic blood pressure (SBP) (or every 10 mmHg increase in diastolic blood pressure [DBP])” [2] “Blood pressure (BP) variability is a dynamic occurrence including short-, medium-, and long-term fluctuations that are the result of a complex interplay between behavioral, humoral, and neural or reflex influences. The extent of this fluctuation depends on several variables, including blood pressure status (i.e., normotonic versus hypertensive), changes in plasma volume, fluctuations in preload and post-load, respiratory cycle, use of antihypertensive drugs, and individual responses to various Response to everyday stimuli such as physical activity, mental stress, sleep duration/quality, smoking, alcohol consumption, seasonal changes in outdoor temperature, and other physiological and pathological factors”. [1]. “Blood pressure variability (BPV) is presently considered a novel risk factor for cardiovascular disease. It can be estimated using various computational and statistical methods (mainly weighted standard deviation or average real-world variability) by various blood pressure devices (mainly ambulatory blood pressure monitoring [ABPM])” [2]
“On the other hand, patients with acute coronary syndromes (ACS) often present with vasomotor instability, which increases the tendency for enhanced response to antihypertensive therapy, and blood pressure fluctuations occur early in ACS therapy”. [3] However, the prognostic impact of in-hospital blood pressure fluctuations on major adverse cardiac events (MACE) and clinical outcomes in otherwise high cardiovascular risk patients is uncertain. The aim of this study was to evaluate the relationship between in-hospital blood pressure variability and MACE in patients with acute myocardial infarction.

Materials AND METHODS

2.1. Patient selection

Patients included in the are responding of the following criteria: (1) Typical anginal pain; (2) Diagnostic of an acute coronary syndrome (ECG and troponin dosage). **Exclusion criteria** :An handicap that inhibited the ability of ABPM placement, a history of a chronic renal disease , Secondary hypertension, or congestive heart failure.

2.2. Study design

Between September 2022 and february 2023, 121 patients were hospitalized in the cardiology department in ARRAZI hospital ,CHU MOHAMED VI , MARRAKECH, for ACI.it

was a prospective study, where all patients followed up was done during their hospitalization (between 3 and 26 days). For logistical reasons (Ex: lack of devices) 41 patients hospitalized for ACS didn't beneficiate from the ABPM . Of the 80 patients who were offered the ABPM, 6 were excluded to complete the study due to a technical problem, leaving 74 participants for the study analysis.

2.3. Study population

We enlisted 74 patients who fulfilled the inclusion and exclusion criteria in this study. During the time of hospitalization, demographic data, comorbid conditions, history of previous cardiovascular or kidney diseases and baseline measures were collected. The patients included were treated according to the recent European Society of Cardiology guidelines for the management of ST-segment elevation myocardial infarction (STEMI) [4] and non-STEMI.[5] After the ACS, all patients received clopidogrel (75 mg/d), acetyl salicylic acid (75 mg/d), and β-blockers, angiotensin-converting enzyme inhibitors, and statins. A history of cardiovascular disease was defined as having had one or more of the following: angina pectoris, myocardial infarction, heart failure, aortic dissection, or stroke. Chronic kidney disease was defined as estimated glomerular filtration rate (<60 mL/min/1.73 m2) .

2.4. Ambulatory BP monitoring

the patients were equipped with the ABPM devices for 24 hours within the first seven days after the hospitalization for the ACS in the cardiac care unit. The monitor was programmed to obtain measurements of BP each 20 min between 08:00 and 23:59 hours, and each 30 min between 00:00 and 07:59 hours. After the results importation into the ABPM's software, we obtained the Mean SBP, DBP, mean arterial pressure, and BP load values. The criteria included for good-quality ABPM is not to exceed 25% errors by the software.

2.5. Calculation of BPV indices

BPV index :

The BPV index was defined as the weighted standard deviation (SD) of 24-h BP, daytime BP, and nocturnal BP (SBP and DBP). As a measure of short-term BPV from reading to reading, we used the SD-weighted time interval between consecutive readings (SD24) and the mean of daytime and nighttime SD (SDdn) weighted by the duration of daytime

and nighttime intervals within 24 hours. SDdn is the average of the day and night SD values, corrected for the hours included in the two time periods according to the following formula: SDdn = ([Daytime SD × hours included in daytime] + [Nighttime SD × hours included in nighttime hours])/ (hours included in the day + night). This method removes the effect of diurnal BD differences from BDV estimates.

2.6. Outcome ascertainment

During their stay in the hospital, each patient was followed up on for an average of seven days. Major adverse cardiac events (MACEs) that occurred at any time during in-hospital follow-up were used to evaluate clinical outcomes. Using only the most severe MACE event, the cumulative MACE for each patient was calculated in the following order: death, shock, a stroke in the cerebrovascular system, heart failure, hypertension, and an arrhythmia that could end one's life are all possible outcomes. At follow-up, death was defined as death from any cause. At the follow-up, heart failure was defined as the presence of rales in more than one third of the lung fields that did not go away with coughing or pulmonary edema on a chest x-ray. 5] Cardiogenic shock is characterized by persistent hypotension and inadequate tissue perfusion. 7] ischemic or hemorrhagic Cerebrovascular stroke, is characterized as deficient blood supply to the mind prompting cell death, [8] Hypertensive emergency was characterized as seriously raised BP >180/110 mm Hg in the convening of ACS.[9] “Life-threatening arrhythmias as well as a ventricular tachycardia, ventricular fibrillation, and complete heart block”.[10]

RESULTS

Of the 74 patients, 35,13% were admitted in heart care unit for STEMI and 64,8% for NSTEMI. the masculine sex was predominant of the AMI patients (59,4%), with a mean age of 58.2 years. The most cardiac risk factor was smoking, followed by high blood pressure, diabetes mellitus.

MACE occurred in 13 patients, Seven patients presented an acute heart failure, Three patients had a malignant arrythmias, two patients had a cardiac arrest, and the sitting of a cardiogenic shock in three patients.

Table 1 features of the 74 patients for ACS that who received ABPM

Variable	
Sex,n (%)	
Male	44(59,4%)
Female	30(40,5%)
Age	58,2
Diabetes mellitus	33(44%)
Hypertension	40(54%)
Dyslipidemia	
Smoking	54(59%)
Chronic Kidney disease	4(5,4%)
Previous cardiovascular disease	12(16,2%)
MACE	13(17,56%)
AMI STEMI/NSTEMI	8(10,8%)/5(6,75%)
Systolic blood pressure(mmHg)	113,4
Distolic blood pressure(mmHg)	68,2
SD-SBP	11,615
SD-DBP	7,76
ARV-SBP	9,42
ARV-DBP	6,70

The mean systolic and diastolic blood pressures over the course of a 24-hour period were 113,4mmHg and 68,mmHg , respectively. The systolic-diastolic BPV (SD-BPV/SD-DBP) and systolic-diastolic ARV (ARV-SBP/ARV-DBP) were 11,615 mmHg, 7,76 mmHg, 9.42 mmHg, and 6,70 mmHg, respectively, over the course of 24 hours. The group with MACE had a higher mean systolic BPV value (SD-SBP and ARV-SBP) than the group without MACE. On the other hand, there was no significant correlation found between the prevalence of MACE and VTD.

The correlation between BPV and MACE was not significant :

Patients with MACEs:

Table 2 : MACE,s patients blood pressure features

SD-SBP	**12,78**
SD-DBP	8,695
ARV-SBP	11,61
ARV-DBP	7,81

Patients without MACEs :

Table 3 : Non MACE,s patients blood pressure features

SD-SBP	**10,45**
SD-DBP	6,84
ARV-SBP	7,23
ARV-DBP	5,6

Table 4 exposed the mean BPV in patients with high blood pressure was significantly higher (p<0,0001) than in patients without HBP

Table 4 : BPV in patients with and without HBP

BPV	**Patients with HBP**	**Patients without HBP**
SD-SBP	12,42	10,8
SD-DBP	9,22	6,3
ARV-SBP	11	7,84
ARV-DBP	7,47	5,93

Table 5 exposed the mean BPV in patients with hypertension who experienced MACE was higher than in patients without hypertension who experienced MACE (p<0,0001)

Table 5 : BPV in AMI patients with and without HBP experienced MACE

BPV	**Patients with HBP**	**Patients without HBP**

SD-SBP	14,2	11,2
SD-DBP	10,18	7,21
ARV-SBP	12,63	10,59
ARV-DBP	9,29	6,33

While The BPV in patients who didn't experienced MACE was nearly the same in patients with or without HBP. (p<0,0012)

Table 6 : BPV in AMI patients who didn't experienced MACE with and without history of HBP

BPV	**Patients with HBP**	**Patients without HBP**
SD-SBP	10,72	10,18
SD-DBP	7,13	6,55
ARV-SBP	7,34	7,12
ARV-DBP	5,75	5,45

However the BPV was significantly more important for HBP patient who experienced MACE than HBP patients didn't experienced MACE: SD-SBP (14,2 +versus 10,72 %) and ARV-SBP (12,63 versus 7,34 %), on the other hand , for patients with no history of HBP there was no significant difference in BPV between the one who experienced MACE and the one who didn't .(p<0,001)

Discussion :

The high rate of AMI is more occurred in masculine gender, might be the cause of an expanded occurrence of smoking in Moroccan men ,metabolic sicknesses, as hypertension and diabetes[11].

The Entrance (2012) tracked down that the mean time of intense coronary conditions (ACS) patients product 59 years, and 76% were male [12]; these socioeconomics were practically equivalent to those in the current review.

The rate of MACE in our study was 17,56%. This result is higher than those of the 2019 *Cipto Mangunkusumo National Hospital study [*1] and *Anastasia et al*. (2019)[13] observations on ACS patients , and saw that as 15,8% and 11.9%, separately had MACE.

Very few studies have examined the effect of BPV diagnosed by ABPM in ACS patients in recent years.

“The BP vacillation and fluctuation during ACS has been introduced as a new finding during the board of these fundamentally sick patients”.[3]

Subsequently, our review, examined the effect of BPV examination involving ABPM during initial 7 days of confirmation as another gamble factor for in-hospital MACE.

The mean BPV value found in this study was slightly lower than the value found in the study by Harefa (2021), which looked at the relationship between major adverse cardiac events (MACE) and 24-hour blood pressure variability in hospitalized patients with acute coronary syndrome : a retrospective cohort study [1] - During the seven-day observation period, MACEs occurred in 37 percent and 15 percent of patients, respectively, in the Cesare Cuspidi study [14] and Harefa study [1] compared to 17,56 percent in our study, which is in the same line.

In Harefa's study, the mean SD-SBP and SD-DBP were 11.98 4.68 mmHg and 8.82 3.63 mmHg, respectively. Systolic and diastolic ARVs, on the other hand, were 9.36 3.48 mmHg and 7.73 2.98 mmHg, respectively. Our findings are very similar to Harefa's, which may be due to similar patient management and close monitoring of blood pressure in the intensive care unit (ICU) by Hassan et al. 2017) used 200 samples in a

prospective cohort study and discovered a significant association between the rate of MACE and the high BPV in patients admitted for ACS, while the first seven days of their hospitalization. BPV was measured in Hassan's study using a weighted standard deviation of blood pressure (wSD-BP) and a standard deviation of the 24-hour systolic-diastolic blood pressure (SD-SBP/SD-DBP). Hassan et al. found “a r=0.56, p=0.003 correlation between the incidence of MACE in the high wSD-BP group (>12.6 mmHg) and the high SD-SBP group (>13.5 mmHg)” [15]. The study indicate that BPV and MACE did not have a significant correlation while the first seven days of patients with ACS. Hassan and colleagues' contribution adds information on the relationship between short-term BP variability and cardiovascular complications in the setting of ACS, a clinical condition in which many factors may contribute to acutely alter physiological BP variability. Not with standing, the typical BPV esteem in the MACE bunch was higher than in the non-MACE bunch. The outcome is in accordance with the results showed by Hassan et al study [14]and Harefa .[1].

The non- important correlation among BPV and MACE found in the current review could be a cause of the lack of the review populace, which was more modest than the one Hassan and all alludes to, yet in addition because of different cardiovascular risk factors and patient’s medical history. The BPV attributes in each comorbid disease impacted the normal BPV of the whole review populace and impacted the connection among BPV and MACE.

Conclusion :

We believe that screening for BPV in HBP patients may be very useful in predicting MACE in this fragile population, since BPV may be an imperative risk factor for in-hospital MACE in AMI patients, whether STEMI or non-STEMI, especially in patients with a history of HBP.

Ethical Approval:

As per international standard or university standard written ethical approval has been collected and preserved by the author(s).

Consent

As per international standard or university standard, patient(s) written consent has been collected and preserved by the author(s).

References :

[1] Harefa *et al.*, « The association between 24-h blood pressure variability and major adverse cardiac events (MACE) in hospitalized patients with acute myocardial infarction: a retrospective cohort study », *Egypt. Heart J.*, vol. 73, nº 1, p. 88, oct. 2021, doi: 10.1186/s43044-021-00213-1.

[2] G. Bilo *et al.*, « A new method for assessing 24-h blood pressure variability after excluding the contribution of nocturnal blood pressure fall », *J. Hypertens.*, vol. 25, nº 10, p. 2058‑2066, oct. 2007, doi: 10.1097/HJH.0b013e32829c6a60.

[3] C. Rosendorff et Writing Committee, « Treatment of Hypertension in Patients with Coronary Artery Disease. A Case-Based Summary of the 2015 AHA/ACC/ASH Scientific Statement », *Am. J. Med.*, vol. 129, nº 4, p. 372‑378, avr. 2016, doi: 10.1016/j.amjmed.2015.10.045.

[4] J.-P. Collet *et al.*, « 2020 ESC Guidelines for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation », *Eur. Heart J.*, vol. 42, nº 14, p. 1289‑1367, avr. 2021, doi: 10.1093/eurheartj/ehaa575.

[5] B. Ibánez *et al.*, « 2017 ESC Guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation », *Rev. Espanola Cardiol. Engl. Ed*, vol. 70, nº 12, p. 1082, déc. 2017, doi: 10.1016/j.rec.2017.11.010.

[6] A. J. Kinsara, « Ambulatory blood pressure monitoring in daily practice », *Indian Heart J.*, vol. 69, nº 6, p. 788‑789, 2017, doi: 10.1016/j.ihj.2017.09.223.

[7] M. D. Samsky, D. A. Morrow, A. G. Proudfoot, J. S. Hochman, H. Thiele, et S. V. Rao, « Cardiogenic Shock After Acute Myocardial Infarction: A Review », *JAMA*, vol. 326, nº 18, p. 1840‑1850, nov. 2021, doi: 10.1001/jama.2021.18323.

[8] A. Terént et B. Andersson, « The prognosis for patients with cerebrovascular stroke and transient ischemic attacks », *Ups. J. Med. Sci.*, vol. 86, nº 1, p. 63‑74, 1981, doi: 10.3109/03009738109179211.

[9] M. Suneja et M. L. Sanders, « Hypertensive Emergency », *Med. Clin. North Am.*, vol. 101, nº 3, p. 465‑478, mai 2017, doi: 10.1016/j.mcna.2016.12.007.
[10] A. Aggarwal, M. K. Rohit, et K. K. Talwar, « Managing arrhythmia in acute myocardial infarction », *Indian Heart J.*, vol. 63, nº 1, p. 98‑103, 2011.
[11] « World Bank Open Data », *World Bank Open Data*. https://data.worldbank.org (consulté le 18 avril 2023).
[12] A. Moustaghfir, M. Haddak, et R. Mechmeche, « Management of acute coronary syndromes in Maghreb countries: The ACCESS (ACute Coronary Events - a multinational Survey of current management Strategies) registry », *Arch. Cardiovasc. Dis.*, vol. 105, nº 11, p. 566‑577, nov. 2012, doi: 10.1016/j.acvd.2012.07.002.
[13] D. Sari, E. Mudjaddid, E. Ginanjar, et M. Muhadi, « Hubungan Antara Depresi dan Ansietas Dengan Major Adverse Cardiac Event (MACE) Dalam 7 Hari Pada Pasien Sindrom Koroner Akut di RSCM », *J. Penyakit Dalam Indones.*, vol. 5, janv. 2019, doi: 10.7454/jpdi.v5i4.186.
[14] C. Cuspidi, M. Tadic, et G. Grassi, « Short-term blood pressure variability in acute coronary syndrome », *J. Clin. Hypertens.*, vol. 19, nº 12, p. 1249‑1251, oct. 2017, doi: 10.1111/jch.13105.
[15] A. K. M. Hassan, H. Abd-El Rahman, K. Mohsen, et S. R. Dimitry, « Impact of in-hospital blood pressure variability on cardiovascular outcomes in patients with acute coronary syndrome », *J. Clin. Hypertens. Greenwich Conn*, vol. 19, nº 12, p. 1252‑1259, déc. 2017, doi: 10.1111/jch.13107.