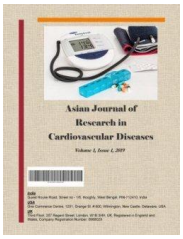

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Correlation between Electrocardiogram and Coronary Angiography in ACS with Persistent ST Segment Elevation: Institutional Cross-sectional Study

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Authors' contributions

This work was carried out in collaboration among all authors. Author AB did conceptualization, performed methodology, collected, synthesized and analyzed the data as well as wrote original draft and edited the manuscript. Author FAB did validation, data curation, supervision, wrote, reviewed and edited the manuscript. Author AWK performed data collection, reviewed and edited the manuscript. Author DA collected data, reviewed and edited the manuscript. Author AEH did data curation, data analysis of manuscript. Author LO did conceptualization, performed methodology, data validation, supervision, wrote and edited the manuscript. Author MC did validation, supervision, wrote and edited the manuscript. All authors have read and approved the manuscript.

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ABSTRACT

Background: The electrocardiogram provides more information on the exact location of the lesion, prediction of the final infarct size, and estimation of the prognosis. Nevertheless, coronary angiography remains the gold standard for identifying the culprit artery. The aim of our work is to study the correlation between electrical and coronary data and to determine the reproducibility of the electrocardiogram in the identification of the culprit lesion.

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Methods: This is a retrospective study of 91 cases of ST+ ACS, collected in the cardiology department B of the Souissi maternity hospital over a 6-month period.
Results: The mean age of the general population was 59.5 ± 9.2 years with 78% men and 22% women, 80% of whom were menopausal. The percentage of patients with typical infarct chest pain was 95%.
Electrically, the electrocardiogram showed ST-segment elevation in all patients. The anterior territory was affected in 64.8% of cases, nearly half of which were extensive anterior. The inferior territory was affected in 25 patients (27.5%).
Angiographic analysis of the lesions showed monotruncal coronary involvement in almost half of the cases. The majority of cases (65.6%) involved the anterior interventricular artery.
Conclusions: The ECG remains an essential tool in the early identification of the artery responsible for the infarction to guide the revascularisation procedure.
The combination of ECG and coronary angiography is essential for better assessment of acute myocardial infarction in order to optimize its management.

Keywords: Correlation; ECG; coronary angiography.

ABBREVIATIONS

ACS : Acute Coronary Syndrome
ASA : Antéro-Septo-Apical
CABG : Coronary Artery Bypass Grafting
Cx : Circumflex artery
ESC : European Society of Cardiology
LAD : Left Anterior descending artery
LV : Left Ventricular
LVEF : Left Ventricular Ejection Fraction
MI : Myocardial Infarction
OR : Odds Ratio
RV : Right Ventricular
RCA : Right Coronary Artery
STEMI : ST-Elevation Myocardial Infarction
NSTEMI : No ST-Elevation Myocardial Infarction

1. INTRODUCTION

An Electrocardiogram (ECG) is an essential tool for the initial diagnosis and management of myocardial infarction. It is crucial for localization and determination of the extent of infarction which permits the prediction of prognosis [1,2]. It is important to note that ECG and coronary angiography do not cover the same etiopathogenic aspects: the first one reflects myocardial physiology during acute ischemia, and the second one is luminography [3]. Coronary angiography is the gold standard for finding the culprit vessels, however ECG remains the first exam to identify acute ischemia and guide angioplasty process, particularly in patients with multivessel coronary disease.

The main purpose of this study is to evaluate the utility of ECG compared to coronary angiography in identifying the culprit vessel responsible for ST-elevation myocardial infarction in our patients.

2. METHODS

2.1 Study Population

We performed a retrospective study of 91 patients admitted for ST+ acute coronary syndrome (ST+ ACS) into the cardiology department B of the Souissi maternity hospital for a period of six months from 01/01/2021 to 30/06/2021. Patients who did not undergo coronary angiography were excluded from our study.

2.2 Data Acquisition and Study Outcomes

The retrospective analysis was conducted by collecting data from our institution's health system register and the clinical files of the patients.

The study's aims:

- Assess the usefulness of ECG versus coronary angiography to identify culprit vessels in ST-segment elevation myocardial infarction in our patients.
- Comparing our results with the literature.

2.3 Operational Definition of Terms

All included patients were diagnosed according to the following European Society of Cardiology definition criteria [4]:

Acute myocardial infarction (modified from the fourth universal definition of myocardial

infarction) is defined by the detection of an elevation or decrease in cardiac troponin with at least one value above the upper reference limit of the 99th percentile associated with clinical evidence of infarction of at least one of the following elements: symptoms of myocardial ischaemia, new ischaemic electrocardiographic changes, development of pathological Q waves, imaging evidence of new viable myocardial loss or regional wall motion abnormality, or angiographic identification of a coronary thrombus. The European and American societies define ST-segment elevation criteria as follows: New ST elevation at the J point in two contiguous leads with the cut-points: ≥0.1 mV in all leads other than leads V2 –V3 where the following cut points apply: ≥0.2 mV in men ≥40 years; ≥0.25 mV in men <40 years, or ≥0.15 mV in women.

Anatomical, electrical and coronary correspondence of different cardiac wall is represented as follows [5]:

- Anteroseptal (AS): anteroseptal dihedral angle, antero-superior third of the septum and adjacent anterior wall, and gives direct signs from V1 to V3 leads, possibly V4. The proximal left anterior descending artery (LAD) is often responsible.
- Apical: refers to the apex and its side, and gives direct signs in V4 and V5 and indirect signs such as micro voltage in standard leads (DIII and aVF). Distal LAD is often responsible.
- Antero-septo-apical: combines the 2 previous locations and gives direct signs from V1 to V5 and indirect signs in DIII, aVF and/or V8 - V9. Proximal LAD is responsible.
- Lateral: high lateral involvement gives direct signs in DI and aVL and indirect signs in DIII and aVF, whereas low lateral involvement gives direct signs in V5 and V6 and indirect signs in V1 and V2. Extended lateral involvement combines two previous types of involvement. The coronary artery responsible is circumflex (Cx), marginal or diagonal.
- Extensive anterior: association of anteroseptal, apical and lateral locations. LAD is responsible.
- Inferior: refers to the middle part of the posteroinferior wall and postero-septal dihedral angle, and gives direct signs in DII, DIII and aVF, and indirect signs in DI-aVL (and sometimes also from V1 to V4). The coronary artery responsible is the right coronary artery (RCA) or circumflex.
- Infero-basal: refers to the upper third of the posterior wall, the posteroseptal dihedral angle and the adjacent septum, gives direct signs in V7, V8 and V9 and indirect signs in V1 to V4. The responsible artery can be Cx or marginal +/- RCA.
- Infero-lateral: refers to the posterior wall and lateral wall and gives direct signs in DII, DIII, aVF and V5-V6. The coronary artery responsible is Cx, marginal or RCA.
- Deep septal: refers to the entire septum and adjacent dihedral angles and gives direct signs in DII-DIII-aVF and V1-V4. The coronary artery responsible is LAD, rarely RCA.
- Circumferential: Combination of extensive anterior and inferior locations. The responsible coronary artery is the left main artery (LMA) or proximal LAD.

In inferior myocardial infarction (MI), Cooksey et al. found that DIII is oriented towards the right inferior segment, whereas DII is mainly oriented towards the left inferior segment and also tends to be oriented towards the lower left lateral region or the upper wall of the left ventricle. Therefore, DIII lead is more influenced by RCA involvement, whereas DII lead is influenced by circumflex artery involvement [6]. Indeed, careful analysis of the electrical changes in DI and aVL leads seems to improve sensitivity and specificity in identifying the culprit artery [7,8]. Occlusion of Cx means involvement of the posterolateral and inferoapical wall. Patients with Cx involvement less frequently show ST depression in lead aVL and more often an isoelectric or ST élevation in leads DI and aVL.

2.4 Statistical Analysis

The data collected was entered using Excel 2010 software. Statistical analysis was performed using JAMOVI version 1.6 software.

The quantitative variables were expressed as a mean plus or minus standard deviation when the distribution of the variable is normal (Gaussian) or as the median when the distribution of the variable is asymmetrical (non-Gaussian).

The qualitative variables were expressed in number and percentage. The p-value was considered significant for a value less than 0.05.

3. RESULTS

3.1 Epidemiologic and Clinical Aspects

The mean age of our population was 59.5±9.2 years in which 78% were men and 22% were women, 80% of whom were postmenopausal. Among the patients, 40.7% were diabetic, 38.5% were hypertensive and 63.7% were smokers. Dyslipidaemia was found in 34.1% of the cases and coronary heredity in 4%. There were 91 patients meeting the inclusion criteria. Percentage of patients presenting with a typical infarct chest pain was 95%, and the majority of patients were admitted out of time, i.e. 62.6%.

According Killip classification, 33% of our patients had heart failure and 3.3% had cardiogenic shock.

3.2 Paraclinical Aspects

ECG showed ST elevation in all patients. Anterior wall was affected in 64.8% of cases. Of these, the extended anterior territory represented 50%. Inferior territory was affected in 25 patients (27.5%).

Transthoracic echocardiography was performed for all patients. The Incidence of left ventricular dysfunction was 64.8% of which 29.7% had ejection fraction less than 40%.

Angiographic analysis of lesions showed single-vessel coronary involvement in almost one half of the cases. The major part of these lesions involved LAD (65.6%).

3.3 Management and Outcomes

Angioplasty was chosen in 69.2% of cases, coronary artery bypass grafting (CABG) in 3.3%, and medical treatment alone, with or without ischaemia/viability tests, in 27.5%.

Evolution was successful in 91.2% of patients. We observed 8 complications including 4 deaths.

Table 1. Distribution of patients according to the characteristics of the general population

Characteristics	General population
age	59,5 ±9,2
Male	71(78%)
Diabetes	37(40,7%)
HTA	35(38,5%)
Tobacco	58(63,7%)
Dyslipidemia	31(34,1%)
Menopause	18(19,8%)
Coronary heredity	4(3%)
Delays less than 12hours	34(37,4%)
Heart failure	30(33%)
Extended anterior	36(39,6%)
Anterior	23(25,3%)
Inferior	25(27,5%)
Lateral	3(3,3%)
Extended to RV	4(4,4%)
Echocardiography characteristics	
Akinesia	74(81,3%)
Hypokinesia	61(67%)
Normokinesia	1(1.1%)
LVEF	
Preserved	32(35,2%)
Moderately Reduced	32(35%)
Reduced	27(29,7%)
Angiography characteristics	
Monotroncular	45(49,5%)
Bitroncular	22(24,2%)
Tritroncular	23(25,3%)
Normale	1(1.1%)

Characteristics	General population
Culprit lesion	
Anterior interventricular (IVA)	59(65,6%)
Right coronary (RC)	17(18,9%)
Circonflexe (Cx)	10(11,1%)
Others	4(4,4%)
Treatment	
ATL	63(69,2%)
CABG	3(3,3%)
Medical treatment +/- explorations	25(27,5%)

Table 2. Electrical criteria guided to culprit artery during myocardial infarction

Electrical criteria	RC (n= 16)	Cx (n= 9)	P value
1. ST->1mm en DI	13(81%)	2(22%)	0.034
2. ST->1mm en aVL	12(75%)	2(22%)	0.012
3. ST- en aVL>DI	15(93%)	1(11%)	0.002
4. ST+ en DIII>DII	13(81%)	1(11%)	0.017
5. ST->1mm en V1 et/ou V2	6(37%)	3(33%)	0.524
6. ST+>1mm en V5 et/ou V6	0	3(33%)	0.014
7. ST+>1mm en V4R	7(44%)	0	0.023
8. ST+>1mm en V7 et V8	6(37%)	3(33%)	0.835
Criteria 3 +Criteria 4 positifs	12(37%)	0	0.002
Criteria 3 + Criteria 4 négatifs	0	7(77%)	0.001

3.4 Correlation between ECG and Coronary Angiography

Anterior MI accounted for 64.8% of our patients. LAD was the culprit artery in 96% of cases. Left main artery was involved in 3 of our patients. Cx and Bisector were each found in 1 patient. ST elevation was mainly found in the ASA followed by EA in 42% and 41% respectively. ASA wall infarction was due to damage of the middle LAD in 52% and proximal LAD in 36%, whereas extended anterior wall infarction was related to damage of proximal LAD in 48% and middle LAD in 37%.

Inferior MI represented 27.5% of all MI in our study. RCA was the vessel involved in 56% of our cases followed by Cx in 28%. Inferior MI was due to RCA involvement in the majority of cases. Inferior MI extended to the RV was due to RCA involvement in 75%.

Table 2 lists ECG criteria in addition to inferior ST elevation. These criteria were studied for their reproducibility in pointing to RCA or Cx involvement during MI.

MI of lateral wall represented 3.3% of all MI in our study. They were related to an involvement of Cx in most of our cases.

4. DISCUSSION

4.1 Key Results

In our study, the electrocardiogram showed ST-segment elevation in all patients. The anterior territory was affected in 64.8% of cases, almost half of which were extensive anterior. The inferior territory was found in 25 patients (27.5%).

Angiographic analysis of the lesions showed monotruncal coronary involvement in almost half of the cases. The majority of cases involved LAD: 65.6% of cases.

The 18-lead ECG is an indispensable tool in the management of emergency chest pain [1].

ECG must be systematically interpreted by territories. These territories have an anatomical correspondence between the myocardium wall and coronary arteries [9].

The myocardial wall concerned can be well defined by using 18 leads. The electrical territories are useful to find the culprit coronary artery during infarction [10]. However, there is not always a simple correspondence between electrical territory and a coronary artery due to potential natural bypasses (collaterals) and/or variation of dominance between right or left coronary arteries.

In our study, LAD was the culprit vessel involved in 96% of cases. ST-segment elevation was mainly found in leads V1, V2, V3 and V4. ASA wall infarction was due to damage of the middle LAD in 52% and proximal LAD in 36%, whereas the extended anterior wall infarction was related to damage of proximal LAD in 48% and middle LAD in 37%. Aldrich et al. reported similar results. In decreasing order, the leads most affected by ST elevation were: V2, V3, V4, V5, aVL, V1, V6. Thus, in the 68 patients with anterior wall infarction, ST elevation was found in 99% of cases. V2 and V3 are the most common leads of maximum elevation [11].

In inferior MI, the most frequent culprit artery is RCA. Occlusion of RCA manifested on the ECG by an ST elevation in DIII that is greater than the one recorded in DII associated with an ST depression in DI and aVL [12]. Cx occlusion is manifested by a greater ST elevation in DII than DIII but also by an isoelectric or ST elevation in aVL. Cooksey et al. found that DIII lead is oriented towards the right inferior segment, whereas DII is primarily oriented towards the left inferior segment and also tends to be oriented towards the lower left lateral region or the upper left ventricular wall. Therefore, DIII is more influenced by RCA involvement, whereas DII is influenced by Cx involvement [6]. Besides ST-segment elevation in leads DII, DIII and aVF, which is the key to making the diagnosis of acute inferior myocardial infarction, there are some ST-segment changes in the opposite leads (DI, aVL, and V1 to V3) and right leads (V3R to V5R) which may provide information that identifies the culprit artery (RCA or Cx) [13]. This is concordant with the results of our study [14,15].

5. CONCLUSIONS

The ECG remains an essential tool in the early identification of culprit artery in acute MI with ST elevation to guide revascularization. However, combination of ECG and coronary angiography is essential for optimal management.

We believe our findings will help to better understand the correlation and identification of the culprit artery for early and adequate management of Acute coronary syndrome for our population in Africa.

6. LIMITATIONS

There was a limitation in our study. It was a retrospective study that included a small population in a single center.

CONSENT

It is not applicable.

ETHICS APPROVAL

Respect for anonymity and confidentiality were taken into consideration when collecting the data. In addition, it only covers questions of a general nature or relating to a biomedical test, experiment, or study relating to the human beings examined. Ethics Committee for Biomedical Research of Mohammed V University, Rabat, Morocco. (CERB) http://fmp.um5.ac.ma/sites/fmp.um5.ac.ma/files/docs/rglement_interieur_cerb_2010.pdf.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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