Journal Homepage: -www.journalijar.com
INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)
Article DOI:10.21474/IJAR01/8664
DOI URL: http://dx.doi.org/10.21474/IJAR01/8664

RESEARCH ARTICLE

EVALUATION OF THE Q WAVE BY COMPARISON WITH THE RESULTS OF ECHOCARDIOGRAPHY AND CMR AND ANGIOGRAPHY.

Y.Kettani, S.Hallab, N.Doghmi and M.Cherti.
Cardiology B service; Ibn Sina Hospital Center, Rabat-Morocco.

Manuscript Info

Manuscript History
Received: 10 January 2019
Final Accepted: 12 February 2019
Published: March 2019

Abstract

Background: Q waves on the electrocardiogram are often considered to be reflective of irreversibly scarred Myocardium due to antecedent transmural myocardial infarction. However, there are some indications that residual viable tissue may be present in Q wave infracted regions. It is clinically relevant to know how many Q-wave regions contain viable tissue because these patients may benefit from revascularization in terms of improvement of function and long-term survival. A technical advance in contrast-enhanced magnetic resonance imaging (MRI) has significantly improved image quality. We investigated whether healed myocardial infarction can be visualized as hyper enhanced regions with this new technique, and whether assessment of the transmural extent of infarction yields new physiological data.

Methods: 100 MRI examinations were carried out in two groups: patients with Q wave and patients without Q wave at the electrocardiogram. Patients with healed myocardial infarction were prospectively enrolled after enyzmatically proven necrosis and imaged by the echocardiography. The MRI procedure used a segmented inversion-recovery gradient-echo sequence after gadolinium administration. Findings were compared with those of coronary angiography, electrocardiography, cine MRI, and Echocardiography.

Results: The mean age of patients with cardiac MRI was 57.9 ± 12.9 years, with extremes of 28 and 85 years. A male predominance with 56 men (56%) and 44 women (44%) is a sex ratio of 1.3. One or more cardiovascular risk factors were found in 86 patients (86%). Thirteen patients (13%) were coronary patients known or followed for effort angina, And finally 5 patients (5%) had a field of coronary heredity. 47 patients had NYHA Stage II or III Dyspnea (47%) and worsened to become NYHA Stage IV in 20 patients (20%) with Paroxysmal Night Dyspnea in 27 patients (27%).) and an orthopnea in 26 patients (26%).78 patients had chest pain (78%), 14% of patients had palpitations (n = 14); The delay between onset of symptoms of our patients and their hospitalizations varied between the same day and 180 days with an average of 24 days +/- 36 days and a median of 7 days and this can be explained by the variety of clinical presentation between Acute chest pain that pushes the patient consulted on the field and a flare of heart failure that settles gradually. The initial clinical evaluation shows that the patients were all aware, with a GCS at 15;

Corresponding Author:-Y.Kettani.
Address:-Cardiology B service; Ibn Sina Hospital Center, Rabat-Morocco.

The signs of right heart failure were present in 20% of cases, Crackling Rails in 29% of cases.
Chest x-ray: 30% of patients (n = 30) already had cardiomegaly. The electrocardiogram show Q Wave in 42% of cases (n = 42), The result of Echocardiography and cardiac magnetic resonance was compared between the two group of patient (Q wave and non Q wave) The results of our comparison were significant between the two group of patient with P <0.05 in most times which indirectly means that the presence of a Q wave corresponds to more akinesia on MRI and echocardiography.
Coronarography was performed in 73% of patients (n = 73), Although the presence of a Q wave at the ECG corresponds to more occlusion at the coronarography, the comparison was not statistically significant, and this can be explained either by coronary reperfusion or by the presence of collaterality or following MINOCA…
The CMR was able to detect sequelae of necrosis in 81% (n = 81) of cases, of which 34% (n = 34) was viable vs. 47% (n=47) not viable. Finally we deduce that the presence of necrosis Q wave corresponds to more necrosis in echocardiography and cardiac magnetic resonance imaging, but despite this the territory remains viable in 42% of cases. And the results are statistically significant.
The comparison of different methods of exploration respectively to coronary angiography showed statistically significant results, as far as the ECG and the ETT are concerned, it means that the 2 methods can miss the affected territories, on the other hand the MRI despite the difference in outcome with coronary angiography but the statistic was not significant, and this can be explained by the number of coronary angiography performed that was less than MRI and the ability of MRI to detect non visible lesions at the coronarography to see MINOCA whose number in our series was not negligible.
Conclusions: Chronic Q waves on electrocardiography do not exclude the presence of viable myocardium; in 38% of the Q-wave regions in 55 patients, viable tissue was present. Thus patients with a previous Q-wave infarction, severely depressed left ventricular function, and heart failure should be referred for viability testing.

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Introduction:

The diagnosis of previous myocardial infarction is clinically important. Population surveys have shown that survivors of myocardial infarction have a mortality rate three to 14 times that of the general population (1). The mortality rate is increased whether the index myocardial infarction is symptomatic or asymptomatic (1,2) or is classified electrocardiographically as Q-wave or non-Qwave.3,4 The diagnosis can, however, be difficult to confirm if infarction was not documented at the time of the acute event. There is a limited period in which biochemical evidence of infarction is present, and for many people the electrocardiogram will be non diagnostic, because the majority of acute myocardial infarctions are not associated with the formation of Q waves (3).

Current non-invasive imaging methods have inherent limitations that reduce the accuracy of diagnosis. For example, if a patient has a healed myocardial infarct that is subendocardial, regional wall motion by echocardiography, and regional perfusion by nuclear scintigraphy, and regional metabolism by positron emission tomography may all be normal because subendocardial defects cannot be detected by these techniques. Contrast-media-enhanced magnetic resonance imaging (MRI) has high spatial resolution and can detect myocardial infarction in human beings.(4) Limited differences in image intensities between hyper enhanced and non hyper enhanced regions, however, have restricted use of this technique to the study of acute myocardial infarction, and uncertainty remains over whether chronic, healed infarcts can be detected.

A recent technical advance in contrast-enhanced MRI has led to significant improvement in image quality.(5) Our study of acute myocardial infarction with this technique showed typical differences in image intensity between infarcted and non-infarcted regions of 500% compared with about 50% for previously reported MRI approaches.(5) Studies in dogs with this new technique showed clear distinction of infarcted from non-infarcted tissue whatever the time since infarction, with excellent correlation of hyperenhancement by MRI with infarct size by histopathology.(6,7) So far, data on the sensitivity and specificity of this new technique in patients with healed myocardial infarction are lacking. The aim of our study was to test whether contrast enhanced MRI can detect healed myocardial infarction. We postulated that both transmural and non-transmural healed infarction could be visualized. MRI was done several months later. In all patients, findings on contrast enhanced MRI were compared with the results of coronary angiography, electrocardiography, cineMRI and Echocardiography. To assess the specificity of the findings, contrast-enhanced MRI was also done in patients with Q wave and non Q wave patient.

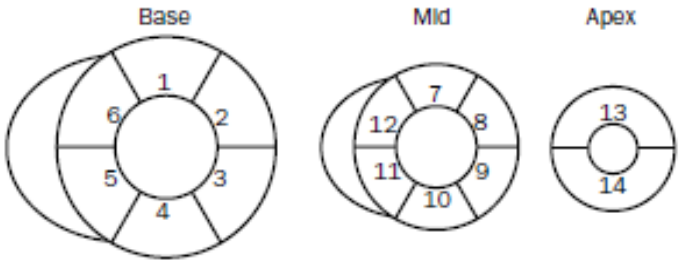

Figure 1:-Segmental model used for scoring of contrast enhanced MRI, cine MRI, and coronary angiography

Methods:-

100 MRI examinations were carried out in two groups: patients with Q wave and patients without Q wave at the electrocardiogram. Patients with healed myocardial infarction were prospectively enrolled after enyzmatically proven necrosis and imaged by the echocardiography. The MRI procedure used a segmented inversion-recovery gradient-echo sequence after gadolinium administration. Findings were compared with those of coronary angiography, electrocardiography, cine MRI, and Echocardiography.

Results:-

The mean age of patients with cardiac MRI was 57.9 ± 12.9 years, with extremes of 28 and 85 years. A male predominance with 56 men (56%) and 44 women (44%) is a sex ratio of 1.3. One or more cardiovascular risk factors were found in 86 patients (86%):

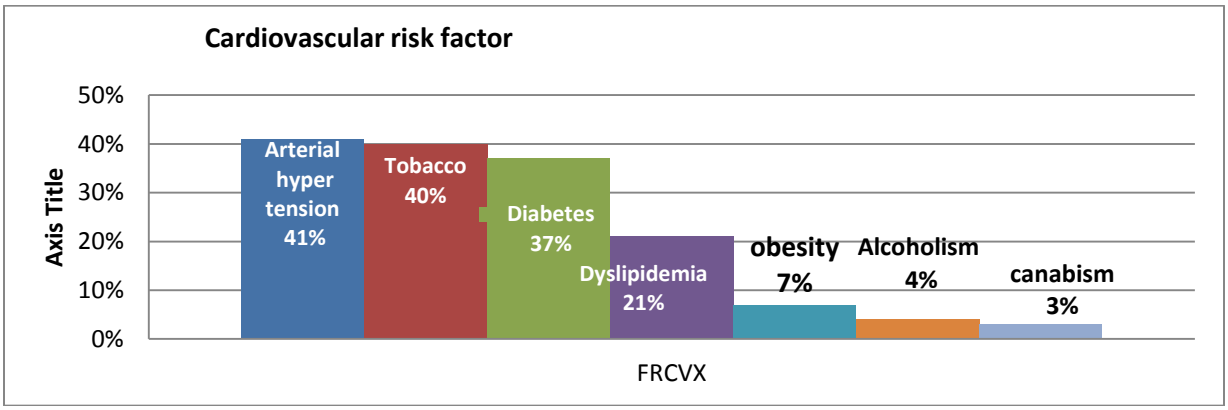

Figure 2:-Cardiovascular Risk Factor

The distribution of cardiovascular risk factors according to the same patient was as follows:

- 39 patients had only one FRCVX (39%);

- 47 patients had> 2 cardiovascular risk factors (47%); including 4 patients with 4 cardiovascular risk factors (4%)
- 14 patients had no cardiovascular risk factors (14%).

Thirteen patients (13%) were coronary patients known or followed for effort angina, six patients (6%) were followed for pulmonary problems of all types (BK, Asthma, COPD ...), seven patients (7%) were followed. for neurological problems (AVCI, Epilepsy ....), seven other patients (7%) were operated (cholecystitis, appendicitis, cataract ...) And finally 5 patients (5%) had a field of coronary heredity.

- 47 patients had NYHA Stage II or III Dyspnea (47%) and worsened to become NYHA Stage IV in 20 patients (20%) with Paroxysmal Night Dyspnea in 27 patients (27%).) and an orthopnea in 26 patients (26%).
- 78 patients had chest pain (78%),

Table I:-Comparison of the chest pain between Q wave patient and non Q wave patient

		Absence of Q wave at the Electrocardiogram (n=45)	Presence of Q wave at the Electrocardiogram (n=55)	P
		n(%) m(DS)	n(%) m(DS)	
Chest pain	Absence	15(15)	7(7)	0.013
	Presence	30(30)	48(48)	
Type of chest pain	constrictive type	26(26)	38(38)	0.028
	burn type	3(3)	7(7)	
Intensity of pain	Intense	17(17)	34(34)	0.032
	Moderate	8(8)	8(8)	
	Low	4(4)	6(6)	
duration of pain	Extended	19(19)	37(37)	0.02
	short	11(11)	11(11)	
Seat of pain	retrosternal	28(28)	44(44)	0,05
	epigastric	1(1)	4(4)	

m ± DS = moyenne ± déviation standard, n=effectif

14% of patients had palpitations (n = 14)

The delay between onset of symptoms of our patients and their hospitalizations varied between the same day and 180 days with an average of 24 days +/- 36 days and a median of 7 days and this can be explained by the variety of clinical presentation between Acute chest pain that pushes the patient consulted on the field and a flare of heart failure that settles gradually. The initial clinical evaluation shows that the patients were all aware, with a GCS at 15,

Cardiovascular examination:

- heart sounds Well received at a steady pace in 92%
- without breath in 88% of cases,
- without noise added in 97% of cases,
- Peripheral pulses were present and symmetrical in 96% of cases.
- The signs of right heart failure were present in 20% of cases mainly lower limb edema in 20% of cases, turgid jugular veins in 16% of cases, hepatic jugular reflux in 10% of cases and finally hepatomegaly in 9% of cases.

Table II:-clinical characteristic

	m ± DS	Extrêmes
Pression artérielle systolique (mmHg)	**122,98 ± 21,722**	**70 – 200**
Pression artérielle diastolique (mmHg)	**73,51 ± 13,223**	**45 – 110**
Fréquence cardiaque (bat/min)	**87,65 ± 25,19**	**32 – 200**
Fréquence respiratoire (cycles/min)	**15,17 ± 3,519**	**10 – 26**

m ± DS = moyenne ± déviation standard, n=effectif

Pleuropulmonary examination:

- Crackling Rails in 29% of cases
- Sibilants and snoring in 5% of cases
- Pleural effusion syndrome in 10% of cases.
- The abdominal examination was no abnormality in 98% of cases except 2 patients who presented with ascites

Chest x-ray:

- 30% of patients (n = 30) already had cardiomegaly.
- 26% of patients (n = 26) had bilateral hilar overload, 3% had bronchial syndrome and 4% had pneumonia. Pleural effusion syndrome was confirmed in 4%.

The electrocardiogram:

- Wave Q: Occurs in 42% of cases (n = 42),
- Abrasion of the R wave: present in 18% of cases (n = 18)
- ST segment elevation present in 44% of (n = 44)
- ST segment depression present in 29% of cases
- Negative T waves: present in 33% of cases
- The Block of Branch: present in 32% of the cases:
- Rhythm disorders in 16% of cases,
- Conduction disorders type BAV in 2%
- Cavitary hypertrophy in 16%
- LVH in 12% of patients.

The result of Echocardiography and cardiac magnetic resonance was compared between the two group of patient (Q wave and non Q wave) and the results are resumed in this table III and IV:

Table III:-comparison of the Echocardiography and CMR between Q wave patient and non Q wave:

		Cardiac Magnetic Resonance			Echocardiography		
		Q wave patient (n=55)	Non Q wave patient (n=45)	P	Q wave patient (n=55)	Non Q wave patient (n=45)	P
		n(%)	n(%)		n(%)	n(%)	
Apex et Seg adj.	Akinesia	23(23)	17(17)	0,32	35(35)	21(21)	0,009
	Dyskinesia	0	7(7)		0	4(4)	
	hypokinesia	7(7)	12(12)		5(5)	12(12)	
	normokinetic	16(16)	9(9)		15(15)	8(8)	
Antéroseptal	Akinesia	28(28)	19(19)	0,06	28(28)	20(20)	0,03
	Dyskinesia	1(1)	0		0	0	
	hypokinesia	9(9)	17(17)		7(7)	15(15)	
	normokinetic	17(17)	9(9)		20(20)	10(10)	
Inferoseptal	Akinesia	31(31)	20(20)	0,4	28(28)	20(20)	0,3
	Dyskinesia	1	0		0	0	
	hypokinesia	8(8)	17(17)		12(12)	15(15)	
	normokinetic	15(15)	8(8)		15(15)	8(8)	
Antérieur	Akinesia	29(29)	17(17)	0,025	18(18)	11(11)	0,004
	Dyskinesia	0	0		0	0	
	hypokinesia	7(7)	16(16)		10(10)	22(22)	
	normokinetic	19(19)	12(12)		27(27)	12(12)	
Inférieur	Akinesia	13(13)	6(6)	0,03	23(23)	13(13)	0,12
	Dyskinesia	0	0		0	0	
	hypokinesia	6(6)	14(14)		11(11)	17(17)	
	normokinetic	36(36)	25(25)		21(21)	15(15)	

Antérolatéral	Akinesia	9(9)	4(4)	0,23	35(35)	21(21)	0,05
	Dyskinesia	0	0		0	0	
	hypokinesia	10(10)	14(14)		5(5)	12(12)	
	normokinetic	36(36)	27(27)		15(15)	8(8)	
Inférolatéral	Akinesia	12(12)	6(6)	0,03 7	35(35)	21(21)	0,09
	Dyskinesia	0	0		0	0	
	hypokinesia	6(6)	14(14)		5(5)	12(12)	
	normokinetic	37(37)	25(25)		15(15)	8(8)	

m ± DS = moyenne ± déviation standard, n=effectif

Table IV:-Comparison of ejection fraction between Q wave and non Q wave patient

FEVG	Echocardiography	33,47(11,35)	38,33(11,83)	0,04
	CMR	36,844(12,57)	38,80(10,85)	0,4

m ± DS = moyenne ± déviation standard, n=effectif

The results of our comparison according to the presence or absence of a necrosis Q wave or equivalent were significant between the two group of patient with $P < 0.05$ in most times which indirectly means that the presence of a Q wave corresponds to more akinesia on MRI and echocardiography.

Coronarography was performed in 73% of patients (n = 73)

Table V:-Comparative study of the different coronary arteries affected according to the presence or absence of a Q wave at the ECG

Anterior interventricular coronary	Normal	19(19)	14(14)	0,18
	non-significant lesion	0	2(2)	
	tight lesion	7(7)	9(9)	
	Occlusion	15(15)	7(7)	
Circumflex coronary	Normal	30(30)	25(25)	0,8
	non-significant lesion	1(1)	0	
	tight lesion	6(6)	4(4)	
	Occlusion	4(4)	3(3)	
right coronary	Normal	24(24)	19(19)	0,8
	non-significant lesion	2(2)	2(2)	
	tight lesion	5(5)	5(5)	
	Occlusion	9(9)	6(6)	
	Dissection	1(1)	0	

m ± DS = moyenne ± déviation standard, n=effectif

Although the presence of a Q wave at the ECG corresponds to more occlusion at the coronarography, the comparison was not statistically significant, and this can be explained either by coronary reperfusion or by the presence of collaterality or following MINOCA…The CMR was able to detect sequelae of necrosis in 81% (n = 81) of cases, of which 34% (n = 34) was viable vs. 47% (n = 47) not viable.

Table VI:-Necrotic territory according to viability and comparison between Q wave patient and Non Q wave.

CMR Necrosis	Presence	32(32)	49(49)	0,02
	Absence	13(13)	6(6)	
viability of necrosis	Absence	19(19)	28(28)	0,07
	Presence	13(13)	21(21)	

m ± DS = moyenne ± déviation standard, n=effectif

Finally we deduce that the presence of necrosis Q wave corresponds to more necrosis in echocardiography and cardiac magnetic resonance imaging, but despite this the territory remains viable in 42% of cases. And the results are statistically significant.

The CMR advance in terms of diagnosis:

- 75% of diagnoses were related to atherosclerotic ischemic disease,

- 25% belongs to another diagnosis, mainly primary dilated cardiomyopathy, followed by different types of MINOCA, especially myocarditis, takotsubo, coronary emboli, non-compaction of LV, and microcirculation.

Table VI:-Comparison of the results of the different methods of non-invasive exploration compared to coronary angiography

Anterior interventricular coronary	44%	61%	69%	55%
Anterior interventricular coronary	34%	70%	74%	55%
Circumflex coronary	38%	53%	37.5%	25%
right coronary	26%	64%	39%	41%
P	0,05	0 ,01	0,06	

m ± DS = moyenne ± déviation standard, n=effectif

The comparison of different methods of exploration with respect to coronary angiography showed statistically significant results, as far as the ECG and the ETT are concerned, it means that the 2 methods can miss the affected territories, on the other hand the MRI despite the difference in outcome with coronary angiography but the statistic was not significant, and this can be explained by the number of coronary angiography performed that was less than MRI and the ability of MRI to detect non visible lesions at the coronarography to see MINOCA whose number in our series was not negligible.

Discussion:-

The findings in the current study demonstrate that chronic Q waves on the electrocardiogram do not exclude the presence of viable myocardial tissue in patients with severely depressed left ventricular function.

La Canna ET al (8) comparably showed that only 13% of dysfunctional regions in patients with severely depressed left ventricular function had an EDWT >5 mm. In line with these previous studies, regions with an EDWT <6 mm virtually never had viable tissue echocardiography. Cwajg ET al (9) showed that only 19% of the regions with an EDWT <6 mm were viable during dobutamine stimulation. Baer et al (10) used magnetic resonance imaging and demonstrated that regions with EDWT <5 mm never improved in contractile function after revascularization, indicating that regions with very thin walls do not contain viable tissue and do not improve in function after revascularization. In regions with an EDWT >5.5 mm, however, the response to dobutamine varied significantly.
La Canna ET al (8) demonstrated that 42% of the dysfunctional segments with a preserved EDWT (>5 mm) were nonviable on dobutamine stress echocardiography. Moreover, Baer ET al (10) demonstrated that 38% of the segments with an EDWT <5.5 mm did not improve in function after revascularization. On the basis of these results, it can be concluded that assessment of EDWT can be used as an initial screening technique for assessment of viability.

It can safely be concluded that regions with an EDWT <6 mm do not contain viable myocardium and do not improve in function after revascularization. However, in segments with an EDWT >6 mm, additional testing is needed because approximately 40% of these regions do not contain viable myocardium and will not improve in function after revascularization. The aim of this study was to evaluate the incidence of viable tissue in regions with Q-wave infarctions. Previous studies in small subsets of patients have already indicated that some patients with Q-wave infarctions have viable myocardium. Brunken et al15 showed in 20 patients that positron emission tomography with F18-fluorodeoxyglucose revealed residual glucose metabolism in 21 (68%) of 31 Q-wave regions. Similarly, Tillisch ET al16 evaluated 17 patients with positron emission tomography in combination with F18-fluorodeoxyglucose and showed that 16 (57%) of 28 regions with Q waves on the electrocardiogram improved in contractile function after revascularization. Besides these 2 studies, no studies have focused on the incidence of viable myocardium in patients with Q-wave infarctions. In this study, a combination of resting echocardiography and CMR was used to assess viability in a large cohort of patients. These echocardiography techniques are more widely available than positron emission tomography. On the basis of the combined information of echocardiography and CMR the incidence of viable myocardium in 55 patients with Q-wave infarctions were 38%, in line with the previous studies. Hence, electrocardiographic evidence of "transmural" infarction (Q waves) together with regional dysfunction at rest does exclude the presence of viable myocardium. In particular, the incidence of viable myocardium in regions with Q-wave infarction was comparable to the incidence of non viable myocardium (Table VI). This finding is of clinical importance because many patients have Q-wave infarctions, depressed left ventricular function, and heart failure symptoms. In the presence of viable myocardium, these patients may benefit from revascularization in terms of improvement of left ventricular function and longevity (11-14). As evidenced by the

high incidence of viable myocardium in regions with Q-wave infarctions in this cohort of patients, viability testing should be performed, and Q waves in combination with contractile dysfunction per se does not rule out the presence of viable myocardium.

Limitations

In this study, myocardial viability was assessed by Contrast enhanced at the CMR. This is a safe and widely available imaging method with a good sensitivity and specificity for the evaluation of myocardial viability. (11) Still, functional improvement of contractile dysfunction after coronary revascularization is considered the final proof of myocardial viability. In this study, functional improvement after coronary revascularization was not assessed.
Patients who underwent previous coronary revascularization were included in the study. Coronary revascularization might have influenced the presence and the number of Q waves as well as the presence of viable myocardium.
However, the time interval between revascularization and the current study was 6 month in all patients.

Conclusions:-

Chronic Q waves on electrocardiography do not exclude the presence of viable myocardium; in 38% of the Q-wave regions in 55 patients, viable tissue was present. Thus patients with a previous Q-wave infarction, severely depressed left ventricular function, and heart failure should be referred for viability testing.

Initial evaluation by resting echocardiography may already exclude the presence of viable tissue when EDWT is < 6 mm. However, in regions with Q waves, additional testing is needed because 38% of these regions show akinesia during echocardiography.

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