ORIGINAL ARTICLE

Prevalence of Different Causes of Low Voltage Electrocardiogram

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ABSTRACT

Background: Low QRSV -ECG voltage in healthy subjects may be a normal variant. Otherwise it may be a reading indicative of the conditions where the electrical signal from the heart is weakened. The causes of low voltage complexes on the electrocardiogram are variable comprising of cardiac and extra cardiac causes.
Aim: To study the prevalence of low voltage ECG amongst various clinical entities.
Methods: This cross-sectional indoor based study was conducted at the Department of Medicine & Cardiology, Shaikh Zayed Hospital, Lahore from 1st January 2001 to 30th June 2001. One hundred patients presenting in various departments with clinical features suggestive of any of the diseases, known to be the possible cause of low voltage ECG were included. After detailed history and clinical examination and besides CBC, ESR, chest X-ray, ECGs of all the patients were evaluated for low voltage. Cardiac enzymes, fasting lipids, mantoux test, USG abdomen/pelvis, body mass index, sputum examination and bronchoscopy were specified according to the clinical scenario.
Results: It was seen that though low QRSV on ECG is caused by different cardiac and extra cardiac clinical entities like pericardial effusion, myocardial infarction, hypothyroidism, obesity, anasarca etc. But the statistically significant results were obtained in pericardial effusion (68%), hypothyroidism (40%) and myocardial infarction (29%). While comparing all these 3 significant causes of low voltage ECG with one another via Post Hoc analysis, pericardial effusion had a significant p value (<0.05).
Conclusion: It was concluded that amongst all the causes of LQRSV-ECG, pericardial effusion is the most statistically significant clinical entity producing low voltage QRS complex on ECG
Keywords: Electrocardiogram, LQRSV-ECG, Causes, Prevalence

INTRODUCTION

Low electrocardiographic QRS voltage is traditionally defined by zenith-to-nadir QRS amplitudes of the QRS complexes of less than 0.5 mV in all the frontal leads and less than 1.0 mV in all the precordial leads.[1] Low voltage QRSV on ECG can be due to an intrinsic disease of the myocardium that may be acute and critical (e.g., myocardial Infarction, myocarditis). But most of times this low voltage QRSV is due to chronic processes such as cardiomyopathies (cause may be amyloid heart disease, hypothyroidism or hyperthyroidism, beri beri, alcoholism and IHD)[2,3].

Extra cardiac causes of LQRSV on ECG include fluid, fat, or air in between heart and electrodes (e.g., obesity, pneumothorax, anasarca) Multiple myocardial infarctions may lead to low electrocardiographic QRS voltage (LQRSV) because of cancellations or diminished electromotive force generation; Infiltrative cardiomyopathies (e.g., amyloidosis) may lead to LQRSV involving both the limb and precordial leads, despite marked cardiachypertrophy or dilatation[4].

Decreased voltage due to hyper-inflation of the lungs or pneumothorax can be acute or chronic due to COPD. Increased fluid around the heart can be due to pleural or pericardial effusion.[5] Pericardial effusion leads to LQRSV, the reason may be multifactorial: inflammation of the pericardium, short-circuiting of the heart's potentials as they are transmitted to the body surface; and the intrapericardial pressure, like in tamponade; all or some may be culprit[6,7,8]. The delays in recovery of LQRSV after pericardiocentesis in tamponade suggest that the effects on the ECG in pericardial effusion/tamponade are multifactorial.

SUBJECTS AND METHODS

This cross-sectional hospital based study was conducted at the Department of Medicine & Cardiology, Shaikh Zayed Hospital, Lahore from 1st January 2001 to 30th June 2001. One hundred patients presenting in various departments in Accident & Emergency, OPD, CCU, Medical and Cardiology Wards, with symptomatology suggestive of clinical features, known to be the causes of low voltage ECG i.e. acute myocardial infarction, myocarditis, amyloidosis, pericardial effusion, pleural effusion and anasarca were included. Only those patients were excluded from the study having low voltage ECG but the standardization of ECG recording machine was set at low voltage. After clinical examination and besides CBC, ESR, chest

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X-ray, ECGs of all the patients were evaluated for low voltage. Cardiac enzymes, fasting lipids, mantoux test, USG abdomen/pelvis, body mass index, sputum examination and bronchoscopy were specified according to the clinical scenario.

RESULTS

Amongst 100 patients, 19 patients (59.3%) males and 13 patients (40.7%) females having low voltages and 40 patients (58.8%) males and 28 patients (41.2%) females having no low voltages (Table 1). When different diseases were analyzed by comparing serum cholesterols (upto 180 mg % and >180 mg %) with low voltage. It was observed that serum cholesterol has got no relation with the voltage of QRS complex (Table 2). When applying the ANOVA test, QRS voltage in limb leads were significant (P<0.05) among the comparable groups (Table 3). When comparing the causes having >10 number of cases with one another, it was found that the pericardial effusion has got significant p value (P<0.05), highlighting that amongst the groups mentioned, pericardial effusion was the statistically significant cause of low voltage QRS. Amongst the pericardial effusion, those with tamponade encountered about 65% of the total cases of low voltage QRS complex in this group (Table 4).

Table 1: Frequency of low voltage ECG according to gender (n=100)

Gender	Absent (n=68)	Present (n=32)
Male	40(58.8%)	19(59.3%)
Female	28(41.2%)	13(40.7%)

Table 3: Comparison of QRS voltage in limb leads

Group	Sum of Squares	Df	Mean Square	P value
Between	1212.982	3	404.327	.000
Within	3168.436	75	42.246	

Table 2: Low voltage ECG having serum cholesterols upto 180 mg % and >180 mg %

Diagnosis	Serum cholesterol 180 mg % (n = 13)		Serum cholesterol >180 mg % (n = 43)	
	Absent	Present	Absent	Present
Acute myocardial infarction	5 (%)	3 (%)	21 (%)	6 (%)
Hypothyroidism	2 (%)	-	4 (%)	4 (%)
Pericardial effusion	-	1 (%)	1 (%)	-
Myocarditis	1 (%)	1 (%)	-	-
Amyloidosis	-	-	-	1 (%)
Obesity	-	-	5 (%)	1 (%)
Total	8 (%)	5 (%)	31 (%)	12 (%)

Table 4: Analysis of QRS voltage in limb leads

Disease (1)	Disease (2)	Mean difference (1-2)	Std. Error	P value
Acute MI	Hypothyroidism	2.7429	2.3306	.243
	Pericardial effusion	9.2679	1.9615	.000
	Ascites	-1.5238	1.8852	.421
Hypothyroidism	AMI	-2.7429	2.3306	.243
	Pericardial effusion	6.5250	2.6201	.015
	Ascites	-4.2667	2.5635	.100
Pericardial effusion	AMI	-9.2679	1.9615	.000
	Hypothyroidism	-6.5250	2.6201	.015
	Ascites	-10.7917	2.2332	.000
Ascites	AMI	1.5238	1.8852	.421
	Hypothyroidism	4.2667	2.5635	.100
	Pericardial effusion	10.7917	2.2332	.000

The mean difference is significant at the 0.05 level

DISCUSSION

The American College of Cardiology/American Heart Association (ACC/AHA) Committee defined the criteria for low voltage QRS complexes on the ECG as amplitude of the QRS complexes less than 5 mm in each standard limb lead, or less than 10 mm in the precordial leads.[9] The differential diagnoses are many, and may include myocardial disease (e.g.MI, myocarditis) pericardial disease (effusion, tamponade) and metabolic and infiltrative diseases. The ECG complexes may also be attenuated by any condition that increases the distance between the heart and ECG leads, such as anasarca, pneumothorax, pleural effusion and morbid obesity[10].

Inappropriate calibration is another common pitfall. The standard ECG should be calibrated to a voltage sensitivity of 10 mm/mV on vertical axis. In other situations, like pleural effusion, ascites,

anasarca, low voltage ECG has got nothing to evaluate the amount and prognosis of the disease.[11] Eisenberg et al[12] and Tajiri et al[13] showed that small and moderate sized pericardial effusions have a progressively damping effect on ECG voltage. In hypothyroidism with myxoedema, low voltage ECG is caused by combination of both, severe thyroid hormone deficiency and large pericardial effusion.

Eisenberg et al[12] stated that low voltage ECG was present in moderate and large effusions only and also that low voltage ECG is suggestive, of pericardial effusion and cardiac temponade. Unverferth et al[14] also reported 52.6% had both ECG sign and echographically demonstrable pericardial effusion. Small QRS deflections in cardiac failure, anasarca, pleural effusion, emphysema, ascites and myxoedema is usually the result of impaired voltage generated, or transmitted to skin electrode, the later is due to abnormal conducting fluid or medium[15,16]. The results of the present study are comparable to the studies quoted in the international literature. Pericardial effusion is the most significant cause of low voltage QRS voltage (68%) having significant value ($P<0.05$), amongst all known comparable causes of low voltage.

Acute myocardial infarction, 2/3rd of the studied patients were of anterior wall and rest of inferior wall; all were of ST-elevation type and low voltage QRS was 28.5%. Gelfand[17] reported 22% of acute myocardial infarction. The result of the present study is comparable. In 8 obese patients, low voltage ECG prevalence is 16%. This is in contrast to the study done by Alpert et al[18]. The difference in results might be due to multiple reasons. First of all, the present study is not statistically significant because very less number of patients. Secondly, we include only morbidity obese patients (BMI >40 mg/m^2), who were supposed to have high prevalence of low voltage. Also both of our obese patients had hyperlipidaemia and one was with hypothyroidism, both of the co-existing disease may be contributory to the low voltage QRS complex. Amongst the non-cardiac causes of low voltage, large pleural effusion has got (25%) massive ascites (12.5%) and anasarca (25%). But the results may be the false representatives of low voltage in these entities because of statistically insignificant number of patients.

CONCLUSION

Amongst the various causes of low voltage ECG the most important and significant are those related to the heart e.g. myocardial infarction, pericardial effusion. It is pericardial effusion (with or without tamponade) which is the most important statistically significant cause of low voltage QRS complex.

REFERENCES

1. Macfarlane PW, Veitch Lawrie TD. Theory and practice in health and disease. New York: Pergamon Press; 1989;291-9.
2. Chinitz JS, Cooper JM, Verdino RJ. Electrocardiogram voltage discordance: interpretation of low QRS voltage only in the limb leads. J Electrocardiol 2008;11:243-9.
3. Farrell RM, Syed A, Syed A, Gutterman DD. Effects of limb electrode placement on the 12- and 16-leadelectrocardiogram. J Electrocardiol 2008;41(6):536-45.
4. Spach MS, Kootsey JM. The nature of electrical proportion in cardiac muscle. Am J Physiol 1983;244:H3.
5. Byes D, Luna A. Textbook of clinical eectrocardiography. 1st ed. New York: Futura Publishing Company, 1993; 3-5.
6. Humphreys LE, Cummins P. Regulatory proteins of the myocardium. J Mor Cell Cardiol 1984; 16: 643-57.
7. Katz AM. Physiology of the heart. 2nd ed. New York: Ranev Press, 1992;179-94.
8. Murray JM, Knox MK, Weber A. Potentiated state of the trompomyosin action filament. Biochemistry 1982; 21: 960-15.
9. Kadish AH, Buxton AE, Kennedy HL, et al. ACC/AHA clinical competence statement on electrocardiography and ambulatory electrocardiography: a report of the ACC/AHA/ACP-ASIM Task Force on Clinical Competence (ACC/AHA Committee to Develop a Clinical Competence Statement on Electrocardiography and Ambulatory Electrocardiography). J Am Coll Cardiol 2001; 38:2091-100.
10. Madias JE, Bazaz R, Agarwal H, Win M, Medepalli L. Anasarca-mediated attenuation of the amplitude of electrocardiogram complexes: a description of a heretofore unrecognized phenomenon. J Am Coll Cardiol 2001; 38:756.
11. Yeo WT, Teo SG, Loh PYJ, Poh KK. Misleading ECG recordings. Singapore Med J 2011;52:772-6.
12. Eisenberg MJ, Romenral LM, Heidernrelch PA, Schiller NB, Evans GT. The diagnosis of pericardial effusion and cardiac temponade by 12-lead ECG. Chest 1996; 110: 318-24.
13. Tajiri J, Morita M, Higashi K, Fujii H, Nakamura N, Sato T. The cause of low voltage QRS complex in primary hypothyroidism: pericardial effusion or thyroid hormone deficiency? Jpn Heart J 1985;26(4):539-47.
14. Unverferth DV, Williams TE, Fulkerson PK. Electrocardiographic voltage in pericardial effusion. Chest 1979; 75; 157-60.
15. Sweetwood HM. Clinical electrocardiography for nurses. 1st ed. Rockville, Maryland (USA): Aspen Systems Corporation 1983; 402.
16. Dunn MI,. Lipman Massie clinical electrocardiography. 8th ed. Chicago: Mosby Publishers, 1980; 32.
17. Gel'fand IM, Gel'shteĭn GG, Zingerman LS, Lukashevich IP, Shifrin MA. ECG manifestations in severe involvement of the coronary arteries in patients with chronic ischemic heart disease. Kardiologiia 1983;23(6):66-72.
18. Alpert MA, Terry BE, Hamm CR, Fan TM, Cohen MV,. Effect of weight loss on the ECG of normotensive morbidly obese patients. Chest 2001;119(2):507-10.