Original Article

A Cohort Retrospective Study of Framingham Score and ECG Abnormality among Coal Mining Worker

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ABSTRACT

INTRODUCTION: *ECG is widely used as a screening method detecting cardiovascular disease, in coal mine worker's medical check-up. As the study has proven, coal mine workers have a double cardiovascular risk from their workplace hazard and their own medical risks as individuals. An early detection and risk assessment method is needed to predict ECG abnormalities in the future.* **AIM**: *This study will analyze the relationship between ECG Abnormality and Framingham Risk Score on coal mine workers* **METHOD**: *We examine ECG result from medical check-up of male coal worker during 2018 and 2021. Using Minnesota Code, we determine ECG abnormality categories in the 2021 result, then compare it with coal handling type worker and Framingham Score in 2018 as the main medical factor.* **RESULT**: *From 755 male coal workers with normal ECG in 2018, 158 (20,9%) were found with ECG Abnormalities in 2021. Cohort's multivariate study shows that type of coal worker is considered a determinant, but Framingham risk score still has the highest influence (p multivariate <0,002).* **CONCLUSION**: *Framingham risk score can be the method for predicting Abnormal ECG.*

1. Introduction

The primary energy provider in Indonesia is coal mining, which employs millions of people. Prior to oil and gas, the government receives around 33% of the energy produced by coal[1]. Few studies discuss heart illness in mining, although the pulmonary disease is a frequently discussed subject. in Spain (2019), 170 myocardial infarction deaths were associated with coal mining, with PM 2.5 suspected as the primary cause[2]. These ultra-fine particles can harm the cardiac through their pathogenic mechanisms[3–5]. The level of cardiovascular disease risk increases with the amount of coal mine workers' exposure to it. It was demonstrated in Hunan, China (2015), where it was noted that the prevalence of irregular ECGs was 37,6%[6] from miners.

On the other hand, atherosclerotic cardiovascular disease (ASCVD) risk increases with the age of 402,[7–10] or younger[11], history of cardiovascular disease in family[12,13], smoking habit[14,15], Body mass index (BMI) above 25kg/m2 [16–18], diabetes[13,19], high blood pressure[2,8,12,14,20], and poor lipid profile[13–15,21], which make coal mine workers as individuals has a double burden, due to their medical risks to cardiovascular. Early detection and risk assessment methods are needed to prevent any cardiovascular disease that will happen to coal mine workers.

An electrocardiogram (ECG) can help detect heart problems early on. This record of the electrical activity of the heart can reveal a lot about different cardiac conditions such as ischemia and infarction[22]. Fortunately, the medical examination of coal mining companies' employees includes the use of ECG. Another common technique for determining heart disease risk is heart risk calculation. *Framingham Risk Score* is one that is frequently utilized. Age, gender, and medical information from employee health check-ups, such as blood pressure, lipid profiles, and body mass index, are all included in this model's calculating algorithm. The probability of acquiring atherosclerotic cardiovascular disease (ASCVD) over the following 10 years is expressed as a percentage[8]. This study will aim to analyze the relationship between ECG Abnormality and *Framingham Risk Score* on coal mine workers.

2. Method

Study Design and Setting: This research design is a fixed historical cohort, using medical-checkup data of a Coal Mining company's employees in 2018 and 2021 (constant time of three years).

Sample Size and Sampling Technique: Total sampling technique was conducted on the entire population of a Coal Mining company's employees who carried out medical check-up from 2018 to 2021. The sample size calculated using a proportion comparison test formula with a p-value is 46,1% according to Goldman *et.al*[23] (2019) research on the prevalence of abnormal ECG in High *Framingham Risk Score* and p2 is 26,3% according to Wowor *et.al*[18] study on normal population abnormal ECG. The minimum sample counted is 89 for each *Framingham Risk Score* category.

Ethical Review: This research has passed the ethical review with no. KET-1106/UN2.F1/Etik /PPM.00 .02/2022 issued by the Ethics Committee of Medical Faculty University of Indonesia.

Research Variable: We examine ECG results from medical checkups of male coal workers during 2018 and 2021. Using Minnesota Code, we determine employees with normal ECG in 2018, as the start, then determine their abnormality ECG categories in 2021. ECG abnormalities will be presented in the groups of positive ECG abnormalities and negative ECG abnormalities as the main dependent variable. Furthermore, positive ECG abnormalities will be divided into a variant of ECG abnormality, according to the Minnesota Code[24]. There are nine (9) types of ECG abnormalities, however, for later analysis, it will be redivided into three categories of ECG abnormalities: Rhythm Disorders, QRS Abnormalities, and ST-T Segment Abnormalities.

Framingham Score Risk, as the main independent variable collected from categorized into High-Medium (Score >10%) and Low Risk (Score <10%), counted using a formula from its official website framinghamheartstudy.org. This variable was collected from the 2018 medical check-up results. Coal handling type workers are categorized into miners and supporting, according to Lai Z *et.al* (2015)[6] research. Smoking, diabetes, and family history of cardiovascular disease were divided into two categories, while the numeric variable such as age, systolic blood pressure, BMI, Total Cholesterol, and HDL-Cholesterol was analyzed accordingly.

Process and Data Analysis: The secondary data was assessed for eligibility through inclusion and exclusion criteria such as male workers only, no workers with a history of any heart disease, and no workers on cardiologist's therapy. After characterizing the data descriptively, each variable was compared to Abnormal ECG to identify determinant variables, using proportional comparison (chi-square) for categoric variables and mean comparison (independent t-test / Mann Whitney) for numeric variables. The determinant variables were then compared again to abnormal ECG as multivariate analysis (Cox-Regression) to identify the relationship.

Results

A total of 755 samples of normal ECG coal mine male workers were collected from 2018- 2021 medical check-up data, eligible through inclusion and exclusion criteria. Table 1 the show characteristics of all variables descriptively, as 20,9% of coal workers had positive abnormal ECG in 2021.

78.9% of coal mine workers are categorized as miners, who have an average age of 36.5 years old. The average Body Mass Index (BMI) is slightly overweight (25.03 kg/m2) with a 51.1% prevalence of BMI above 25 kg/m2. Normal mean of systolic blood pressure, Total and HDL cholesterol stated with an abnormal prevalence of those categories is below <50%. Furthermore, 37.4% of workers are smokers, obtained from interviews during medical check-ups. For medical history, mining workers suffering from diabetes and workers with families suffering from the cardiovascular disease had a fairly small prevalence. Deeper / further analysis was conducted on abnormal ECG variants using the Minnesota code. From 158 abnormal ECG data, 173 variants were

found and divided into 9 Minnesota categories as described in Figure 1. For further analysis, these nine categories are divided into three major groups: Rhythm disorder (x-pattern), QRS Abnormality (chess-pattern), and ST-T abnormality (line-pattern). The most common major group abnormal EGC is rhythm disorder (43,45%), then QRS Abnormality (35,26%) while ST-T abnormality is the least (21,39%). The arrhythmia category is the most found among coal mine workers (35,84%).

Table 1. Characteristics of Workers

Variable	Frequency - n (%)	Mean (SD)	Median (min–max)
Age (years)		36.5 (7.3)	
< 40	519 (68.7)		
≥ 40	236 (31.2)		
Job Type			
Miners	596 (78.9)		
Supporting	159 (21)		
Smoking			
Yes	283 (37.4)		
No	472 (62.6)		
Diabetes			
Yes	26 (2.4)		
No	729 (97.6)		
Family History of CVD			
Yes	47 (6.1)		
No	708 (94.9)		
Abnormal ECG in 2021			
Normal ECG	597 (79.1)		
Abnormal ECG	158 (20.9)		
Framingham Risk Score			
Low Risk	642 (85.1)		
High Medium Risk	113 (14.9)		
BMI (kg/m2)		25.03 (3.85)	
< 25	369 (48.8)		
≥ 25	511 (51.1)		
Systolic Blood Pressure (mmHg)		112.9 (11.2)	
< 140	731 (96.8)		
≥ 140	24 (3.17)		
Total Cholesterol (mg/dl)		197.3 (35.5)	
< 200	435 (57.6)		
≥ 200	320 (42.3)		
HDL Cholesterol (mg/dl)			50 (35 - 96)
≥ 40	635 (84.1)		
< 40	120 (15.8)		

Identifying the determinant variable was carried out by comparing all variables to abnormal ECG incidents. *Framingham Risk Score* and age were found related to abnormal ECG (p<0,05), while the type of coal worker, BMI, and systolic blood pressure was considered as determinants even though found not significant (p<0,25). We calculated the Adjusted Relative Risk of abnormal ECG for these five variables using multiple cox regression analysis. The result is shown in table 2, *Framingham risk scores* are strongly related to the incident of abnormal ECG.
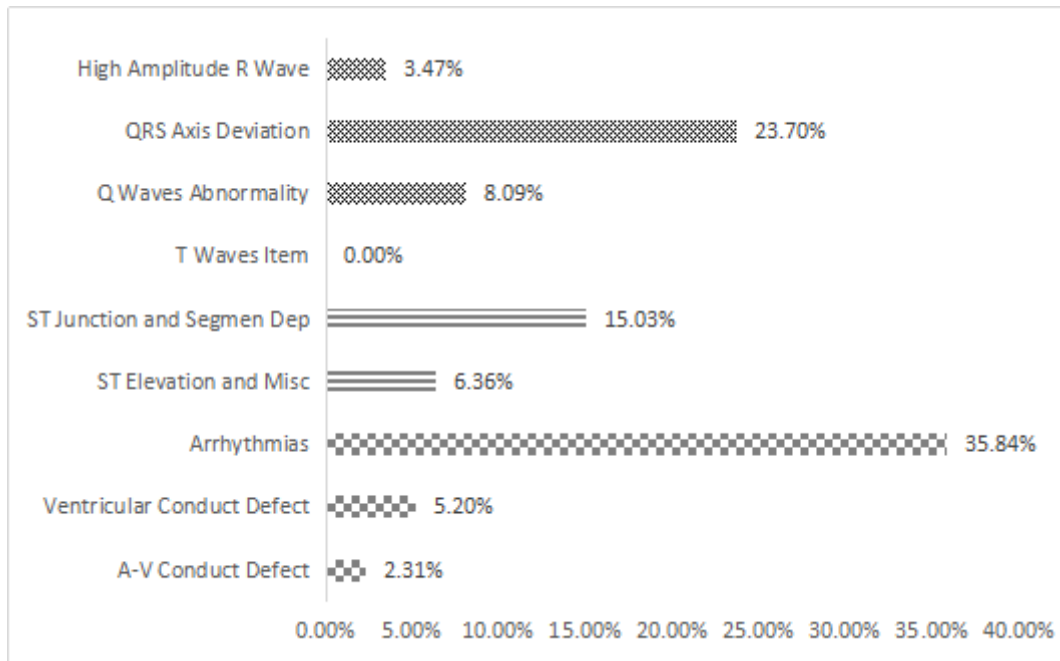
Figure 1. Abnormal ECG Distribution

Table 2. Relationship between Determinant Variables and Abnormal ECG

Variables	Abnormal ECG (+)	Abnormal ECG (-)	p	aRR (95% CI)
Framingham Risk Score*				
High-Medium Risk	36 (31.9%)	77 (68.1%)	0.038	1.68 (1.03–2.75)
Low Risk	112 (19%)	520 (81%)		
Type of Coal Worker*				
Supporting	36 (22.6%)	123 (77.4%)	0.646	1.09 (0.75–1.58)
Miners	112 (20.5%)	474 (79.5%)		
Age (Years)#	37.8 (7.4)	36.2 (7.2)	0.303	1.01 (0.99–1.04)
BMI (kg/m²)#	24.5 (3.4)	25.2 (3.9)	0.051	0.96 (0.91–1.00)
Systolic Blood Pressure (mmHg)#	115.4 (13.7)	112 (11.8)	0.401	0.99 (0.98–1.01)

* n (%)
\# Mean (SD)
aRR: adjusted RR

Discussion

A significant regression study indicates that the *Framingham risk score* of coal mine workers in 2018 has a relationship with the incident of abnormal ECG in 2021. Workers who have a Framingham High-Medium Risk Score have a 1.682x higher risk of ECG abnormalities. This risk can increase with a range of 1.029x to 2.751x. Moreover, *Framingham Risk Score* has a strong influence than other determinant variables. This result is consistent with Goldman *et.al*[23]., (2019) research on the prevalence of abnormal ECG in the high *Framingham Risk Score* in a normal population. A total of 46.1% of patients who had a high Framingham score had an ECG abnormality[23].

ECG is a screening tool for detecting the early sign of heart disease, even before the patient develops symptoms[22]. One of the popular heart diseases is atherosclerotic cardiovascular disease (ASCVD). It has risk factors including age[2,7–10], smoking habit[14,15] history of cardiovascular disease in family[12,13], overweight BMI[16–18], diabetes[13,19], high blood pressure[2,8,12,14,20], and poor lipid profile[13–15,21], as mentioned before. On the other hand, the *Framingham risk score* calculates almost a similar variable. This similarity caused the *Framingham risk score* to have a significant relationship with ECG, even for three years ahead.

More importantly, this study also compares the *Framingham risk score* with each specific variable. it is proven that the Framingham risk has a stronger relationship than its variables. We may conclude that in this coal mining study, the *Framingham risk score* can be a method for predicting abnormal ECG, which are good early screening tool for heart disease.

This study analyzes the type of coal miner as an occupational factor. Following Lai, Z *et.al*[6] study, we divide a total of 755 workers into miners and supporting groups. The result is not significant, but this variable is considered a determinant (p=0,082) with the supporting group having more prevalence of abnormal ECG. This result is not consistent with the following study because of the different types of coal mines. Lai, Z *et.al*[6] conduct their research on underground mining, while this study is on the surface type of mining. Underground mining tends to have more hazard risk in coal dust[6] with additional heat stress[25]. Dey N *et.al*[25] mention that heat stress can affect the heart rate of coal workers, resulting in abnormal ECG.

Miners tend to expose to coal dust more often than support workers, and this workplace hazard has the potential to affect cardiac health. Ultra-fine particle (UFP) has, at least, three pathological mechanisms to damage the heart[4]. The main pathological is disturbing parasympathetic cardiac activity when inhaled. From Hisam *et.al*[3] study, 5 pieces of literature say that UFP will lower parasympathetic cardiac activity, while 2 others say the opposite. Whatever the output, disturbing parasympathetic will cause rhythm disorder, that seen the most in this ECG abnormality study. Last but not least, coal UFP will interact with cellular mechanisms and increase Reactive Oxygen Species (ROS) production. The continuous production of these ROS will cause oxidative stress and continue in various endothelial and even myocardial damage, representing ST-T abnormality and QRS abnormality[5]. These three pathological pathways are known as the "Cardiac Death Triangle"[4].

Exposure to UFP should be related to ECG abnormality. In this study, exposure to UFP is limited only by the type of coal worker. As a study weakness, we can't objectively count the exposure for each coal worker, and this research was conducted during the pandemic era, which may decrease the exposure. Further studies are needed to confirm the UFP relationship to ECG.

Conclusion

As the study has proven, coal mine workers have a double cardiovascular risk from their workplace hazard and their medical risks as individuals. This study concludes that the Framingham risk score can be a method for predicting and risk assessing abnormal ECG three years ahead, which are good early screening tools for heart disease.

Declaration

References

1. Nursanto E, Sukamto U. *Pengolahan Batubara dan Pemanfaatannya untuk Energi. Prosiding Seminar Nasional Teknik Kimia "Kejuangan" Yogyakarta.* Yogyakarta. 2015.
2. Dos Santos JPA, Ribeiro ALP, Andrade-Junior D, Marcolino MS. Prevalence of electrocardiographic abnormalities in primary care patients according to sex and age group. A retrospective observational study. Sao Paulo Med J. 2018;136(1):20–8. https://doi.org/10.1590/1516-3180.2017.0222290817
3. Hisam Z. Coal miners: the ground realities - Newspaper - DAWN.COM. 2014; Available from: https://www.dawn.com/news/1122021
4. Weichenthal S. Selected physiological effects of ultrafine particles in acute cardiovascular morbidity. Environ Res. 2012;115:26–36. https://doi.org/10.1016/j.envres.2012.03.001
5. Zhang W, Huang Q, Zeng Z, Wu J, Zhang Y, Chen Z. Sirt1 Inhibits Oxidative Stress in Vascular Endothelial Cells. Oxid Med Cell Longev. 2017;2017:1–8. https://doi.org/10.1155/2017/7543973
6. Lai Z, Wang X, Tan H, Huang Y, Lu C. Effect of underground work on cardiovascular system in coal miners. J Cent South Univ (Medical Sci. 2015;40(10):1103–8.
7. Kanchi R, Perlman SE, Chernov C, Wu W, Tabaei BP, Trinh-Shevrin C, et al. Gender and Race Disparities in Cardiovascular Disease Risk Factors among New York City Adults: New York City Health and Nutrition Examination Survey (NYC HANES) 2013–2014. J Urban Heal. 2018;95(6):801–12. https://doi.org/10.1007/s11524-018-0287-x
8. D'Agostino RB, Vasan RS, Pencina MJ, Wolf PA, Cobain M, Massaro JM, et al. General Cardiovascular Risk Profile for Use in Primary Care. Circulation. 2008 Feb 12;117(6):743–53. https://doi.org/10.1161/circulationaha.107.699579

9.   Vaccarezza M, Papa V, Milani D, Gonelli A, Secchiero P, Zauli G, et al. Sex/gender-specific imbalance in CVD: Could physical activity help to improve clinical outcome targeting CVD molecular mechanisms in women? Int J Mol Sci. 2020;21(4). https://doi.org/10.3390/ijms21041477
10. Chinushi Y, Watanabe H, Chinushi M, Aizawa Y. ST-T Abnormalities on ECG in Relation to Cardiovascular Risk Factors. J Arrhythmia. 2011;27(3):202–7. https://doi.org/10.1016/s1880-4276(11)80045-1
11. O'Neil A, Scovelle AJ, Milner AJ, Kavanagh A. Gender/Sex as a Social Determinant of Cardiovascular Risk. Circulation. 2018;137(8):854–64. https://doi.org/10.1161/circulationaha.117.028595
12. Emery CF, Stoney CM, Thayer JF, Williams D, Bodine A. Sex and family history of cardiovascular disease influence heart rate variability during stress among healthy adults. J Psychosom Res. 2018 Jul;110:54–60. https://doi.org/10.1016/j.jpsychores.2018.04.011
13. Harms PP, van der Heijden AA, Rutters F, Tan HL, Beulens JWJ, Nijpels G, et al. Prevalence of ECG abnormalities in people with type 2 diabetes: The Hoorn Diabetes Care System cohort. J Diabetes Complications. 2021;35(2):107810. https://doi.org/10.1016/j.jdiacomp.2020.107810
14. Kondo T, Nakano Y, Adachi S, Murohara T. Effects of tobacco smoking on cardiovascular disease. Circ J. 2019;83(10):1980–5. https://doi.org/10.1253/circj.cj-19-0323
15. Barbaresko J, Rienks J, Nöthlings U. Lifestyle Indices and Cardiovascular Disease Risk: A Meta-analysis. Am J Prev Med. 2018;55(4):555–64. https://doi.org/10.1016/j.amepre.2018.04.046
16. Powell-Wiley TM, Poirier P, Burke LE, Després J-P, Gordon-Larsen P, Lavie CJ, et al. Obesity and Cardiovascular Disease: A Scientific Statement from the American Heart Association. Circulation. 2021;143(21). https://doi.org/10.1161/cir.0000000000000973
17. Gómez-Ambrosi J, Silva C, Galofré JC, Escalada J, Santos S, Millán D, et al. Body mass index classification misses subjects with increased cardiometabolic risk factors related to elevated adiposity. Int J Obes. 2012;36(2):286–94. https://doi.org/10.1038/ijo.2011.100
18. Wowor RL, Umboh GDKJML. Factors Effects Left Ventricular Hypertrophy on Male Students Participants. Jikmu. 2015;5(1):54–62. https://doi.org/10.30596/amj.v3i2.4547
19. Almourani R, Chinnakotla B, Patel R, Kurukulasuriya LR, Sowers J. Diabetes and Cardiovascular Disease: an Update. Curr Diab Rep. 2019;19(12). https://doi.org/10.1007/s11892-019-1239-x
20. Fuchs FD, Whelton PK. High Blood Pressure and Cardiovascular Disease. Hypertension. 2020;285–92.
21. Nicholls SJ, Nelson AJ. HDL and cardiovascular disease. Pathology. 2019;51(2):142–7.
22. Williams L, Wilkins. *Satu-Satunya Buku Ekg Yang Anda Perlukan*. 5th ed. Penerbit Buku Kedokteran EGC; 2016. 65–82 p.
23. Goldman A, Hod H, Chetrit A, Dankner R. Incidental abnormal ECG findings and long-term cardiovascular morbidity and all-cause mortality: A population based prospective study. Int J Cardiol. 2019;295:36–41. https://doi.org/10.1016/j.ijcard.2019.08.015
24. Macfarlene PW. Minnesota coding and the prevalence of ECG abnormalities. Heart. 2000;84(6):582–4. https://doi.org/10.1136/heart.84.6.582
25. Dey NC, Amalendu S, Saha R. Assessment of cardiac strain amongst underground coal carriers-A case study in India. Int J Ind Ergon. 2007;37(6):489–95. https://doi.org/10.1016/j.ergon.2007.01.005